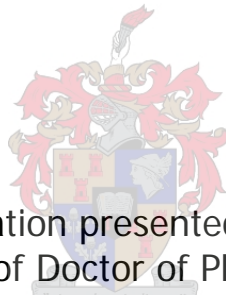


A model for psychophysiological regeneration of elite team athletes

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Declaration

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Summary

There is general consensus that athletes, striving to compete and perform at the highest level, should optimally balance training and competition stress with adequate regeneration. Although a well-planned training programme is of utmost importance, the time between training sessions and competitions is critical for the modern-day athlete. It is suggested that athletes should apply a variety of recovery methods to enhance the regeneration process. Although team sport is a popular entity throughout the world, there is limited published research on the regeneration process in team athletes and recovery methods to enhance the regeneration process.

The aim of this study was to develop a model that could serve as a guideline for the regeneration of team athletes within the South African context. Two phases were involved in the process of developing a model. Phase one involved a research of literature in order to assess which strategies can be implemented for athletic regeneration, and what information team athletes are given for regeneration. The second phase involved an investigation into the recovery strategies that are currently used for regeneration by elite South African team players during the competitive phase of the year. Research questions focused on the recovery methods used by players, the perceived importance of various recovery methods to the players, and the relationship between sport and level of participation in the use of recovery strategies. This study did not attempt to assess the knowledge of the players on recovery methods.

The study was approved by the Ethics Committee of Stellenbosch University.

A total of 890 elite South African team sport players (mean age 22.26 ± 3.37 years) from hockey (n=213), netball (n=215), rugby (n=317) and soccer (n=145) participated in the study. The total group of players consisted of 57% males (n=507) and 43% females (n=383). Players included in the study had to participate in the highest division of the major competitions and tournaments of their sport during the 2007-season. Of the total group, 75% (n=668) of the players were from national and provincial teams, and 25% (n=222) from A-division club teams. Data were collected by means of a survey through a once-off cross-sectional research design. A self-administered questionnaire, specifically designed for the study, was used for data collection. Informed (written) consent was given and responses

were treated as confidential and anonymous. The response rate for the total group was 74%.

Players had to indicate, amongst others, how they perceived the importance of various recovery methods to their physiological and psychosocial regeneration. The following recovery methods received the highest ratings in terms of importance for the total group (in rank order): *sleep, regular healthy meals, fluid intake, prayer, socialise with friends, discussion with teammates after training/match, discussion with coach after training/match, active cool-down, snacks after match, music, and an ice bath.*

With regard to the recovery methods that players actually used, players had to indicate whether they use the specific recovery method and when they are using it (after training, between training sessions, after matches, on non-training days where applicable). Results revealed that the recovery method that was used the most after training by all players from the four sport codes was an active cool-down. The recovery method used the most after matches by hockey, netball and soccer players was an active cool-down. Rugby players use a strategy for fluid replacement the most. The two recovery methods used the most after matches are the same for the different levels of participation, namely, an active cool-down and a strategy for fluid replacement. Results from the current study showed that the only recovery method that is used on a regular basis is an active cool-down after training and matches by hockey, netball and soccer players. Other recovery methods are not applied regularly.

Results from this study suggest that there is a need for athlete and coach education with regard to the use of a variety of recovery methods in the regeneration process of team players. A model is proposed for the psychophysiological regeneration of elite team players that could serve as a guideline for team players within the South African context. The model emphasises a multi-dimensional holistic approach to the regeneration of team athletes. Players experience stress in many areas (e.g., physical, emotional, social) and different regeneration strategies are needed to address these areas. This necessitates a focused and planned strategy for regeneration. Regular monitoring of the fatigue and regeneration status of players through invasive and non-invasive techniques was finally emphasised.

Key words: Regeneration; Recovery methods; Elite team athletes; Hockey; Netball; Rugby; Soccer.

Opsomming

Daar word algemeen aanvaar dat sportmense, in hulle strewe om op die hoogste vlak te kompeteer en presteer, 'n optimale balans moet handhaaf tussen oefen- en kompetisiestres en voldoende regenerasie of herstel. Hoewel 'n goed-bepande oefenprogram van die uiterste belang is, is die tyd tussen die oefensessies en kompetisies van kritieke belang vir die hedendaagse atleet. Daar word voorgestel dat sportmense 'n verskeidenheid herstelmetodes moet gebruik in die tye tussen oefensessies en kompetisies om die regenerasieproses aan te help. Hoewel spansport 'n populêre entiteit is, is daar beperkte gepubliseerde navorsing oor die regenerasieproses by spansportspelers en die herstelmetodes wat hierdie proses kan aanhelp.

Die doel van die studie was om 'n model te ontwikkel wat as 'n riglyn kan dien vir die regenerasie van elite spansportspelers binne die Suid-Afrikaanse konteks. Twee fases was betrokke in die proses om die model te ontwikkel. In die eerste fase is 'n literatuurondersoek gedoen om te bepaal watter strategieë geïmplementeer kan word vir regenerasie, asook watter inligting aan spansportspelers gegee word met betrekking tot hulle regenerasie. In die tweede fase is 'n ondersoek gedoen na die huidige situasie met betrekking tot herstelstrategieë wat deur elite Suid-Afrikaanse spansportspelers gedurende die kompetisiefase van die jaar gebruik word. Navorsingsvrae het gefokus op die herstelmetodes wat deur die spelers gebruik word as deel van 'n herstelstrategie, die spelers se persepsies van die belangrikheid van verskillende herstelmetodes, asook die verwantskap tussen die herstelmetodes wat gebruik word, die sportsoorte en vlak van deelname. Hierdie studie het nie probeer om die kennis van die spelers met betrekking tot herstelmetodes te bepaal nie.

Die studie is goedgekeur deur die Etiese Komitee van die Universiteit Stellenbosch.

'n Groep van 890 elite Suid-Afrikaanse spansportspelers (gemiddelde ouderdom 22.26 ± 3.37 jaar) van hokkie ($n=213$), netbal ($n=215$), rugby ($n=317$) en sokker ($n=145$) het aan die studie deelgeneem. Die totale groep spelers het uit 57% mans ($n=507$) en 43% vrouens ($n=383$) bestaan. Om in die studie ingesluit te word, moes spelers op die hoogste vlak van die belangrikste of grootste kompetisies of toernooie van hulle sport gedurende die 2007-seisoen deelneem. Die totale groep het bestaan uit 75% spelers ($n=668$) uit nasionale en provinsiale spanne en 25% spelers ($n=222$) uit A-afdeling spanne.

Data is deur middel van 'n eenmalige opname ingesamel. 'n Self-gedadministreerde vraelys wat spesifiek vir die studie ontwerp is, is gebruik vir die data-insameling. Ingeligte (geskrewe) toestemming is gegee en response is as vertroulik en anoniem hanteer. Die terugvoerkoers vir die hele groep was 74%.

'n Aanduiding van die spelers se persepsies oor die belangrikheid van verskillende herstelmetodes vir hulle fisiologiese en sielkundig-sosiale regenerasie is onder andere bepaal. Die volgende herstelmetodes het die hoogste tellings behaal by die hele groep (in rangorde): *slaap, gereelde voedsame maaltye, vloeistofinname, gebed, sosialiseer met vriende, bespreking met spanmaats na 'n oefening of wedstryd, bespreking met afrigter na 'n oefening of wedstryd, aktiewe afkoeling, peuselhappies na 'n wedstryd, musiek* en 'n *ysbad*. Om te bepaal watter herstelmetodes spelers werklik gebruik, moes spelers aandui of hulle 'n spesifieke metode gebruik asook wanneer hulle die metode gebruik (na oefeninge, tussen oefensessies, na wedstryde, en op nie-oefendae waar van toepassing). Resultate het aangetoon dat 'n aktiewe afkoeling as herstelmetode die meeste na oefeninge deur al die spelers van die verskillende sportkodes gebruik is. 'n Aktiewe afkoeling word ook die meeste deur hokkie-, netbal- en sokkerspelers gebruik na wedstryde. Rugbyspelers gebruik 'n strategie vir vloeistofvervanging die meeste. Die twee herstelmetodes wat die meeste na wedstryde deur spelers van verskillende vlakke van deelname gebruik word, is 'n aktiewe afkoeling en 'n strategie vir vloeistofvervanging. Resultate dui aan dat 'n aktiewe afkoeling die enigste herstelmetode wat op gereelde basis na oefeninge en wedstryde gebruik word. Geen ander herstelmetode word gereeld deur spelers gebruik nie.

Uit die resultate kan afgelei word dat daar 'n behoefte is aan opleiding vir afrigters en spelers met betrekking tot die gebruik van 'n verskeidenheid herstelmetodes in die regenerasieproses van spansportspelers. 'n Model is voorgestel vir die sielkundig-fisiologiese regenerasie van elite spansportspelers wat kan dien as 'n moontlike riglyn vir spansportspelers binne die Suid-Afrikaanse konteks. Die model beklemtoon 'n multi-dimensionele holistiese benadering tot die regenerasie van spansportspelers. Spelers ervaar stres op baie gebiede (bv., fisiek, emosioneel, sosiaal) en verskillende regenerasie-strategieë is nodig om hierdie areas aan te spreek, wat 'n gefokusde en beplande strategie vereis. Gereelde monitering van spelers deur middel van indringende en nie-indringende tegnieke is ook beklemtoon.

Sleutelwoorde: Regenerasie; Herstelmetodes; Elite spansportspelers; Hokkie; Netbal; Rugby; Sokker.

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Chapter One

Introduction

In their quest for excellence, athletes have to cope with tough training programmes, and perform well in competitions on a regular basis. Most elite team athletes participate in demanding training and competition schedules, with a competitive season entailing cycles of training, tapering, and competing from one week to the next. Players from top clubs may have additional commitments such as inter-provincial league matches and tournaments, or other cup matches, or representing their country in international competitions. The repetitive and seemingly unrelenting match fixtures, often combined with the stress of travel, might push athletes beyond their physiological and psychological limits (Bompa, 1999; Reilly & Ekblom, 2005; Reilly, Waterhouse & Edwards, 2005). Athletes rush from one peak to the other and, according to Kellmann (2002a: 4), "the recovery phases become too short in today's limits of human performance."

Traditional ways of training and competing have revolved around work-based training, with performance challenges solved by simply doing more training. Modern athletes are facing more mental, emotional and social demands daily than ever before, with pressure on personal relationships, media demands, sponsor needs, more public interest, e-communications, cellular phones, and information overload (Botterill & Wilson, 2002). Athletes and coaches are challenged to address the repeated imbalance between stress and recovery, with the basic assumption that a greater training load and growing stress necessitate increasing recovery (Bompa, 1999; Coutts, 2001; Fuller & Paccagnella, 2004; Goldsmith, 2006; Kallus & Kellmann, 2000; Kellmann, 2002a; Peterson, 2003).

The purpose of training is to displace or upset the homeostasis of an athlete's functional systems. The natural consequence is some degree of fatigue. Fatigue is thus essential for improvement, but it also requires proper recovery to complete the developmental cycle. Recovery is seen as an essential component of athletic training. It is often stated that optimal performance is only achievable if athletes balance training and competition stress with adequate time for regeneration, because it is emphasised that adaptation takes place during the regeneration phases (Norris & Smith, 2002). During the demanding training and competition schedules, systems can be impaired to the extent that future capacity and athletic performance are compromised. Normal physiological fatigue is accentuated by

emotional fatigue, from which it often takes longer to recover (Smith & Norris, 2002). Unless the athlete recovers quickly and optimally, the athlete may not be able to train adequately, perform the planned workload, or achieve the expected performance level (Bompa, 1999; Smith & Norris, 2002). Kellmann (2002a) stated that an awareness of the importance of the regeneration process often marks the difference between a mediocre and an outstanding athlete.

It is not only the frequency of competitions that leaves less time for adequate regeneration, but also training errors. Lambert and Borresen (2006: 372) wrote: "For competitors at elite level there is a fine line between doing too little or too much training. ... too much training results in maladaptations or the failure to adapt, causing symptoms of chronic fatigue and poor performance." The authors stated that neglected or inadequate recovery are amongst the training errors that can detract athletes from peak performances. To optimise performance in sports, regeneration should be programmed as an integral component of training, such as training periodisation with regeneration microcycles, alternating hard and easy days, rest days, and specific recovery strategies should be implemented (Hoffman, Epstein, Yarom, Zigel & Einbinder, 1999; Hooper & Mackinnon, 1995). Central to modern training is the concept of periodisation. It is a systematic and methodical planning tool used to divide the annual plan into smaller training phases, making it easier to plan and manage the training programme. The focus on training is balanced by the inclusion of regeneration periods, as well as strategies for recovery that should be implemented throughout the programme (Bompa, 1999; Norris & Smith, 2002; Peterson, 2005). It is also important to actively and regularly monitor levels of fatigue in athletes. Several invasive and non-invasive, practical techniques for monitoring are available (Bompa, 1999; Steinacker & Lehmann, 2002).

It is clear that work alone is not enough to produce the best performances. An athlete needs to adapt to training and cope with other stress inherent in sports participation. Calder (2000a) stated that recovery is one of the basic principles of training, but one that is most frequently forgotten by coaches and athletes. Several studies of high-performance athletes emphasised optimal regeneration as an important factor in athletic life. Durand-Bush and Salmela (2002) interviewed four men and six women, having won at least two gold medals at separate Olympics and/or World Championships, to examine the factors that contributed to the development and maintenance of expert athletic performance. The importance of recovery on the physical and psychological components was emphasised as one of the

factors. Lance Armstrong, professional road cyclist and seven-time winner of the Tour de France cycle tour said: "Recovery. That's the name of the game in cycling. Whoever recovers the fastest does the best" (Hawley & Burke, 1998: 25).

Athletic performance is a result of a synergistic interaction of a complex of physical, emotional, mental, and social factors that interact with an external environment. Benjamin and Lamp (1996: 5) referred to the "whole-athlete model" which emphasised the fact that athletes bring the totality of their lives to their sports participation. The athlete's relationships with other athletes, coaches, trainers, team physicians, and management are important components of the system. Factors in the sport environment such as training and competition schedules, travelling, family and friends, academic or professional responsibilities, and even community situations, are also important to consider. These relationships can have a profound effect on the physical, mental and emotional state of the athlete, on the group dynamics of the sport setting, and ultimately on sport performance. A change in any one part of the system can affect the athlete as a whole. Numerous authors have mentioned the importance of various factors in the athletic environment that can influence the athlete's performance. Noakes (1991) suggested that non-training time has a major influence on training itself. It is therefore important that all factors outside the realm of training should be evaluated as to their possible negative influence on fatigue.

Jones (2003: 159) wrote: "The experience of being stressed is an emotional one," and recommended "emotion-focused strategies" for coping with stress. Botterill and Wilson (2002: 145) described the emotional domain as very powerful, stating that "when individuals are emotionally healthy, they have tremendous capacities to process and harness emotions. They usually enjoy extensive natural energy, and the tasks in the physical and mental domains are handled with enjoyment, gratitude, and efficiency; recovery is also proactive and efficient. When the emotional domain is exhausted, the performer's capacities in all three domains can be affected, and feelings of burnout, guilt, indifference, anxiety, and depression can occur." Athletes are advised to identify the best strategies for emotional recovery that suit their individual needs. Going to a movie, humour and laughter, music, spending time in nature, writing, reading, or art and dance might enhance emotional recovery. Physiological arousal can be modified by techniques such as deep breathing, muscle relaxation, meditation, and mental imagery (Botterill & Wilson, 2002; Jones, 2003). Spirituality is attracting more attention as a moderator of stress, with some evidence that

religious commitment is protective of physical and mental health. Using prayer as stress management technique is also reported in literature (Jones, 2003).

Sporting behaviour takes place in a social context, and for team athletes also in their team context. The benefits of social support (Sullivan & Gee, 2007) and effective intra-team communication (Robbins & Rosenfeld, 2001) are well researched and might be regarded by some as common knowledge. Social support is an important resource, and has far-ranging effects on athletic stress and coping. Aspects of social support such as advice, suggestions, information, concern, and listening within the team structure can become a key resource for facing demands, which might affect the rate of regeneration of the individual within the social group (Jones, 2003).

Dirks (2000) stated that trust in leadership is a meaningful concept in many teams. He emphasised the important relationship between trust in leadership and team performance, and discussed the importance of team-building practices. Botterill and Wilson (2002) wrote that the emotional climate for work, performance, and recovery is superior when there is a high level of trust, respect and support in the team. Emotional dynamics in a team can be powerful, with research by Totterdell (2000) showing that professional cricket players performed better when their team mates were happy. Debriefing after a match can assist in dealing with the emotional demands of competition. An effective debriefing process after a match can start with an active cool-down period, followed by interaction with team mates and feedback from the coach (Fuller & Paccagnella, 2004).

Midgley, McNaughton and Sleaf (2003) focused on infection in elite athletes and stated that elite athletes of today are more predisposed to contracting an infectious disease than their counterparts of past decades, due to physiological factors and negative psychological perturbations inherent in training and competition. Psychological stress close to important competitions, as well as the physiological and psychological stress associated with the competition itself, can compromise immune function. The authors wrote that the development of immunosuppression is related to the total amount of stressors the elite athlete is exposed to. Interventions that reduce stress will prove valuable in maintaining immunocompetence and reducing infection risk. Segerstrom and Miller (2004) also referred to studies in the field of psychoneuro-immunology which showed that stressful experiences alter features of the immune responses, with the immune system responding particularly to signals from the nervous system and the endocrine system. Efforts to cope with the

demands of stressful experiences can lead to engagements in behaviours such as alcohol use or changes in sleeping patterns, that could also modify immune system processes. The authors suggested that optimism and coping moderated immunological responses to stressors. Several recommendations for maintaining immunocompetence in athletes were stated, which included the importance of adequate recovery between hard sessions, scheduling complete rest periods, spending time pursuing a non-physical pastime, and interventions that reduce stress, such as progressive relaxation, imagery, hydrotherapy, massage, music, and adequate sleep. Lifestyle and nutrition are also important aspects of maintaining immunocompetence (Botterill & Wilson, 2002; Midgley et al., 2003).

The athlete, understanding the importance of regeneration for physical performance, should plan for and implement a variety of recovery procedures as part of an effective recovery strategy. Peterson (2005: 64) wrote: "The concept of effective, regular, and varied recovery activities has become part of the language of today's smart, professional athlete." Recovery techniques should be applied at specific times before, during and after training and competition. A number of recovery strategies have already been mentioned. Methods for speeding recovery from exercise are either passive or active. Passive recovery mostly presumes total inactivity (McArdle, Katch & Katch, 2001), such as sleep, and passive rest (reading, watching television, listening to music). Sleep is seen as one of the major means of physiological and psychological regeneration (Dale, 2004; Noakes, 2003; Pickett & Morris, 1975). With reference to physiological regeneration, examples of recovery techniques that can be applied, are kinotherapy or active rest (Dupont, Moalla, Guinhouya, Ahmaidi, & Berthion, 2004; Jemni, Sands, Friemel, & Delamarche, 2003; Sairy et al., 2003), various forms of touch therapy (e.g., massage), thermotherapy, contrast baths (Bompa, 1999), and cryotherapy (Knight, 1995). The role of nutrition in the recovery process is also well-documented.

The challenge lies with the coach and athlete to effectively employ various means of recovery for continued athletic performance. Botterill and Wilson (2002: 153, 154) wrote:

With education and awareness of rest and recovery strategies, they (athletes) will know when to push themselves and realize that it is appropriate to push as long as the necessary rest and recovery efforts are being made. Though athletes will continue to push themselves, they will also give themselves permission to take the necessary rest and recovery measures in order for optimal quality training and performance

enhancement to occur. A self-aware athlete will not only know when to increase or implement the recovery techniques, but also know which recovery strategies will be most useful at that particular time in life and training. Clearly athletes—indeed, all people—need to recover physically, mentally, and emotionally. At times even social and spiritual recovery needs to be facilitated.

It is clear that there has been a growing recognition of the importance of regeneration in athletic performance. It has also been shown that there is a need for embracing psychological, emotional, social, and physiological elements that could assist athletes in their total regeneration process. The present study is an attempt to assess the main elements for regeneration that elite team athletes in South Africa are currently focusing on, as well as the reasons for why athletes choose to use specific recovery strategies.

In chapter two, conceptual aspects in terms of athletic regeneration are discussed, as well as the various elements of the regeneration process, and ways to monitor regeneration status in athletes. Chapter three presents a review of existing literature with regard to various recovery strategies and modalities or techniques used. In chapter four the research problem is identified, and research objectives and questions stated. Chapter five describes the research methodology, whereas chapter six presents the research results. Finally, chapter seven presents a discussion of the results, proposes a model for the regeneration of elite team players, and discusses limitations of the study and suggestions for further research.

Chapter Two

Conceptual framework

Introduction

This chapter firstly describes regeneration and factors associated with the regeneration process. Secondly, methods to monitor levels of fatigue and regeneration state are discussed.

Regeneration, restoration, and recovery

It is difficult to find a clear description or definition of athletic recovery, regeneration, or restoration in literature. The terms are often seen as synonyms by coaches, athletes, and some authors referring to “an essential component of athletic training and a counterbalance to training and non-training stress” (Kellmann, 2002a: 3). Hanin (2002) indicated that performance below potential and expectations (underperformance) can happen for different reasons (e.g., weather conditions, competition site, opponents, the athlete’s health status), but one of the common reasons stated for underperformance is excessive work with inadequate regeneration.

Kellmann and Kallus (2001: 22) defined regeneration or recovery as “an inter- and intra-individual multi-level process in time for the re-establishment of performance abilities. Recovery includes an action-oriented component, and those self-initiated activities can be systematically used to optimize situational conditions and to build up and refill personal resources and buffers.” It is thus implied that active processes are involved with the aim of re-establishing psychological, physiological, emotional, social, and behavioural components that will allow the athlete to tax these resources again (Kellmann & Kallus, 2001). Recovery is defined by Hanin (2002: 201) as “an intentional self-initiated and goal-oriented activity (on-task or off-task) aimed at regaining one’s level of working capacity reflected in an optimal pre- and mid-performance state. Optimal (adequate, successful) recovery is a well-planned activity that matches the situational needs of an athlete and results in regaining an optimal performance state.” Calder (2000a: 3) described recovery as a general term “used to describe the psychological and physiological adaptations to workloads after an athlete has been exposed to training or competition.” According to Calder, regeneration refers to

recovery of psychological traits, particularly associated with mood states, while restoration refers to returning physiological markers to normal levels.

Recovery has become a popular term amongst modern-day athletes and coaches, and it often is understood as a specific once-off method that is applied after a competition or training session (e.g., ice-bath or massage). In this study, the term regeneration is used to emphasise a holistic approach, emphasising the psychological, physiological, emotional, social, and behavioural stressors that must be adapted to in the athletic environment. Benjamin and Lamp (1996: 5) referred to the "whole-athlete model" which emphasised the fact that athletes bring the totality of their lives to their sports participation, while Kentt  and Hassm n (2002: 58) described the athlete as a "psychosociophysiological entity." Regeneration for the purpose of this study links to the definition of Kellmann and Kallus (2001: 22) as "the inter- and intra-individual multi-level process in time for the re-establishment of performance abilities." For the purpose of this study, the term recovery is used with reference to a range of specific means and methods or techniques that can systematically be integrated into the athlete's programme at various times to enhance regeneration on different levels, and links to "those self-initiated activities that can be systematically used to optimize situational conditions and to build up and refill personal resources and buffers" as described by Kellmann and Kallus (2001: 22), mentioned previously. Recovery thus focuses on the use of time between successive training stimuli and sessions by applying various techniques to address fatigue factors before another training stimulus is introduced. If this process is managed and applied effectively, overall regeneration of the athlete should be the result.

Athletic regeneration is therefore a complex, multidimensional process, which requires short-term and long-term planning (Jeffreys, 2005), and not just a focus on a "system restart" (Kellmann, 2002a: 6). It is also important that the athlete is educated in terms of the need for total regeneration and the application of various recovery methods to enhance the regeneration process. Bompa (1999) recommended that, before using recovery techniques, the coach, athlete, psychologist, and medical personnel should work closely together to avoid misconceptions and maximise the effectiveness of the athlete's regeneration through the specific techniques applied. The coach, trainer, physiotherapist, or other specialists working with athletes can direct the regeneration process, but it is up to the athlete to apply various strategies away from the training environment. The athlete needs to be empowered to make the correct choices and be proactive in facilitating the regeneration process. When

regeneration is inadequate (incomplete or insufficient), the athlete is often described as being in a state of under-recovery (Davis, Botterill & MacNeill, 2002; Hanin, 2002; Kellmann, 2002a).

Numerous texts stated that overreaching, staleness, overtraining, and burnout are, amongst others, the result of neglecting the regeneration process. The researcher acknowledges the fact that these phenomena do exist, but it is beyond the scope of this research project to discuss these concepts extensively.

Factors associated with regeneration

Regeneration, as stated already, is a multidimensional process that depends on a number of intrinsic and extrinsic factors. Stress, and the fatigue it causes in the athlete, should be understood for effective management of the various factors. Although a number of recovery methods are applied to a team as a whole, it should be realised that regeneration should be individualised according to the athlete's unique situation and needs.

Stress and fatigue

Weinberg and Gould (2003: 81) described stress as "a substantial imbalance between demand (physical and/or psychological) and response capability, under conditions where failure to meet that demands has important consequences." Stress consists of four interrelated stages. In the first stage of the process, some type of demand is placed on the athlete. The second stage of the stress process is the athlete's perception of the demand. The third stage is the athlete's physical and psychological response to the perception of the situation. If the athlete's perception of an imbalance between demands and response capabilities causes him/her to feel threatened, increased state anxiety results, leading to increased worries, heightened physiological activation, or both. Changes in concentration, and increased muscle tension accompany increased state anxiety. The fourth stage is the actual behaviour of the athlete under stress (Weinberg & Gould, 2003). It is therefore important for the coach and professionals working with athletes to understand the stress cycle. Apart from determining and knowing the demands that are placed on athletes, an assessment should be done of who is experiencing or perceiving the most stress. Coaches should also know athletes' reactions and behaviours when they are feeling increased stress. By understanding the stress cycle, specific efforts can be made to reduce and help athletes reduce stress.

Bompa (1999) stated that stress is a significant by-product of training and competition, with Weinberg and Gould (2003) stating that there are literally thousands of specific sources of stress. Stress is additive and is produced amongst others by training intensity, competition, peers, family, coach, and spectators. Testing sessions and team selections can also be stressful. Smith (2003) wrote that a substantial body of evidence suggests that elite performers require around 10 years of practice to acquire the necessary skills and experience to perform at an international level. Athletes reaching national and international levels have therefore already invested a lot of personal time and have spent many hours training, and have faced many stressors involved in competing at that level.

Hanton, Fletcher and Coughlan (2005) studied the content and quantity of competitive and organisational stressors in elite sport performers. Competitive stress was described as an ongoing transaction between an individual and the environmental demands associated primarily and directly with competitive performance, while organisational stress emphasised the interaction between an individual and the sport organisation. Ten international elite performers (mean age 22 years) who were national squad members and had participated at the highest level (Olympic Games, World Championships, and/or World Cup) were interviewed. Five categories were identified, namely, performance issues relating to competitive stressors, and organisational stresses relating to environmental issues, personal issues, leadership issues, and team issues. Analysis revealed that athletes reported nearly four times as many organisational demands than competitive demands. Higher-order themes within the dimension of performance issues (with the most frequently cited theme(s) in brackets) were: preparation (inadequate mental preparation), injury (risk of injury, risk or being deliberately injured by opponent), pressure (pressure of international competition), opponents (intimidated by opponents, competing against better athletes), self (body type and physical appearance), event (start of the event), and superstitions (unable to perform in lucky kit, superstitious about a particular venue). Higher-order themes within the environmental issues were: selection (perceived unfairness during selection), finances (lack of financial support, differential financial support), training environment (extreme weather conditions, pressure of training full-time), accommodation (disturbed sleep, inadequate facilities), travel (travelling long distances, inconvenient arrival time), competition environment (long competition day, rules and regulations), and safety (terrorist threats). Higher-order themes within the personal issues were: nutrition (poor provision of food, foreign cuisine), injury (frustration due to injury), and goals and expectations (own high expectations). Leadership issues had the following higher-order themes: coaches (coach very

demanding, coach-athlete tension), and coaching styles (aggressive style, indecisive style). Team issues encapsulated organisational stressors pertaining to the team, namely, team atmosphere (tension between athletes, athletes not training together), support network (governing body abusing its power), roles (officials not fulfilling their role, lack of role structure), and communication (lack of communication between administrators, and athletes).

Nicholls, Backhouse, Polman and McKenna (2008) reported that professional rugby union players experience a multitude of sport and non-sport stressors. Results from their study showed that the players experienced more stress on training days in comparison with rest or match days. The authors also emphasised the need for more attention to post-match states so that players can be educated on different intervention strategies they can employ to address negative low-activated unpleasant states, which prevailed post-match.

Mechanisms that can address the stressors, and reduce the amplitude or the duration of fatigue should have a beneficial effect on the entire regeneration process (Jeffreys, 2005). Various types of fatigue are indicated, namely, metabolic (energy stores), muscular, endocrine, neural, psychological, emotional, and social (Bompa, 1999; Calder, 2000a). Jeffreys (2005) suggested that an understanding of the nature of fatigue and the stress-related factors on athletes is an important step in setting up and managing an optimal regeneration programme. Fatigue cannot be seen as having a single cause. Stressors can originate from many sources, all of which can accumulate into fatigue. Athletes responses to training loads will depend upon the total stress load and how this relates to their capacity to handle the stressors. It is therefore vital that an interdisciplinary approach should be taken to address the individual needs of athletes. Appropriate regeneration strategies and recovery methods should be implemented continuously, often according to different time scales, depending on the contribution of each type of stressor to total fatigue.

Jeffreys (2005) mentioned that athletes' physical capabilities are often built progressively to allow them to handle large loads, but their psychological and emotional capabilities are often neglected. Emotional and psychological stressors can have a dramatic effect on total stress and may therefore negatively affect regeneration and the level of athletic performance. A total regeneration strategy must focus on addressing all the domains for athletes to be maximally effective. Athletes need to develop their abilities to identify and deal with psychological and emotional stressors. Kenttű and Hassmén (1998) recommended that an

approach to enhance regeneration should attempt to achieve a balance in the training and non-training stress experienced, the athlete's ability to cope with the stress, and the recovery actions taken.

Kellmann (2002c) referred to publications by the German researcher, Schönpflug, who indicated that the athlete's reactions to stress depended on permanent and consumptive resources, which offered the athlete some resistance to stress. The consumptive resources refer to regeneration and recovery, while permanent resources referred to the athlete's own skills and abilities. Consumptive resources activated and supported permanent resources. Limited consumptive resources, or failure to replenish, negatively affected the regeneration of permanent resources immediately. This consequently increased the risk of a total exhaustion of resources. Athletes should therefore be encouraged to create, care for, use wisely, and replace both sources to effectively cope with stress.

Individualising the regeneration process

Kellmann (2002a) mentioned that regeneration is specific to the individual. Athletes should have individual regeneration strategies, and also be given a number of options as how to enhance regeneration. They should be able to choose appropriate strategies that they are comfortable with, that address their regeneration needs, and that are suitable for a specific situation (Kellmann, 2002c). Jeffreys (2005) stated that this empowerment can also facilitate enhanced compliance with the programme. Hanin (2002) referred to studies involving athletes from cross-country skiing, soccer, ice hockey, squash, and badminton, which clearly showed individual preferences for regeneration strategies. Sellwood, Brukner, Williams, Nicol and Hinman (2007) wrote that, with all physical activity, there is a psychological component that can enhance performance, particularly in elite athletes who use many different types of recovery strategies that do not have a lot of empirical evidence behind them. What may be considered beneficial by one athlete as a recovery technique is not necessarily of any benefit to another. Over time, athletes develop their own recovery strategies that they use after competitions and training sessions. It is suggested that the perceived psychological benefit of using a familiar recovery technique might have a greater influence on performance than perhaps the actual physiological benefit of that technique.

Supercompensation

Texts on regeneration will often refer to measures taken to facilitate supercompensation. It is recommended that strategies are planned and methods implemented with the aim of achieving supercompensation. Supercompensation occurs when the overload training (breakdown) and the following recovery are balanced correctly while adaptation and an overshoot in performance occur (Budgett, 1998; Kentt  & Hassm n, 1998). Bompa (1999: 15) described supercompensation as "the relationship between work and regeneration as basis for physical and psychological arousal before a main competition." It follows that the greater the training load, the more recovery is needed (Lambert & Borresen, 2006).

A supercompensation cycle can be explained as follows: After an exercise bout, the body experiences fatigue. During the non-training period, the biochemical stores are not only replenished, but exceed normal levels. The body compensates fully, followed by a rebounding or supercompensation phase, with a functional increase in athletic efficiency (Bompa, 1999). When balancing the breakdown process (a natural result of training) with the regeneration process correctly, an overshoot in performance capacity therefore occurs. It is emphasised that adaptation of various systems occurs during the regeneration phase (Norris & Smith, 2002). According to the supercompensation principle, more powerful training stimuli would require a longer recovery period (Kentt  & Hassm n, 2002). Bompa (1999) stated that psychological supercompensation takes longer than physiological supercompensation, because the nervous cell relaxes slower.

The training programme

Training mistakes can negatively affect the athlete's performance. Errors in the training process of team athletes can include more than three hours of training per day, more than a 30% increase in training load each week, ignoring the training principle of alternating hard and easy training days, no training periodisation and respective regeneration microcycles, no rest days (Kellmann, 2002a), and excessive number of competitions (Smith, 2003).

One of the training mistakes often mentioned, is the lack of planning the programme according to the principles of periodisation. Bompa (1999: 194) explained that periodisation has ancient origins and was used by Greek Olympians. The term "originates from *period*, which is a portion or division of time into smaller, easy-to-manage segments, called phases of training." Periodisation of an annual plan divides the year into smaller training phases,

making it easier to plan and manage a training programme and ensure peak performance for main competitions. The annual training cycle (training year) is divided into three main phases, namely, preparatory, competitive, and transition (often called off-season), which is subdivided into smaller cycles. Smith (2003) described periodisation as a process of planning that enables the utilisation of correct loads and adequate regeneration for avoiding excessive fatigue.

Purposefully planning for regeneration on a macro- and micro-level, and the use of recovery techniques to assist the regeneration process to counter the training and competition stress, are therefore key elements of periodisation (Norris & Smith, 2002). Team sports have a series of competitions scheduled in a block of two or three microcycles, which can result in a high state of fatigue. Regeneration microcycles should be specifically planned for, especially following a series of important competitions. Planning according to periodisation also allows for training to alternate between sessions or days of high-intensity and low-intensity training, alternating between the energy systems that are taxed.

It is also important to plan for rest days during regular training, in training camps, and during competition phases, and specifically a day off from training once a week (Bompa, 1999; Kellmann, 2002c). Kentt  and Hassm n (2002) tried to motivate athletes to take a day off training once a week by allocating bonus points that can be added to their recovery points earned for the week.

Kellmann (2002c: 307) mentioned that vacation time in Germany is described as a "recovery holiday." It is not only necessary to plan for rest days on a weekly basis, but athletes should also take longer periods off from training and competition to deeply replenish their resources. A weekend off can provide regeneration and replenishment to a certain extent, but it should not substitute a long-term vacation. Kellmann (2002c) suggested a break of at least three weeks.

Siff and Verkhoshansky (1993: 462) summarised what constitutes an effective training programme: "a carefully designed sequence of physical and mental stress in given conditioning workouts, with one's condition being constantly monitored and restoration being planned in a way and at a rate appropriate to one's current level of stress."

Monitoring fatigue and regeneration state

Prolonged and/or intense exercise, stressful competition, other non-training stressors, and failure to fulfil regeneration demands can lead to the development of progressive fatigue and underperformance (Kellmann, 2002a). It is important for athletes and coaches to have a system of actively monitoring their levels of fatigue on a daily and weekly basis to identify times when their regeneration is less than expected. Lambert and Borresen (2006: 373) stated that "it is logical to assume that if subtle symptoms of chronic fatigue can be monitored and detected before they manifest as serious, persistent symptoms of fatigue, the athlete will have a better chance of sustaining a high volume of training because the errors in training causing the symptoms can be identified and rectified." The need to monitor fatigue and recovery in team sport athletes was also emphasised by Coutts, Reaburn, Piva and Rowsell (2007). Results from their study showed that overreaching occurred in a group of rugby league players with only a relatively small increase in their training load. It is therefore important to monitor adaptation, starting pre-season. Kentt  and Hassm n (2002) suggested that a monitoring system for training and regeneration should consider psychosocial influences and interactions as well as physiological ones, which was supported by the research of Filaire, Lac and Pequignot (2003) involving 20 professional soccer players during a competitive season.

A monitoring system can also help athletes to develop self-awareness. Self-aware athletes will have the ability to identify periods of low regeneration and less-than-optimal performance, they will know when to increase recovery techniques, and know which techniques will be most useful at that particular time in life and training. These athletes are more likely to take responsibility for their own development and growth as individuals and as athletes. They will continue to push themselves and realise that it is appropriate to push, but they will also give themselves permission to take the necessary regeneration measures (Botterill & Wilson, 2002; Jeffreys, 2005; Kentt  & Hassm n, 2002).

Various methods for monitoring athletes can be implemented. Norris and Smith (2002) mentioned that, although competition is the highest form of training, and an excellent form of testing and monitoring, it should not be the only method of monitoring. A hierarchy of monitoring procedures ranges from the whole competitive performance, to isolated, sport-specific field tests, questionnaires, and non-invasive techniques, to invasive and intrusive protocols (Bompa, 1999; Norris & Smith, 2002; Steinacker & Lehmann, 2002). Assessing biochemical profiles of athletes can give coaches valuable information on athletes' states,

although Smith (2003) mentioned that these techniques require performance efforts and blood tests that are not always endorsed by coaches. Kentt  and Hassm n (2002) wrote that it is sometimes argued that psychological testing is most effective in detecting staleness in athletes at an early stage, because psychological changes are very reliable and mood shifts display a dose-response relationship with training load, and variations in mood states often covary with physiological markers. Hooper and Mackinnon (1995) also held this viewpoint by stating that comprehensive physiological testing has not been shown to be better than non-invasive and less costly psychological testing using the POMS or daily logs. It is suggested that all suitable resources should be incorporated in various ways.

A trustworthy system must be designed to provide accurate information with the least amount of time and effort, that can be used easily by athletes and training staff in practical settings (Hooper & Mackinnon, 1995; Lambert & Borresen, 2006). Information should be gathered with reference to every training session (Lambert & Borresen, 2006), on a daily and weekly basis (Hooper & Mackinnon, 1995; Lambert & Borresen, 2006), and fortnightly and after longer periods of training (Hooper & Mackinnon, 1995).

Given how difficult it is to assess for reliable physiological markers, researchers have focused on athlete's self-reports of physical and psychological aspects. A number of methods for monitoring athletes and their level of fatigue will be discussed in more detail.

Training logs or monitoring charts

An integrative and inexpensive, but effective method of monitoring is the use of a training log or monitoring chart. Calder (2000a) stated that a training diary or logbook is one of the most important tools for every athlete. Apart from training details, recordings of morning resting heart rate, bodyweight variations, and incidences of infections and/or injuries can be made. Subjective ratings of fatigue, the quality and quantity of sleep, muscle soreness, levels of academic work, or money stress, inability to respond to relaxation techniques, the quality of primary relationships (family and friends), and the quality of secondary relationships (coach and team-mates) can be indicated on a scale varying between very low or bad, and very high or good. A lifestyle profile can be incorporated, where athletes can identify areas within their lifestyle that could be compromising their regeneration and performance. It is suggested that the coach or trainer should look at the athlete's charts on a regular basis, adapt or modify the training programme if needed, and assess regeneration strategies (Bompa, 1999; Jeffreys, 2005; Kellmann, 2002b; Smith & Norris, 2002).

The use of training logs can be enhanced by the regular use of questionnaires. These assessment tools should be used at training camps, as well as over an entire season as part of regular training routines. These assessment tools can start an educational process for athletes and coaches, as well as fostering the interdisciplinary co-operation between all involved in the athletic environment (Kellmann, 2002b). Some questionnaires that can be used as tools in the assessment of the state of regeneration are discussed in the following sections.

The Borg Rating of Perceived Exertion (RPE)-scale

Borg's *Rating of Perceived Exertion* (RPE) scale is commonly used in exercise testing, training, and rehabilitation to assess the level of perceived exertion of an individual. The RPE was constructed so that certain psychophysical functions could be assessed according to the basic assumption that psychological strain increases linearly with exercise intensity and that perception follows the same linear pattern. The Borg RPE scale has the number 6 as starting point and ends with the number 20. Every uneven number is verbally anchored, e.g., number 7 is *extremely light* and number 19 is *extremely hard* ("the most strenuous exercise ever experienced"). A revised 10-point RPE scale was also developed, with the number 1 being *very light* and number 10 being *very, very heavy* (almost maximal) (Borg, 1998: 47). The use of the RPE is popular, because it is economical to administer, is user friendly, and has shown to be a reliable and valid method for monitoring training (Kentt  & Hassm n, 2002). Although Kellmann (2002b) mentioned a possible disadvantage of the use of the RPE in monitoring regeneration, namely, the fact that it is a one-item construction, not able to assess the multidimensional aspects of regeneration, Kentt  and Hassm n (2002) stated that RPE ratings do require athletes to observe and focus on psychophysiological cues in order to rate the perceived effort. Lambert and Borresen (2006) indicated that, although objective physiological measurements like heart rate may be a more accurate way of calculating training load for steady state endurance training, the subjective measure of RPE remains useful for various types of exercise.

Profile of Mood States (POMS)

The *Profile of Mood States* (POMS) (McNair, Lorr & Droppleman, 1992) has been used extensively in sport psychology research, and in the sport and exercise environments for the assessment of emotional state and mood (Terry & Lane, 2000). The POMS is a 65-item, self-assessment, Likert-format questionnaire that is rated on a scale of 1 (*not at all*) to 4

(*extremely*), with a shorter version of the questionnaire (30 items) also being available. The POMS provides a measure of total mood disturbances and six mood states, namely Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigour-Activity, Fatigue-Inertia, and Confusion-Bewilderment (McNair et al., 1992).

Kellmann (2002b) stated that a correspondence between feelings of tension, fatigue, anger, depression, loss of vigour and mood disturbances and increased high levels of training has been shown, with Hooper and Mackinnon (1995) indicating that the POMS is able to successfully identify athletes showing signs of distress due to intense training of high volume. Low *Vigour* and high *Fatigue* scores on the POMS could reflect a need for regeneration. Hooper, Mackinnon and Howard (1999) used the POMS as part of their measurements to identify variables that could be used for monitoring recovery during tapering for major competitions. Apart from some physiological measurements, it was shown that *Confusion* as measured by the POMS predicted the change in swimming time with tapering. A modification in terms of the instructions is suggested by Raglin (2001), indicating that the POMS can be administered with a "right now" or "today" instructional set to assess mood responses to rapid increases in training load occurring over a span of days rather than weeks.

Kellmann (2002b) indicated that some of the advantages of the POMS include its usefulness in detecting mood fluctuations in exercise, the easy data assessment, the fact that it can be administered to individual athletes and teams, and the fact that it has been shown to be a reliable instrument, although Terry and Lane (2000) stated that the use of the original tables of normative values might be inappropriate for use in the sport and exercise environments. Kellmann (2002b) wrote that a disadvantage of the POMS in terms of regeneration can be that it does not provide information on the cause of mood, therefore no direct recommendations for intervention can be drawn from the data. Hanin (2002) added to that by saying that the POMS does not assess the recovery process directly, although pre- and post-performance states can be assessed.

The Stellenbosch Mood Scale (STEMS)

Terry, Potgieter and Fogarty (2003: 240) developed *The Stellenbosch Mood Scale (STEMS)*, as a measure of mood descriptors in both Afrikaans and English for use in the South African context. Terry et al. (2003) indicated that the STEMS was based on the Profile of Mood States – Adolescents developed by Terry, Lane, Lane and Keohane in 1999. Male and female

student athletes (n = 463) from 26 sports (individual and team sports) participated in the study to construct the 24-item STEMS. The researchers concluded that the STEMS has shown acceptable psychometric properties and that it could be a suitable measure of mood states for use by Afrikaans and English speakers. Another advantage of the STEMS lies in its brevity, making it a useful tool where limited time is available. Seeing that the POMS is widely used to assess mood states in athletes, although it was not originally developed for use in athletes, the STEMS, developed with athletes, could be a valuable instrument specifically within the South African context.

Recovery-Stress Questionnaire for Athletes (RESTQ-Sport)

Kellmann and Kallus (2001) developed the 76-item *Recovery-Stress Questionnaire for Athletes (RESTQ-Sport)* to measure the recovery-stress states of athletes. The recovery-stress state indicates the extent to which persons are physically and/or mentally stressed, whether they are capable of using individual strategies for regeneration, as well as which strategies are used. A scale measures the extent to which the athlete took part in different activities within the previous three days or nights. A Likert-type scale is used with values ranging from 0 ("never") to 6 ("always"). The RESTQ-Sport consists of 12 general stress and recovery scales, as well as seven sport-specific stress and recovery scales.

Kellmann (2002b) indicated that various studies involving German and American athletes showed high correlations between RESTQ-Sport- and POMS-scales. RESTQ-Sport and POMS seem to be sensitive to events in the lives of athletes that affect their recovery-stress state and mood. An advantage of the RESTQ-Sport can be that it has a systematic multi-level approach, as well as the possibility of making specific recommendations for intervention.

An evaluation of the items of the RESTQ-Sport was done by Davis et al. (2007), involving 585 male and female athletes from the Canadian national sport centre. Although the researchers suggested that some individual items need to be further developed, the RESTQ-Sport does measure general parameters of training stress which can be tracked in recovery planning.

Total Quality Recovery (TQR)

The *Total Quality Recovery (TQR)* was initially developed by Kenttã and Hassmén to prevent the occurrence of staleness among racing canoeists, but has since been used in a broader

context (Kenttö & Hassmén, 2002). The TQR method is divided into two sub-dimensions. One dimension focuses on the perception of recovery (TQR perceived scale), while the other focuses on actions performed for regeneration (TQR action scale). The athletes answer two questions: (1) How does it feel? and (2) What have you done? Athletes are instructed to, before bedtime, rate their sense of recovery as an overall psychophysiological rating (i.e., physically and mentally) for the previous 24 hours, including the previous night's sleep. The individual's subjective perception of recovery is emphasised, and should therefore be used to detect intra-individual changes.

The TQR action scales grades and monitors purposeful self-initiated recovery actions. The four main categories that are focused on are: nutrition and hydration, sleep and rest, relaxation and emotional support, as well as active cool-down and stretching. Athletes earn recovery points, which are accumulated over 24 hours. These self-monitoring actions make regeneration management highly individualised, and increase the athlete's awareness of the possible need to accelerate the regeneration process by active measures.

Daily Analysis of Life Demands for Athletes [DALDA]

The *Daily Analysis of Life Demands for Athletes* [DALDA], developed by Rushall (1990), is a self-report inventory used to monitor the physiological stress of training, as well as stressors outside the training environment. The questionnaire of 36 items consists of two parts. Part A involves general sources of stress that occur in daily living (e.g., diet, health, and sleep), while Part B involves symptoms of stress (e.g., muscle pains, general weakness). Athletes respond at each question by indicating either "worse than normal," "normal," or "better than normal." When DALDA is used, a period of baseline assessments should occur, because scores may oscillate due to fatigue from isolated training sessions. If scores remain elevated for more than four consecutive days, a period of rest should occur (Rushall, 1990).

Coutts, Slattery and Wallace (2007) assessed the usefulness of the DALDA and other performance tests for monitoring performance, fatigue and recovery in triathletes. Sixteen male triathletes participated during a period of four weeks of training and two weeks of taper. Weekly assessments of performance using a three-kilometre time trial were done, as well as five-bound jumps for distance twice weekly, and assessments of sub-maximal running heart rate. The DALDA and the five-bound jump for distance were shown to be practical tests for assessing changes in performance, fatigue and recovery of the athletes.

Other researchers (Achten et al., 2004; Halson et al., 2002; Nicholls et al., 2008) also found the DALDA a useful and effective instrument to discriminate between acute and chronic or excessive fatigue. Lambert and Borresen (2006) indicated that DALDA can be administered throughout a training season, and can be scored by the athlete or coach.

Other

The coach should be able to assess through direct communication if there are signs and symptoms of non-adaptation to training stress, which can refer to low levels of regeneration. These can include "heavy legs, sore legs, chronically feels tired, does not feel good and fit to train," bad technique compared to normal (Calder, 2000a: 12), facial expression and colour (Bompa, 1999; Kellmann, 2002b), posture and constantly bending over after efforts (Calder, 2000a; Kellmann, 2002b). Resting heart rate, especially morning resting heart rate measured on a daily basis, is a popular marker of training status, although Lambert and Borresen (2006) indicated that the usefulness of heart rate as a monitoring tool might be reduced due to the variability found in athletes.

Summary

The importance of a balance between hard training and regular competitions and adequate regeneration has been indicated in literature. The regeneration process focuses on the athlete as a "psychosociophysiological entity" (Kentt  & Hassm n, 2002: 58) and should acknowledge the psychological, physiological, emotional, and social stressors in the training environment. Various recovery methods to assist the regeneration process should be emphasised and could be systematically integrated into the athlete's programme. Athletes and coaches should be motivated to have a system of actively monitoring levels of fatigue on a daily and weekly basis to identify times when their regeneration is less than expected.

Chapter Three

Recovery strategies

Introduction

Sporting competitions and training for competitions put the athlete under stress. Athletes might experience inadequate time for regeneration before the next training session or competition. Rushall and Pyke (1990) stated that today's training loads and competition schedules are so demanding that "natural" means of recovery alone can no longer provide adequate regeneration. Bobby McGee, an international long distance coach, wrote: "I believe it is not the training, but the spaces between the training that are the most critical" (McGee, 2000). Athletes, coaches, and trainers are placing more emphasis on these "spaces between training," and are looking for means to accelerate the regeneration process to provide athletes with the competitive advantage.

The athlete, understanding the importance of regeneration for performance, should plan for and implement a variety of recovery methods as part of an effective regeneration strategy. Peterson (2005: 64) wrote: "The concept of effective, regular, and varied recovery activities has become part of the language of today's smart, professional athlete." Kentt  and Hassm n (2002: 70) referred to a statement by Pete Sampras (world-class tennis player) stating in an interview: "Recovery is a huge factor now," referring to the notion that the key to successful performance is not so much harder training, but better recovery actions. The idea of doing less presents a dilemma to athletes who probably became good through tough training, and who believe that more training will make them even better. According to Peterson (2005), implementing recovery techniques, takes away the problem of doing less and focuses the athletes' efforts on what they can do more to help themselves in the regeneration process.

A diversity of recovery methods have been suggested throughout sports literature. It seems as if physiological aspects get most of the attention, as compared to psychological and social aspects. Kentt  and Hassm n (2002) stated that this may be appropriate for endurance sports, but sports with high demands on technique and long-term concentration require a greater focus on psychosocial recovery. Recovery methods should not be restricted to only one or two forms, but a variety of methods should be used.

Methods for quick recovery from exercise are either passive or active. Passive recovery mostly presumes inactivity (McArdle et al., 2001), such as sleep, passive rest (reading, watching television), massage, and modifications that include cold showers, contrast baths, and so forth. Active recovery generally refers to the idea of "cooling-down" or "warming-down" after exercise (Maffetone, 1999; McArdle et al., 2001). Psychological and social factors play a major role in the regeneration of the athlete. The importance of nutrition for recovery has also been researched and documented. The popularity of complimentary and alternative therapies is increasing, and a growing body of evidence supports the use of therapies such as aromatherapy, acupuncture, and herbs in the recovery process.

Siff and Verkhoshansky (1993: 462) explained some aspects of the Russian regeneration system. The authors indicated that Russian experts are of the belief that prolonged use of any given "artificial" means of regeneration would decrease the recuperative effect. It is usually recommended that the same regeneration means should not be applied more than once or twice a week in the same form. It is advisable to have a single day's break after every two days of application. It is not unusual for Russian top athletes to receive over an hour of restoration every day, with regular alternation of individualised methods. The authors concluded that the Russian regeneration system recognises the specificity of each technique or sequence of techniques for a particular sport, phase of training, an individual athlete, time of day, type of stress and type of fitness. The Russian regeneration system applies different techniques before, during, shortly after and a long time after training and competitions. Meticulous records are kept reflecting the athlete's daily variation in physical and psychological states. The athlete is encouraged to shed dependence on a therapist and to learn and apply regeneration procedures.

The various recovery strategies available to the athletes are grouped in this study into four sections, namely natural strategies, physical strategies, psychosocial strategies, as well as complimentary and alternative strategies. The focus of this chapter is firstly, on recovery methods that form part of the natural strategies that can assist the athlete with the regeneration process. Secondly, the physical therapies will be discussed, followed by psychosocial strategies and finally, some therapies from alternative and complementary medicine.

Natural strategies

Bompa (1999) described natural strategies as those recovery methods that do not require any special devices or modalities. Natural strategies focus on the role of kinotherapy or active recovery, nutrition, and sleep in the athlete's regeneration process.

Kinotherapy

According to Fuller and Paccagnella (2004), athletes will usually take part in an appropriate well-planned warm-up before training and competitions, but many fail to recognise the importance of a cool-down period. Maffetone (1999) suggested that a process of active recovery is recommended after all training sessions and most competitions, while passive recovery (total inactivity) should be reserved for the situation in which the athlete is completely exhausted following competition. Bompa (1999: 100) uses the term "kinotherapy" when he refers to the concept of using movement as part of the recovery process.

Hawley and Burke (1998: 188) wrote: "With regard to warming down, ... it would appear that some form of active cool-down is beneficial." Harris and Elbourn (2002: 23) suggested that it is unwise for athletes to go straight from "fifth to first gear," indicating that athletes should be advised to gradually recover from high-intensity exercise through a cool-down period.

Bompa (1999) proposed that active recovery can also be "deflective exercises" that can be used during the transition phase of the training year, and during times of emotional fatigue. Rotstein et al. (1999: 72) mentioned that "diverting activity" may be effective when the central nervous system is the main source of fatigue. A number of authors referred to this idea of "deflective exercises" as active rest, which can give the athlete a physical and mental break from a strenuous training and competition programme. Deflective exercises as an active recovery strategy can include low-intensity training in a different sport, and fun games (Donatucci, 2002).

In this study, the focus is on the cool-down or warm-down period. The effects and benefits of a period of active recovery have been studied over the years, with the focus on the effect of active recovery on lactic acid removal, performance outcomes, muscle glycogen resynthesis, muscle damage and immune function, as well as psychological parameters.

Lactic acid removal

Investigations on the effect of active recovery have focused, to a great extent, on its effect on post-exercise lactate removal. Rontoyannis (1988) referred to the fact that athletes often have to make repeated bouts of intense effort during training and competition, with an accumulation of lactic acid. A balance exists between lactic acid production and removal at rest and during low-intensity exercise. In high-intensity exercise, even more lactic acid is produced. Coetzee, Porthine, Kruger and Lourens (2003) stated that, in spite of the uncertainty that exists with regard to the precise mechanism that leads to fatigue during anaerobic exercise, blood lactate level does provide an objective indication of the relative strenuousness of exercise. Increased blood lactate levels indicate that the production exceeds the removal, especially during exercise that demands a continuous increase in power output (Brooks, Fahey & Baldwin, 2005), where high lactic acid values with corresponding low blood pH-levels can lead to fatigue, and any procedure that accelerates lactate removal could probably augment subsequent exercise performance (McArdle et al., 2001).

Six subjects (mean age 26.4 years) participated in a study by Rontoyannis (1988) to determine the effect of active recovery on blood lactate removal. It was concluded that active recovery accelerated the lactate elimination process from the blood after maximum muscular effort. Ahmaidi et al. (1996) also showed that periods of active recovery can significantly lower plasma lactate concentrations, and improve power output in repeated bouts of intensive exercise. Ten male subjects (mean age 27.3 years) performed two randomly assigned exercise trials. Exercise testing consisted of an incremental aerobic test and two force-velocity tests on a cycle ergometer. One testing session was performed with a five-minute passive recovery after each intensive exercise bout, while the other session was performed with a five-minute active recovery of 32% of the maximal aerobic power. Blood samples were drawn from a superficial forearm vein at rest, at the end of each exercise bout, and at the fifth minute of recovery. The results of the study showed that when repeated bouts of intensive exercise were followed by periods of active recovery, plasma lactate concentration was lower compared with passive recovery levels. Higher power outputs were also found with the active recovery.

Bond, Adams, Tearney, Gresham and Ruff (1991) compared the effects of active and passive recovery on the removal of accumulated blood lactate following high-intensity training. Five

healthy male subjects (mean age 26 years) participated in the study. Subjects performed a supramaximal work bout on a cycle ergometer, working at a rate of 150% of VO_{2max} for 60 seconds. During the active-recovery period, subjects pedalled for 20 minutes at a relative work intensity of 30% VO_{2max} . Subjects sat for 20 minutes on the ergometer in the passive-recovery condition. Venous blood samples were collected at various stages throughout the testing session to determine lactic acid concentrations. An isokinetic muscle test on a cybex dynamometer was done to assess maximal strength of the quadriceps extensor muscle group of the dominant leg. The study indicated that active recovery was more effective than passive recovery in the removal of lactic acid, following intense exercise. No effect on muscle function of maximal strength and work output of the quadriceps muscle group was found.

An investigation by Gupta, Goswami, Sadhukhan and Mathur (1996) regarding the effectiveness of active recovery, passive recovery, and short-term massage on blood lactate removal showed active recovery to be the best modality for enhancing lactic acid removal after exercise. Ten elite level male athletes (mean age 21.1 years) performed exercise sessions on a bicycle ergometer. Supramaximal exercise (150% of VO_{2max}) was executed in sessions of one minute of exercise, followed by 15 seconds recovery, until exhaustion. After the supramaximal exercise, three types of recovery modes were applied on different days, the mode of recovery selected randomly for the athlete. Passive recovery consisted of a relaxed sitting position for 40 minutes. Subjects pedalled for 40 minutes at 30% of VO_{2max} during the active recovery session. Massage was applied to the upper and lower limbs for 10 minutes in the massage-recovery session. Blood samples were collected just after exercise, and at 3, 5, 10, 20, 30 and 40 minutes after completion of the exercise. Heart rate was also recorded every 30 seconds until the end of 30 minutes of recovery. The researchers concluded that, among the three recovery modes in question, active recovery might be considered a much better recovery option than massage recovery and passive rest, particularly when a faster rate of lactic acid elimination is the main aim.

Taoutaou et al. (1996) compared seven endurance-trained athletes (mean age 23.7 years) with seven sprint-trained athletes (mean age 20.4 years) with regard to lactate kinetics during passive and partially active recovery after the training session. For passive recovery, athletes had to remain seated for 60 minutes, while the partially active recovery consisted of cycling (40% of VO_{2max}) followed by 40 minutes of seated rest. Blood samples were drawn at five minutes and also at one minute before exercise, and at 1, 2, 3, 4, 5, 6, 8, 10, 15, 20, 30, 40, 50 and 60 minutes of recovery. The results showed that the partially-active recovery

enhanced blood lactate removal in both groups. It was also showed that endurance-trained athletes recovered faster and sooner than sprinters during partially-active recovery. The effects of active and passive recovery on lactic acid removal in nine competitive, female athletes were examined by Coffey, McCarthy, Miller, Neason and Wyatt (2003). The athletes performed two 30-second Wingate power tests, followed by active or passive recovery. Lactic acid accumulation was measured immediately post-exercise, and 3, 5, and 20 minutes post-exercise. It was found that active recovery significantly increased the rate of lactic acid removal in the female athletes.

Monedero and Donne (2000) investigated the effect of four 15-minute recovery interventions on lactic acid removal after maximal exercise, and subsequent performance after recovery. The subjects, 18 trained male cyclists (average age 25 years), were tested on six separate occasions over a period of three weeks. Each subject performed two five-kilometre maximal cycling efforts on a King-cycle trainer/tester unit and on the cyclist's own bicycle. Following the first five-kilometre test, the subjects remained stationary on the bicycle for one minute, after which the different recovery interventions took place. The second five-kilometre test was performed after the recovery interventions. Performance time for the tests, blood lactate (during the tests and at three-minute intervals during recovery), and heart rate were recorded. During passive recovery, the subjects sat at rest on a chair for 15 minutes. Active recovery consisted of cycling at 50% of VO_{2max} , while massage consisted of effleurage, stroking and tapotement applied to the lower extremities. Combined recovery consisted of pedalling at 50% of VO_{2max} for 3.75 minutes, followed by massage for 7.5 minutes, and finally cycling again for 3.75 minutes. Results showed that active recovery induced a greater blood lactate removal than the other recovery interventions. Combined recovery resulted in the best maintenance of performance capacity during the second five-kilometre maximal effort test. The researchers explained the finding by referring to the high rate of blood lactate removal during the active portions of the combined recovery, as well as a possible higher rate of intramuscular glycogen restoration during the massage portion.

Micklewright, Beneke, Gladwell and Sellens (2003) evaluated the effectiveness of combined active recovery and massage on blood lactate clearance and exercise performance. Twenty-five healthy subjects (mean age 33.9 years) participated in the study. Subjects completed a 30-second Wingate test before and after a 20-minute recovery period. Subjects were randomly assigned to one of five recovery conditions: passive rest, leg massage, active cycling at 37% VO_{2max} , combined rest-active recovery, or combined massage-active recovery.

The researchers noted that the elimination of blood lactate was significantly accelerated during active recovery compared to rest recovery. Combined massage-active recovery was equally effective at elimination of blood lactate as active recovery alone. Massage recovery was no more effective than rest recovery for blood lactate clearance. No significant differences were found between the performances of the groups in the repeated Wingate test.

Sairyo et al. (2003) stated that moderate muscular exercise during the recovery period seemed to allow for faster lactic acid removal, and may therefore be an effective method for promoting recovery from muscle fatigue. The researchers wanted to determine the effect of active recovery on intracellular metabolic acidosis, because a decline of the intracellular pH has been reported to be crucial for the onset of muscular fatigue. Seven men (ages between 27 and 35 years) performed intense wrist flexor exercises, flexing the wrist joint every two seconds until the exercise bout was stopped due to fatigue. After the exercise period, subjects had a recovery period for 10 minutes, either passive or active. During the active-recovery period, the subjects had to exercise at a decreasing percentage (every two minutes) of their maximum voluntary contraction. The order of the active and passive recovery was randomly decided, and each subject had one week rest between the two interventions. Significant differences were found between the effects of the active- versus the passive-recovery session, suggesting that active recovery at a decreasing intensity might be an adequate procedure to accelerate the restoration of normal resting muscle pH after exercise-induced acidosis.

In an attempt to study the effect of active and passive recovery on blood lactate and performance in a sport-specific competition setting, Jemni et al. (2003) investigated men's gymnastics events. Twelve elite, male gymnasts (mean age 21.8 years) competing at national (n=9) or international level (French national team, n=3), participated in the study. Testing involved simulations of gymnastic competitions with expert national "blinded" judges, timekeepers, coaches, physicians and spectators attending the sessions. Each gymnastic session was composed of six events or apparatus, following the Olympic competition rotation order, separated by a 10-minute recovery time, similar to official international competitions. Each gymnast undertook two randomised recovery protocols, separated by two weeks. The rest protocol consisted of an upright sitting position for 10 minutes. During combined recovery, the gymnasts rested for five minutes followed by five minutes of active recovery by doing handstands, single somersault movements and light running. Blood samples were

taken at 2, 5 and 10 minutes. The study showed that lactic acid clearance was higher when gymnasts used the combined active recovery at an intensity below the lactate threshold. Gymnasts using the combined active recovery also had significantly higher scoring performances as rated by the panel of certified judges, when compared to the passive recovery session. The researchers emphasise the importance of combined active recovery between repetitions in gymnastic competitions, also stating that it might help gymnasts reduce the likelihood of injury due to fatigue.

When the effects of active versus passive recovery on blood lactate levels and hand grip strength in rock climbers were studied, Watts, Daggett, Gallagher and Wilkins (2000) found that low-intensity leg exercise resulted in a reduction of accumulated lactate from the blood within 20 minutes following intensive climbing. Fifteen male, well-conditioned expert sport rock climbers (mean age 31 years) climbed a difficult competition-style route on a commercial indoor climbing wall. Active recovery consisted of a recumbent cycle on a Monark ergometer at 25 Watts, while passive recovery involved a resting condition in the same recumbent position as in active recovery. Fingertip blood samples were obtained at 1, 10, 20, and 30 minutes post-climb. Handgrip strength was measured immediately following each blood sample using a handgrip dynamometer. Results indicated that, with active recovery, blood lactate decreased to pre-climb levels within 20 minutes, compared to 30 minutes for passive recovery.

It has been stated that metabolic acidosis might be a possible factor in muscular fatigue during short-term, high-intensity exercise, and accelerating blood lactate clearance immediately after exercise may be beneficial for succeeding in bouts of high-intensity exercise (Martin, Zoeller, Robertson & Lephart, 1998). The researchers examined the comparative effects of sports massage, active recovery, and rest in promoting blood lactate clearance after maximal anaerobic leg exercise. Ten competitive male cyclists (age 21-34 years) performed three successive 30-second supramaximal Wingate cycle tests on a Monark cycle ergometer, with two-minute rest intervals between each. Venous blood samples were taken before exercise, immediately after each Wingate cycle test, five minutes after the final test, and at five-minute intervals throughout each 20-minute experimental condition. During the active-recovery session, subjects pedalled for 20 minutes at an intensity of 40% VO_{2max} . During the passive condition, they remained in a supine position for 20 minutes, while the massage condition consisted of a 20-minute massage of the legs using techniques to promote increased blood flow. The results of the investigation supported the use of active

recovery in accelerating the decrease of metabolic acidosis following high-intensity anaerobic exercise. Active recovery produced significant decreases in measures of blood lactate concentration, while no significant difference was found between a sports massage and rest for changes in blood lactate concentration.

Although many studies focused on the effect of active recovery on lactate removal, Barnett (2006) indicated that lactate removal might not be a valid criterion for assessing recovery and the quality of recovery in athletes. The author mentioned that the half-life of muscle lactate is around 9.5 minutes, and that blood lactate has a half-life of around 15 minutes during passive recovery. Blood lactate returns to around resting levels at 90 minutes after high-intensity exercise, which is a shorter time-frame than the time between training sessions of elite athletes.

Performance outcomes

A number of researchers assessed the effects of active recovery between exercise bouts on performance outcomes. When the effects of recovery mode on performance were studied by Dorado, Sanchis-Moysi and Calbet (2004), the researchers concluded that active recovery facilitated performance during high-intensity, intermittent exercise. The ten subjects performed four supramaximal (120% VO_{2max}) exercise bouts until exhaustion on a cycle ergometer. Recovery periods of five minutes followed the exercise bouts. Active-recovery periods consisted of pedalling at 20% VO_{2max} . Subjects were in a supine position during passive recovery, or were doing stretching exercises of the lower limbs. Blood lactate assessments were done at the end of each exercise bout, and every minute during the recovery period. Subjects performed the different recovery protocols in random order ten days apart. The study revealed that peak power output and increased time to fatigue were enhanced more during the high-intensity intermittent exercise with active recovery at 20% VO_{2max} , than with resting recovery or doing stretching exercises.

The effect of passive or active recovery or low-frequency electromyostimulation was assessed by Lattier, Millet, Martin and Martin (2004). Eight well-trained male subjects (mean age 25 years) participated in the study. Subjects repeated ten runs on a treadmill at 120% of maximal aerobic velocity, lasting one minute each, with a two-minute rest between repetitions. Neuromuscular measurements (isometric maximal voluntary contractions) were done on a Biodex isokinetic dynamometer. Recovery interventions began 15 minutes after the exercise on the treadmill. For passive recovery, the subjects sat upright for 20 minutes.

Active recovery consisted of sub-maximal running at a speed corresponding to 50% of maximal aerobic velocity. Electromyostimulation was done with electrical stimulators on the quadriceps, hamstrings and gastrocnemius muscles. Neuromuscular measurements (contractions of knee extensor muscles and EMG of vastus lateralis and medialis) were done again 10 minutes after the end of recovery periods, and 65 minutes after the exercise. Eighty minutes after the fatiguing exercise, the subjects performed an all-out, uphill running test on a treadmill at 90% of maximal aerobic velocity. No significant differences were demonstrated between the effects of passive, active or electromyostimulation recoveries on the restoration of neuromuscular function after a high-intensity uphill running exercise, although there was a tendency towards better performance after the electromyostimulation.

Short intermittent exercises are often used in training programmes to improve maximal oxygen uptake and anaerobic capacity. Twelve fit, male physical education students, specialising in soccer, participated in a study by Dupont et al. (2004) to compare passive versus active recovery during high-intensity intermittent exercises. Time to exhaustion, using a cycle ergometer, was determined for short intermittent exercises of 15 seconds alternated with 15 seconds of passive recovery or 15 seconds of active recovery at 40% of VO_{2max} . Time to exhaustion was significantly longer for the passive recovery condition than for the active recovery. The researchers stated that the relatively short passive recovery period of 15 seconds between high-intensity bouts might have influenced the players' performances positively.

Coetzee et al. (2003) also involved students in their study on the influence of a passive- and active-recovery period on anaerobic power output. Sixteen subjects (mean age 21.6 years) performed two vertical jumps and a Wingate Anaerobic Test (WAT), followed by a 30-minute recovery period. Active recovery consisted of joint rotations, eight minutes of aerobic running exercises over a distance of 20 meters at 70% of age predicted maximal heart rate, as well as static and dynamic stretching exercises. Subjects remained seated for the passive-recovery session. Subjects produced significantly lower average power values over the 30 seconds of the WAT after the active-recovery period when compared to the passive-recovery period. Vertical jump height increased significantly after active recovery. In a further analysis in which the active men and women were separated from the inactive groups, it was found that the active women reacted better to the active recovery. The researchers concluded that the influence of the recovery period is dependent on the intensity and nature of the active

recovery, stating that the intensity of the active-recovery period might have been too high. The fitness levels of the subjects also had an influence on the outcomes.

The effects of active versus passive recovery on high-intensity, intermittent-sprint performance in hot conditions (34.9°C) were investigated by Bishop, Ruch and Paun (2007). The researchers wanted to assess the physiological and performance responses to high-intensity, intermittent-sprint exercise with either a short active- or passive-recovery in the heat. Eight male recreational team athletes (mean age 21.2 years) participated in two experimental sessions, performed in a random, counterbalanced, crossover design, at least four days apart. A graded-exercise test (GXT) and an intermittent-sprint test (IST) were performed on a cycle ergometer. The IST was based on a motion analysis of international men's field-hockey matches and consisted of 37 minutes of intermittent-sprint exercise. The active-recovery protocol was divided into blocks of two minutes, which consisted of a four-second sprint, an active recovery period of 100 seconds (at 35% VO_{2peak}), and 20 seconds of passive recovery. This comprised a typical motion pattern of various team sports, with high-intensity sprints separated by active and passive recovery. The passive-recovery protocol consisted of blocks containing a four-second sprint and 120 seconds of passive rest until the next sprint. Gas analysis, blood analysis, temperature, heart rate measurements, and ratings of perceived exertion (RPE) were also done. Results indicated that the work produced in the individual sprints was not significantly different in the active-recovery or the passive-recovery exercise protocols. There were also no significant differences for peak power, plasma lactate concentrations, and RPE. Greater heat was produced by the muscles during the active-recovery protocol, but there was also a greater transfer of heat from the muscles to the skin. The researchers stated that one possible benefit of active recovery is that it will maintain blood flow to the active muscles and therefore promote the transfer of heat from the core to periphery. It was suggested that a greater muscle pump during the active-recovery sessions may have maintained a greater blood flow to the surface veins and inactive musculature, allowing greater heat dissipation compared to passive recovery. It was concluded that the two-minute recovery time in the study could have been sufficient for recovery from the four-second all-out sprints, regardless of the type of recovery performed, even in hot, humid conditions.

Connolly, Brennan and Lauzon (2003) assessed the effectiveness of a three-minute (180 seconds) interval of either active or passive recovery in seven male cyclists (mean age 21.8 years). Results suggested that an active-recovery period of three minutes between high-

intensity, short-duration exercise bouts significantly increased peak power and average power, although lactate values did not differ between the active and passive protocol.

Spierer, Goldsmith, Baran, Hryniewicz and Katz (2004) determined the effects of active versus passive recovery on work performance during repeated bouts of supramaximal exercise. Six healthy sedentary subjects (mean age 32 years) and nine moderately trained ice hockey players (mean age 22 years) participated in the study. Subjects performed serial 30-second Wingate anaerobic power tests on a bicycle ergometer, interposed with four minutes of active recovery at 28% of VO_{2max} , or passive recovery at rest, to which subjects were randomly assigned. Peak power, mean power, total work achieved, and fatigue index were calculated. Capillary blood lactate was determined immediately after completion of the Wingate test, and at five-minute intervals for 30 minutes after completion of the last exercise bout. Capillary blood lactate levels were significantly lower during active recovery in the moderately trained ice hockey players. The active recovery at a work rate of 28% of VO_{2max} increased the total work achieved in the sedentary subjects and ice hockey players, when compared with passive recovery. The researchers stated that great amounts of power and work are produced during repeated bouts of anaerobic activity in ice hockey. They suggested that active recovery could be used by players who are substituted.

A judo combat is characterised by short periods of high-intensity efforts with short rest intervals. The judoka often has to compete in several combats on the same day, sometimes with only 15 minutes between combats. The athlete needs to have appropriate anaerobic and aerobic energy systems to maintain performance. If lactic acid is implicated in the fatigue process, fast removal of lactic acid will result in an athlete beginning the next match less fatigued. Franchini, Takito, Nakamura, Matsushigue and Kiss (2003) wanted to determine the effect of either passive or active recovery on blood lactate removal and performance in judokas of different levels. Seventeen male judokas, participating in official championships, participated in the study. The athletes trained at least three times a week, were graded at least one belt before black belt or black belt, and were subdivided according to their competitive level: international or national level, state level, or city level. The judokas were in a combat situation of five minutes, then were subjected to either passive recovery for 15 minutes (sitting) or active recovery for 15 minutes (running at 70% of anaerobic threshold velocity), and then did an intermittent Wingate test. Blood lactate was measured at 1, 3, 5, 10 and 15 minutes after the end of the judo match, after the recovery period, and after the Wingate test. Active recovery resulted in higher blood lactate removal than passive

recovery at 10 and 15 minutes in all the athletes of different competitive levels, but no significant difference in performance between the recovery procedures was found.

Corder, Potteiger, Nau, Figoni and Hershberger (2000) were interested in the effect of relatively short-duration active- and passive-recovery sessions on resistance training. Resistance-trained athletes, such as bodybuilders and power-lifters, have to perform repeated exercises at maximal or near-maximal intensity. Fifteen resistance-trained males (mean age 23.5 years) performed parallel squat workouts. Three recovery conditions were randomly assigned and involved the following: passive recovery or active recovery at 25% of onset of blood lactate accumulation or active recovery at 50% of onset of blood lactate accumulation. Passive recovery involved quiet sitting and active recovery was performed on a cycle ergometer. Each subject completed all three recovery conditions within a two-week period. Subjects performed six sets of 10 repetitions at 85% of 10RM, followed by the recovery session, and then as many repetitions as possible on the parallel squat exercise, using 65% of 10RM. Lactic acid accumulation was decreased significantly more when low-intensity active recovery was done, than using passive rest or the higher-intensity recovery session. Low-intensity recovery was also associated with improved endurance performance.

Delayed onset muscle soreness (DOMS)

Barnett (2006) wrote that many studies examining the efficacy of recovery modalities focus on exercise-induced muscle damage, usually associated with DOMS. DOMS include sensations of pain, tenderness and discomfort and is associated with temporary reductions in force production and decreased range of movement, which may be detrimental to training (O'Connor & Hurley, 2003). Athletes are therefore looking for means to enhance the rate of recovery from DOMS and exercise-induced muscle damage. O'Connor and Hurley (2003) stated that current evidence suggests that light concentric exercise versus no intervention has some positive effects on muscle soreness associated with DOMS.

Resynthesis of muscle glycogen

Muscle glycogen is one of the main energy sources for sport performance, and glycogen repletion after exercise is an important matter for athletes. The effect of passive and active recovery on the resynthesis of muscle glycogen was assessed by a number of researchers. Six healthy, untrained males (mean age 22.7 years) served as subjects in the study by Choi, Cole, Goodpaster, Fink and Costill (1994). Two exercise trials were completed, separated by

one week. Each trial consisted of three, one-minute bouts of cycling on an ergometer at 130% of VO_{2max} , with a four-minute rest period between each workout. The exercise trials were followed by one of two types of recovery periods. In the active-recovery trial the subjects rode at 40% of VO_{2max} for 30 minutes followed by 30 minutes of seated rest. In the passive-recovery trial the exercise bout was followed by 60 minutes of seated rest. Choi et al. (1994) concluded that active recovery resulted in a more rapid decline in blood lactate values. The researchers also reported a reduced rate of glycogen resynthesis during active recovery.

Fairchild et al. (2003) also studied glycogen synthesis in muscle fibres during active recovery from intense exercise. Eight endurance-trained healthy male students (mean age 19.2 years) completed two exercise trials in a randomised order, separated by four weeks. The two exercise trials consisted of high-intensity cycling on an ergometer for two and a half minutes at 130% VO_{2max} , followed by a 30-second cycling sprint. Immediately after the sprint, subjects were assigned to either a passive- or active-recovery session. The passive-recovery session consisted of remaining seated for 75 minutes. The active-recovery session consisted of cycling for 45 minutes at an intensity of 40% VO_{2max} , followed by 30 minutes of passive recovery. Blood samples were taken before exercise and at time intervals during recovery. Muscle biopsies were also taken from the vastus lateralis of both legs. During active recovery, plasma and blood lactate levels decreased more rapidly than during passive recovery. Active recovery also resulted in a faster return of blood pH-levels to pre-exercise levels than during passive recovery. Significant increases in muscle glycogen content occurred in response to passive recovery. Active recovery had no effect on glycogen resynthesis in Type II muscle fibres, but caused a glycogen breakdown in Type I muscle fibres. Fournier, Fairchild, Ferreira and Brau (2004) indicated that glycogen synthesis occurred even under conditions of active recovery from high-intensity exercise. Although glycogen resynthesis can be impaired as a whole in skeletal muscle during active recovery, muscle glycogen stores are replenished in Type IIa and IIb fibers, while being broken down in Type I fibers.

Peters-Futre, Noakes, Raine and Terblanche (1987) assessed the effect of a short period of light activity on the muscle lactate levels and muscle glycogen resynthesis. Eight trained male athletes (mean age 30.8 years) participated in the study. Subjects performed five intermittent exercise bouts, each lasting 90 seconds, at a workload of 120% VO_{2max} , on a cycle ergometer. Bouts of activity were separated by a four-minute rest period. On

completion of the last exercise bout, the subjects reclined on a couch. Venous blood samples were taken before the exercise bouts, and again at 1, 3, 5, 10, 20, 30, 45 and 90 minutes of passive recovery in a supine position. Muscle biopsies were taken before the exercise bouts, immediately after completion of the final bout, and after 90 minutes of passive recovery. In the next phase of the research project, the intermittent exercise bouts were repeated. Thereafter subjects pedalled with one leg at 30% of VO_{2max} for 45 minutes, while the inactive leg was placed on a foot rest. Venous blood samples were taken before the exercise bouts, and again at 1, 3, 5, 10, 20, 30 and 45 minutes during the active recovery period. Muscle biopsies were taken from the active and inactive legs. The researches concluded that the period of light aerobic exercise, as opposed to the passive rest, increased the rate of lactic acid removal from the blood during the post-exercise recovery period. The most rectilinear part of the lactate recovery line occurred between the fifth and fifteenth minute post-exercise. The researchers suggested that the light activity performed as active recovery should not be maintained for longer than 30 minutes, and ought to be of progressively decreasing intensity to optimise the rate of blood lactate removal and glycogen resynthesis. Hawley and Burke (1998) added to this by stating that continued exercise after strenuous activity should not produce additional muscle glycogen breakdown, and should thus not be too intense or too long, while Barnett (2006) stated that active recovery might actually be detrimental to rapid glycogen resynthesis.

Muscle damage, and immune function

Muscle damage due to exercise and impact is a reality for athletes. Researchers are looking at the role of recovery strategies in addressing the effects of muscle damage in athletes. Gill, Beaven and Cook (2006) examined the effectiveness of various post-match recovery interventions on the rate and magnitude of muscle damage recovery in rugby players. The researchers reported that muscle damage is caused by the direct impact between opposing players, and this muscle damage was indicated by raised interstitial creatine kinase concentration. Twenty three elite male rugby players (mean age 25 years) were monitored before, immediately after, 36 hours after, and 84 hours after competitive rugby matches. The players were well-trained and represented their province in the New Zealand National Provincial Championships. Four competition weeks were monitored and subjects were randomly assigned to one of four post-match recovery sessions. Players completed either contrast water therapy where they alternated between one minute cold and two minutes in hot water for nine minutes; or low intensity active exercise (low-intensity cycling for seven minutes); or a lower body compression garment (worn for twelve hours); or passive recovery

(sat on a bench for nine minutes). The researchers concluded that low-impact exercise immediately after a competition enhanced creatine kinase clearance significantly more than the passive recovery.

Wigernaes, Høstmark, Kierulf and Strømme (2000) reported that physical and psychological stress may cause an acute increase in the circulatory white blood cell count. In a period of 15 to 60 minutes after cessation of high-intensity and/or long duration physical activity, the white blood cell count falls significantly, even below resting values. The researchers did a study to examine the effects of different recovery methods on white blood cell count and muscle enzyme activities following strenuous, sub-maximal, steady state exercise bouts. Fourteen active males (mean age 23.4 years), well-trained for running, participated in the study. An incremental lactate threshold test and a VO_{2max} -test were carried out. Subjects were randomly assigned to perform a high-intensity (running for 30 minutes at 80% of VO_{2max}) or a medium-intensity (running for 60 minutes at 70% of VO_{2max}) running trial. Each subject performed the exercise twice (on different days), with a different type of recovery following the exercise bout. Passive recovery consisted of resting in a supine position for 15 minutes, while active recovery consisted of continuous jogging at 50% of VO_{2max} at an incline of three degrees for 15 minutes. Venous blood samples were drawn at rest, immediately after the exercise trial, after 15 minutes, and 120 minutes after cessation of exercise. The results confirmed that "exercise has an appreciable acute stimulating effect on white blood cell count, and that this leukocytosis is followed by a reduction in the white blood cell count when resting after exercise" (Wigernaes et al., 2000: 611). The researchers found that the immediate decrease in white blood cell count could be prevented by the active-recovery session, with a more prominent difference after the high-intensity run. The researchers concluded by stating that the first minutes after exercise are crucial with regards to immunosuppression, as well as a time period of up to four hours after training. Active recovery might thus be an intervention after exhausting training and competition to counteract a rapid and possible harmful decline in white blood cell count after exercise.

During tournament conditions, consecutive soccer games are often only separated by 20 hours, placing various demands on the different systems. Malm, Ekblom and Ekblom (2004) assessed the effect of two consecutive games, separated by 20 hours, hypothesising that players would show signs of short-term immunosuppression. Blood samples were taken from 10 elite junior players (mean age 17.8 years), before the first soccer game, immediately after the second game, and after 6, 24, 48 and 72 hours to investigate cell surface antigens,

testosterone, and cortisol. It was found that, in response to the competitive soccer exercise, some immunological variables were enhanced, while others were depressed. The researchers concluded that aerobic exercise can decrease the immunological alterations, but also that at least 72 hours is needed to normalise immunological variables after two consecutive soccer games.

Stretching

Stretching is quite possibly the most common post-exercise routine athletes are encouraged to use as part of the active-recovery routine after exercise, although stretching is a complex, controversial, and inconclusive issue. No studies could be found on the use of stretching as a recovery modality specifically. Maffetone (1999: 322) stated that stretching should always be individual. According to the author, most athletes do not need to stretch if they participated in "diminishing levels of activity" after their workout or competition. It is suggested that only athletes who require greater-than-normal range of motion may need to stretch. O'Connor and Hurley (2003) referred in their review to evidence showing that static stretching was not effective in the management of muscle soreness, range of movement, and muscle strength deficits due to DOMS.

Psychological parameters

Active recovery could have an effect on psychological parameters in athletes. Suzuki et al. (2004) investigated the effect of active versus passive recovery on the physiological and psychological recovery of 15 elite level rugby players. Subjects were studied in the morning of the day of the rugby match, within 10 minutes of finishing the match, and in the mornings of the first and second day after the match. Blood biochemistry and neutrophil functions were examined as markers of physiological stress. The *Profile of Mood States (POMS)* was used to evaluate their psychological condition. Seven subjects comprised the passive recovery group and went about their normal daily life after the match. Eight subjects performed a one-hour low-intensity exercise session once a day in water during the active recovery period. The data confirmed that competitive rugby is an intense form of exercise resulting in physiological and psychological stress. The results showed that two days of rest was not enough to allow full recovery of neutrophil functions after the rugby match, irrespective of the type of recovery applied. A significant decreased POMS-tension was found for the subjects participating in the active-recovery sessions.

Peterson (2005) wrote that active recovery can have the added benefit of giving the athlete a sense of control over the recovery process. The athlete is actively involved in the recovery strategy rather than sitting and doing nothing, which can add stress for some athletes. The cool-down period can also allow the athlete to reflect on the training session or competition and begin the debriefing process (Fuller & Paccagnella, 2004).

Nutrition

It is often stated that, assuming that the athlete has not suffered injury or severe muscle soreness, the key components of recovery are nutrition and rest (Williams, 2007). Pickett and Morris (1975: 49) wrote: "Next to the air we breathe, food and sleep are the two most crucial physical essentials for maintaining a sound and healthful state of living," which might reflect on the important role of nutritional strategies for recovery. Armstrong (2006) referred in a review to the variety of extreme environments around the world where soccer is played, with players often travelling across time zones into these environments, and stated that nutrition is viewed as one of the key factors to offset the performance decrements that occur in stressful environments.

Researchers refer to the resynthesis of the body's carbohydrate stores (refuelling), and rehydration as the key components of recovery nutrition (Calder, 1996; Calder, 2000a; Hawley & Burke, 1998; Williams, 2007).

Refuelling

The role of muscle glycogen as a fuel during prolonged exercise is well established. It has recently been recognised that diet can also affect the performance of high-intensity exercise of short duration (Maughan et al., 1997). Armstrong (2006) referred to the large energy requirements of competitive football. Play involves intermittent exercise of varied intensities, with rest periods. The mean rate of aerobic energy production for elite football players is reported as 70-80% of maximal aerobic power during the course of a 90-minute match. The total distance covered by players is between 10 and 11 kilometres on average (Armstrong, 2006). Field hockey, netball, and rugby are also multiple-sprint sports in which the prolonged intermittent high-intensity exercise reduces muscle glycogen stores, which can impair performance (Williams, 2007).

The restoration of glycogen stores after exercise should be a priority for players. Maughan et al. (1997) wrote that, if players begin an event with muscle glycogen stores that are low as a result of inadequate glycogen repletion, performance will be impaired. Team sport players are advised to refuel effectively between matches, undertaken every four to seven days during the competition season, as well as the conditioning sessions undertaken between matches. It has been shown that repetition of high-intensity exercise on successive days are difficult, but better restoration of muscle carbohydrate stores can enhance recovery (Burke, Loucks & Broad, 2006). The time to recover between successive competitions or training sessions is often short (less than eight hours), and rapid glycogen synthesis becomes even more crucial under these circumstances (Burke et al., 2006; Jeukendrup & Gleeson, 2004).

Muscle refuelling is best achieved by supplying the body with carbohydrate-rich foods and drinks (Jeukendrup & Gleeson, 2004). Four factors have been recognised as important in promoting the restoration of muscle glycogen stores, namely, the amount of carbohydrate ingested, the type of carbohydrate ingested, the timing of carbohydrate intake, and ingestion of carbohydrate with other nutrients.

Timing of dietary carbohydrate

It is suggested that muscle glycogen synthesis is enhanced during the first few hours of recovery after exercise. Williams (2007) indicated that the process of glycogen resynthesis begins immediately after exercise, and that it is most rapid during the first five to six hours of restoration after exercise. Wright, Claassen and Davidson (2004a) explained that post-exercise glycogen synthesis takes place in a biphasic manner, with a rapid, insulin-dependent phase lasting between 30 and 60 minutes, and a slow, insulin-dependent phase, which, depending on carbohydrate (CHO) availability, can persist for several hours. Exercise leads to an increase in insulin sensitivity, and an increased permeability of the sarcolemma to glucose. After a couple of hours these benefits dissipate, and glycogen storage slows down to typical rates (Burke, 1998; Hawley & Burke, 1998; Jeukendrup & Gleeson, 2004). Eating immediately after exercise will therefore promote speedy refuelling. Jeukendrup and Gleeson (2004) reported that a delay in carbohydrate intake until two hours after exercise resulted in a 45% lower muscle glycogen concentration after four hours, when compared to the same amount of carbohydrate ingested immediately after exercise. Even when recovery periods are brief, players can benefit from consuming carbohydrate (Armstrong, 2006).

Muscle damage, either through direct body contact and bruising, or through eccentric exercise, causes a delay in the recovery of muscle glycogen. According to Burke (1998), the damage causes a disruption of the muscle fibres and interferes with their glycogen-storing capabilities. White blood cells which rush to the area as part of the immune system's functioning, use glucose for their own fuel needs. The major effect on muscle fuel stores appears to occur 24 to 48 hours after the session. Glycogen storage following muscle damage can be partly overcome by increasing carbohydrate intake further, and by capitalising on the first 24-hour period before the main effects take over. Athletes who have completed contact sport, or events in which bruising or muscle damage has occurred, should pay extra attention to eating strategies during the first 24 hours of recovery.

Jentjens and Jeukendrup (2003) concluded in their review on post-exercise glycogen synthesis during short-term recovery, that athletes should consume CHO immediately after strenuous exercise, with this strategy being especially important when there is less than eight hours between exercise bouts. With reference to an eating schedule, it is suggested that the ingestion of CHO at frequent, regular intervals (≤ 30 minutes) may contribute to high muscle glycogen synthesis rates, indicating that serial feedings are more beneficial than one big meal (Jentjens & Jeukendrup, 2003). In addition, the ingestion of small CHO feedings at frequent intervals may reduce the risk of gastrointestinal discomfort (i.e. bloated feeling) (Hawley & Burke, 1998).

Amount of dietary carbohydrate

Burke et al. (2006: 681) stated that a major dietary factor involved in post-exercise refuelling is the amount of carbohydrate consumed, with a direct relationship between the quantity of dietary carbohydrate consumed and post-exercise glycogen storage (Hawley & Burke, 1998). Wright et al. (2004a) suggested that the amount of CHO ingested is more important than the type (referring to Glycemic Index or GI) of CHO during longer recovery periods (more than six hours).

The exact amount of carbohydrate to maximise post-exercise glycogen recovery has not been fully established (Jentjens & Jeukendrup, 2003), with various guidelines being given. It is suggested that athletes should consume carbohydrate-rich foods and drinks that provide at least one gram of carbohydrate for each kilogram of body mass. This should be taken within 15 to 30 minutes after completion of the exercise session. Wright et al. (2004a: 29) suggested the following guidelines: "... optimal muscle glycogen synthesis will be achieved

by the ingestion of 1 to 1.5g CHO/kg BW immediately after exercise, followed by 0.8 to 1.5g CHO/kg BW/hour (ideally divided into small doses every 15 to 60 minutes) for at least 3 to 4 hours thereafter, aiming at a total of 7 to 10g CHO/kg BW over a 24-hour period." Jentjens and Jeukendrup (2003) stated that the rate of CHO intake to obtain maximal glycogen synthesis rates is higher than it has been suggested by a number of authors. They indicated that maximal glycogen synthesis rates occur at CHO intake of $\sim 1.2\text{g/kgBW/h}$. When athletes exercise for three hours or more on a daily basis, Jeukendrup and Gleeson (2004) recommended an increase in CHO intake to 10 to 13 g/kg BW/day. It is suggested that a higher CHO intake can also reduce some symptoms of overreaching, such as changes in mood state and feelings of fatigue.

Type of carbohydrate foods and drinks

CHO-foods can be functionally classified according to the extent to which they increase blood glucose levels. This has led to the concept of the Glycaemic Index (GI), which is a factor seen as useful for athletes in some aspects of sports nutrition (Jentjens & Jeukendrup, 2003). The GI is described as a ranking based on the immediate effect of the food on blood sugar levels (Crosland, 2007), or the rate at which CHO is available for glycogen synthesis (Calder, 2000a), when compared with a reference food such as pure glucose, which have an arbitrary GI of 100. Crosland (2007) indicated that there is some evidence that lower-GI foods may be beneficial prior to exercise, and in the athlete's general diet.

Athletes who train or compete twice or more a day, and/or have a strenuous competition schedule with limited recovery time, are advised to consume CHO-rich foods of moderate to high GI carbohydrate meals within the first six hours post-exercise, and then consume low-GI carbohydrate meals for the remainder of the recovery period (Calder, 2000a; Crosland, 2007; Williams, 2007). Jeukendrup and Gleeson (2004) reported that after six hours of recovery, muscle glycogen is more restored with a high-GI meal compared with a low-GI meal. After six hours, foods with low GI can be included, provided that the overall CHO requirement is met. Athletes who have more than six hours to recover before the next exercise bout, can consume low- or high-GI foods, provided that the amount of CHO to be ingested within the 24-hour period is sufficient (Wright et al., 2004a).

No difference has been found in the rates of refuelling between liquid and solid forms of carbohydrate feedings (Jentjens & Jeukendrup, 2003; Jeukendrup & Gleeson, 2004). Hawley and Burke (1998) stated that a major challenge for athletes is to consume sufficient

carbohydrate immediately after exercise, with practical issues often playing an important role in the choice of food or drink.

It has been suggested that other nutrients eaten with carbohydrate-rich foods could alter the rate of glycogen replenishment. The effect of co-ingestion of protein with carbohydrate on refuelling has been debated. Some studies have shown that ingestion of some protein and/or amino acids in combination with a moderate CHO intake ($\sim 8\text{g/kg BW/h}$) leads to higher muscle glycogen synthesis rates compared with ingestion of the same amount of CHO without protein and/or amino acids. However, when the rate of CHO intake was increased from .8 to 1.2g/kg BW/h , it also resulted in higher muscle glycogen synthesis rates (Jentjens & Jeukendrup, 2003).

Results from the majority of studies indicated that combining protein and/or amino acid-mixtures with carbohydrate did not enhance the rate of glycogen synthesis when the amount of carbohydrate ingested was above 1g/kg BW/hour (Wright et al., 2004a). Jeukendrup and Gleeson (2004) summarised the results from a number of studies by stating that, to achieve rapid muscle glycogen replenishment, ingesting an adequate amount of carbohydrate is more important than adding protein or amino acid mixtures to a recovery meal or drink.

There may be other reasons for including protein and other nutrients such as vitamins and minerals in snacks and meals immediately after exercise. These nutrients are important in recovery processes such as repair and rebuilding, and immune responses, and an immediate intake might be useful in promoting these activities (Hawley & Burke, 1998). It is often also difficult or unappealing to athletes to eat large meals after exercise to consume enough CHO (Burke, 1998; Hawley & Burke, 1998). It is thus suggested that the athlete can consume a moderate CHO intake in combination with protein and/or amino acids, which should result in similar muscle glycogen synthesis, when compared to the ingestion of a large amount of CHO only (Jentjens & Jeukendrup, 2003).

Rehydration

There are some indications that inadequate hydration practices in team athletes might lead to a degree of dehydration, which can affect performance. When the effects of progressive dehydration on skill performance in basketball players were studied, Baker, Dougherty, Chow and Kenney (2007) found that the decrements in performance reached statistical significance

at two percent dehydration of BM. Seventeen highly skilled male basketball players (ages between 17-28 years) participated in six experimental trials, which consisted of two euhydrated conditions, and four dehydrated conditions (1%, 2%, 3%, and 4% of BM). Players performed a sequence of continuous basketball drills designed to simulate a fast-paced game. Drills for speed, agility and lateral movement, explosiveness, shooting, and combinations of the tasks, were performed for 60 minutes, in four 15-minute quarters. Performance measures included skills such as stationary shots and shots after a run, a single maximum vertical jump, repetitive vertical jumps, and single and total sprint times. Heart rate, blood pressure, rating of perceived exertion, and body mass were also measured. Blood and urine samples were analysed. Subjective ratings of fatigue were assessed through the *Fatigue Survey*. Results showed that the skilled basketball players experienced a progressive deterioration in performance as dehydration progressed from one to four percent. The researchers stated that the outcome of most basketball games is decided in the final minutes of play, and players should therefore be advised to implement adequate in-game hydration strategies to prevent a two percent or more dehydration, and the detrimental impact on basketball performance.

In another study on the effects of dehydration in male basketball players (17-28 years), Baker, Conroy and Kenney (2007) reported that dehydration at any level (between one and four percent) resulted in a decreased sensitivity to relevant cues, increased the number of omission errors, and slowed response time in the players. It was concluded that fluid replacement is critical in preventing the decline in attentional vigilance associated with dehydration.

Soccer performance might also be impaired by moderate dehydration levels. Research by Edwards et al. (2007) indicated that acute, exercise-induced moderate dehydration (~2% of BM) was detrimental to a post-match sport-specific fitness test. Eleven moderately active male soccer players (mean age 24.4 years) performed the three different experimental conditions (fluid intake, no fluid, and mouth rinse) on three separate occasions, in an individually randomised order. Subjects started the experimental protocol with a 45-minute cycle on an ergometer in the laboratory at an intensity of 90% on their ventilatory threshold. After a 15-minute rest period, subjects participated in an eight-versus-eight outdoor soccer match on an Astroturf for 45 minutes. The *Yo-Yo Intermittent Recovery Test* was then performed, followed by a test of mental concentration. Water allocations for the fluid intake- and mouth rinse-protocol were divided into three drinking opportunities. Heart-rate, ratings

of perceived exertion (RPE), blood and urine measures of hydration, sweat rates, and heat storage were also measured. Results showed that mental concentration was unaffected by moderate dehydration, while the moderate water loss was detrimental to several physiological parameters. The researchers cautioned that negative psychological factors surrounding a greater perception of effort while dehydrated, could have an influence.

Research by Judelson et al. (2007) showed that hypohydration (reduced total body water) in seven resistance-trained males (mean age 23 years) significantly limited their ability to perform a six-set back squat exercise bout. The hypohydration of 4.8% body mass failed to affect vertical jump height, peak lower-body power, and peak lower-body force. Results from the POMS questionnaire indicated that total mood disturbance increased incrementally at each hydration state, although not statistically significant. It was concluded that "hypohydrated individuals who complete isotonic, multiple-repetition, multiple-set, intermittent resistance exercise tasks will likely experience impaired performance" (Judelson et al., 2007: 1821). The researchers stated that, because hypohydration limited workout volume, overall training volume might suffer in hypohydrated individuals. A hypohydrated condition also had a significantly detrimental effect on aerobic performance of 18 amateur university rugby players (mean age 21 years) in a study by Albridge, Baker and Davies (2005).

Maughan, Shirreffs, Merson and Horswill (2005) reported on the water and electrolyte needs of soccer players during training and matches. Sweat losses of adult players from three European professional soccer clubs during training sessions of 90 minutes were two litres on average, while the average fluid intake was 830 millimetres. The researchers reported that the percentage change in body mass was, on average, the same for training in cool versus warm conditions. This was attributed to the wearing of additional clothing in the cool environment. Players training in cool conditions, drank only about half the volume that was consumed in warmer environments. Armstrong (2006) referred to studies showing that, regardless of weather conditions, fluid replacement lags behind fluid lost as sweat by at least 50%. The authors reported that 16- to 18-year-old male adolescent soccer players did not differ significantly from adult male players in terms of sweat volume and sodium losses, while female soccer players had lower sweat rates. Maughan and Shirreffs (2007) stated that, where sweat losses are small, there is little need for fluid replacement during training or match play.

It is suggested that most athletes typically replace between 30% to 70% of their sweat losses when they train or compete (Finn & Wood, 2004; Hawley & Burke, 1998), and it is likely that athletes will finish the exercise session with some degree of dehydration (Burke, 1998). Even when the exercise session is over, athletes do not fully replace their fluid losses. Without fluid replacement strategies, there can be a time lag of up to 24 hours before body fluid levels are completely restored. Nevill (2000) wrote that soccer and hockey players in the 1992 Barcelona Olympics often played in temperatures of 30°C-35°C for up to two hours (including extra time), and covered about 10 kilometres in the normal match time, with a sprint performed approximately once every 30 seconds. In the tournament situations, players often have less than 20 hours before the next match. This emphasises the priority that should be given to sound rehydration practices.

Burke (1997) mentioned a number of factors that can affect the fluid intake of team athletes, namely, the awareness of sweat losses, the availability of fluid, opportunities to drink, and palatability of fluid.

Timing of fluid replacement

The athlete should start to rehydrate soon after finishing the exercise session. Depending on the magnitude of the losses, the athlete may need 4-24 hours to completely replace and rebalance body fluid losses. The athlete should plan ahead for post-exercise requirements, ensuring that a supply of drinks is available at the training session and competition venue (Maughan & Burke, 2004).

Amount of fluid

The amount of fluid needed to restore fluid levels will vary, depending on how much sweat was lost during the session, and how well the athlete attempted to replace fluid losses during the exercise itself. Shirreffs (2007) indicated that the volume and composition of the fluid consumed are the main factors influencing the post-exercise rehydration process.

Obligatory urine losses persist after exercise, because of the need for elimination of metabolic waste products. The volume of fluid consumed after exercise-induced sweating must therefore be greater than the volume of sweat lost if effective rehydration is to be achieved (Shirreffs, 2007). Players should consume a volume of fluid equal to 150% of the sweat lost during exercise throughout the remainder of the day. Water retention will be

greater if the fluid or food contains a moderately high sodium content ($60 \text{ mmol}\cdot\ell^{-1}$). After encountering a two percent body weight loss, following the abovementioned recommendations should result in normal hydration status within six hours (Armstrong, 2006; Jeukendrup & Gleeson, 2004).

Although body mass change is not always a reliable measure of changes in hydration status (Maughan, Shirreffs & Leiper, 2007), it is suggested that body mass changes should be measured (weighing before and after the session without sweaty clothes) as a quick guide, and often the only measure, for the athlete to assess dehydration state (Meir & Halliday, 2005). It can also serve as a player-education tool in terms of fluid replacement (Burke, 1998; Shirreffs, Sawka & Stone, 2006). These pre- and post-exercise weight changes can give a rough estimate of the dehydration levels, but the athlete should remember that fluid losses will continue for some hours due to continuous sweating and urination.

The main focus of the study by Finn and Wood (2004) was on the incidence of pre-game dehydration in athletes competing in the International Australian Arafura Games, 2001. The researchers also wanted to investigate the suitability of urine colour as a marker of hydration status. Subjects comprised of 93 male athletes (mean age 25 years) from volleyball, touch football and basketball. Results showed that 56% of the athletes had significant or serious pre-game dehydration. Urine colour was also shown to be a simple, valid, inexpensive and immediate self-measurement tool to monitor hydration status by athletes when other laboratory measures are not available or practical. The researchers recommended that education of athletes about the importance of good hydration should be increased. Urine colour cards could be included in information packages for self-assessment by athletes, as long as athletes are aware that it is influenced by unrelated factors (Meir & Halliday, 2005) such as certain foods, medications, vitamin supplements, and illnesses (Finn & Wood, 2004). Maughan and Shirreffs (2007) also supported self-monitoring by the athlete through attention to the frequency, volume and colour of the urine.

Type of fluid

Maughan and Shirreffs (2007) indicated that, where sweat losses are small, there is little need for fluid replacement during training or match play. Performance is however impaired when the sweat-induced loss of body mass reaches one to two percent of the pre-exercise body mass. Jeukendrup and Gleeson (2004) stated that replacement of water and electrolytes in the post-exercise recovery period is of crucial importance, especially where

repeated bouts of exercise must be performed and rehydration must be maximised in the available time. According to Shirreffs (2007), plain water is not the ideal post-exercise rehydration beverage when rapid and complete restoration of fluid balance is necessary after large sweat losses. The post-exercise drink should contain carbohydrate (glucose or glucose polymers) and sodium. Sodium will partly offset salt losses in sweat, but more importantly, maintains the desire to drink. Presence of the glucose also stimulates fluid absorption in the gut, and improves beverage taste.

Retention of the fluid that is consumed also becomes an issue in rehydration, due to continuous fluid losses from sweating and urination. Urine losses are stimulated by the need to get rid of various waste compounds as well as keeping body fluid levels and composition in balance. Burke (1998) emphasised that, when substantial sweat losses are incurred, electrolytes such as sodium are also lost. The replacement of fluid in the form of water or other low-sodium drinks will increase blood volume, but start to dilute its concentration and sodium level. Urine is produced to keep these concentrations within preferred range, even though the athlete is still dehydrated. Only when electrolytes are replaced, can body fluid levels fully equilibrate in volume and concentration.

Although Shirreffs, Sawka and Stone (2006) stated in a review on nutrition in soccer players that most of the 101 soccer players reported on in their review, had relative low sodium losses of less than 3-4 g during a training session or match, Shirreffs (2007) indicated that the addition of sodium to a rehydration drink is justified, because sodium also stimulates glucose absorption in the small intestine, which promotes net water absorption. Although the addition of potassium and magnesium to sports drinks has been the subject of much discussion, Shirreffs (2007) stated that there does not appear to be evidence for the inclusion of any other electrolytes in sports drinks.

Ali, Williams, Nicholas and Foskett (2007) investigated the influence of carbohydrate-electrolyte ingestion on soccer skill performance in players with reduced carbohydrate stores. Sixteen male semi-professional, ex-professional, or first/second university-team soccer players (mean age 21.3 years), involved in regular training and match play, participated in the study. Subjects completed two main trials, seven days apart, in randomised order. Subjects in the carbohydrate-electrolyte (CHO-E) trial were provided with a commercially available sports drink containing 6.4% carbohydrate. Subjects in the other trial drank a non-electrolyte, artificially sweetened placebo (PLA). After ingestion of the test drink, six 15-

minute blocks of an intermittent shuttle running test (LIST) were completed, separated by a three-minute rest period. Each 15-minute block consisted of 10 to 12 repeated cycles of walking, running, jogging, and sprinting. Subjects ingested the equivalent of $2 \text{ mL} \cdot \text{kg}^{-1} \text{ BM}$ of the same drink during the rest period. Ratings of perceived exertion and environmental temperature were measured on the last walk of each 15-minute block of exercise. Heart rate was measured continuously. Blood samples were drawn at various times during the LIST. After completion of the LIST, participants were given a two-minute rest before performing the soccer passing and soccer shooting skills. It was shown that soccer shooting performance was maintained in the CHO-E-trial, but deteriorated in the PLA-trial. Players in the CHO-E-trial were also able to sprint faster throughout the duration of the LIST. It was suggested that the gross motor aspects of sprinting and force development for shooting the ball were compromised after exercise in the PLA-trial. The researchers concluded by stating that sprinting ability is one of the key physical attributes a soccer player can possess. Referring to a match situation, players in the CHO-E-trial showed that they would be able to sprint faster to get to the ball, and still have the ability to make an accurate pass or shot. CHO-E-subjects were unaware that they exerted themselves to a greater extent than the PLA-subjects. The researchers recommended further research on the effect of carbohydrate ingestion on perceived exertion, mood, and cognitive functioning.

Numerous studies have reported that the palatability of a drink affects how much an athlete will voluntarily consume (Maughan & Burke, 2004), with athletes drinking more of a tasty, flavoured drink than plain water when left to choose their own post-exercise fluid strategies (Burke, 1998). In a study involving 24 basketball (male and female) and netball players during nine separate training sessions, Minehan, Riley and Burke (2002) confirmed this when better fluid balances were achieved using flavoured drinks compared to water. In reporting on the effect of palatability of beverages in promoting rehydration, Shirreffs (2007) found the same effect when participants drank a greater volume of sports drinks and orange juice/lemonade mixture than of either water or an oral rehydration solution.

With reference to the temperature of the fluid, Maughan and Burke (2004) stated that although an athlete who is hot and thirsty may regard very cold fluid (0°C) as the most desirable drink, it is easier to drink larger quantities of a cool temperature (15°C).

Other fluids ingested post-exercise

Caffeine

According to Armstrong, Casa, Maresh and Ganio (2007: 135), "caffeine is the most widely used behaviourally active substance on earth." Because of the widespread belief that caffeine exerts a diuretic effect, the researchers wanted to ascertain whether abstaining from or reducing dietary intake of caffeine is scientifically and physiologically supported. The authors reviewed a variety of investigations on fluid balance, electrolyte balance, temperature regulation and exercise-heat tolerance, and physiological and psychological function, spanning more than 75 years. The main findings were summarised as follows: "... consuming a moderate level of caffeine results in a mild increase of urine production. ... there is no evidence to suggest that moderate caffeine intake (<456 mg) induces chronic dehydration or negatively affects exercise performance, temperature regulation, and circulatory strain in a hot environment. Caffeinated fluids contribute to the daily human water requirement in a manner that is similar to pure water" (Armstrong et al., 2007: 140). Maughan (2007) also indicated that, although caffeine is a weak diuretic, this action is often overemphasised.

Alcohol

Alcohol and sport has a long history of association and has been linked since ancient times (O'Brien & Lyons, 2000). Maughan and Burke (2004: 64) wrote: "Alcohol and sport are closely linked through sponsorship and advertising, with many sporting organizations, teams, and events being supported by companies who make beer and other alcoholic drinks." Consumption by athletes generally occurs in a social environment, and is often associated with celebration, although consumption can also be used as a shield to escape from the realization of failure. The actions of intoxicated high-profile sportsmen and women are often attracting attention from the media (Maughan, 2006).

Athletes generally have greater physical demands placed on them than non-athletes, and it is often expected that athletes will have healthy lifestyles. Research has shown that intercollegiate athletes have significantly higher proportions of risky lifestyle behaviour patterns compared with non-athletes, with intercollegiate athletes having been identified as an at-risk group for heavy alcohol consumption (Martens, Dams-O'Connor & Duffy-Paiement, 2006; Nelson & Wechsler, 2001; O'Brien & Lyons, 2000; Vampley, 2005).

Many athletes only consume alcohol on a few occasions each week or month, but they consume large amounts (binge drinking) at these times (Maughan & Burke, 2004). Alcohol has been associated with the rituals of relaxation and celebration in sport, and with risk taking. It has been shown that team sport players have higher alcohol intakes than other types of athletes (Maughan & Burke, 2004; O'Brien & Lyons, 2000). Several studies were conducted to assess alcohol consumption among athletes at tertiary institutions. Martens, Dams-O'Connor, Duffy-Paiement and Gibson (2006) reported that a greater percentage of both male and female athletes than non-athletes reported heavy episodic drinking (five or more drinks in one sitting for men and four or more for women), and frequent heavy episodic drinking (defined as three or more heavy episodic drinking episodes in the past two weeks). Intercollegiate athletes reported consuming more drinks per week than non-athletes. Athletic team leaders reported an average of 8.25 drinks per week, team members reported an average of 7.34 drinks per week, and non-athletes reported an average of 4.12 drinks per week (Leichliter, Meilman, Presley & Cashin, 1998). These intakes are often episodic, when the average intake for a week is compressed into a short space of time. Binge drinking is reported for a number of team sports (Maughan, 2006).

Athletes from different sports appear to have different drinking patterns. O'Brien and Lyons (2000) reported that sports such as rugby, cricket, soccer, and Gaelic football were found to have the highest percentage of athletes who consume alcohol compared to sports such as horse racing, cycling and tennis. Young men between 18 and 24 years have been shown to have an increased chance of problem drinking, and this is the age group where sports participation is the highest.

It is believed that alcohol consumption the previous night may affect performance the following day. A survey was conducted by O'Brien (1993) to investigate the effect that alcohol consumption the night before activity would have on athletic performance. Athletes were asked to consume their normal Friday night quantity of alcohol. Attempts were made to let the athletes have a similar night's sleep, as well as similar food intake for breakfast. Post-alcohol fitness assessments were performed 16 hours after alcohol intake. Results showed that alcohol hangover had a significantly negative effect on the aerobic performance of the rugby players. Anaerobic performance was unaltered. O'Brien and Lyons (2000) reported that alcohol hangover is commonly characterised by a depressed mood, headache and hypersensitivity to outside stimuli. As a result of the alcohol hangover, athletes might not feel they are able to perform maximally.

An increased prevalence of sports-related injury has been reported in athletes who binge drink. This may be a result of undertaking subsequent exercise sessions while in a hangover state, or may reflect poor handling of injuries in the period after the session in which they occurred (Burke, 2004). O'Brien and Lyons (2000) reported a significant difference in injury rates between drinkers and non-drinkers in the 13 selected sports that were studied. Athletes who drank at least once a week had an injury rate of 54.8%, whereas the non-drinking athletes had an injury rate of 23.5% ($p < 0.005$). The authors referred to previous research with rugby players which showed that 48% of the players drank alcohol the night before athletic participation, while a survey involving athletes ($n = 423$) from 13 sports showed that 58% of the elite athletes consumed an alcoholic beverage before competition or a scheduled training session.

Alcohol intake and binge drinking seem particularly linked with post-competition activities, and in some cases social rituals following training sessions (Maughan & Burke, 2004). Consumption of large amounts of alcohol after a competitive event or training session removes the athlete's focus from the strategies that are important in recovery and injury management, and may thus adversely affect a player's dietary choices by displacing carbohydrate from the diet at a time when the restoration of glycogen stores and rehydration should be priority (Burke, 2004; Maughan, 2006).

According to Maughan (2006), the diuretic action of ethanol is well recognised. Alcohol acts via suppression of the release of anti-diuretic hormones. Alcohol consumption has been shown to increase urinary losses during post-exercise recovery. There appears to be no difference in recovery from dehydration whether the rehydration beverage is alcohol-free or contains up to two percent alcohol. Drinks containing more than three percent alcohol (beer, wine, spirits) tend to delay the recovery process by promoting urine loss (Maughan, 2006; Maughan & Burke, 2004). O'Brien and Lyons (2000) reported that beer was the most popular alcoholic drink among rugby, soccer, hurling, and Gaelic football players, and stated that it might be due to the myth that beer can be an effective beverage for refuelling and rehydration.

Burke (1998: 36) wrote: "... alcohol can be a small part of a healthy diet. A drink after a hard day's training can help you relax, and can add sparkle to social occasions. If you choose to drink, make it work for you, rather than to pull your sports potential back to the level of those who would have you believe that 'team bonding' (getting drunk together) is all that

sport has to offer.” The following hints were given for using alcohol sensibly in the sports environment: do not save up for a binge after matches; rehydrate and refuel with carbohydrates before alcoholic drinks are taken; set a limit; have non-alcoholic drinks available as thirst-quenchers, and treat alcohol as a luxury item.

Dietary supplements and ergogenic aids

Many publications report on the widespread use of supplements among various groups of athletes for many different reasons, with the market for nutritional supplements being a multi-billion dollar business (Hespel, Maughan, & Greenhaff, 2006). Promoting recovery after training or competition is indicated as one of the reasons why athletes use supplements (Maughan, 2007), with other reasons stated as improved endurance, increased energy, improving strength and power (tissue growth and repair), health reasons (immune function), and weight reduction and fat loss (Hespel et al., 2006; Maughan, King, & Lea, 2004). The widespread use of supplements is acknowledged, but it is beyond the scope of this study to discuss and report on the many hundreds of supplements available to athletes.

Education and professional advice

The importance of planning a nutritional strategy for match day was emphasised by Williams and Serratos (2006), because many players fail to adhere sound nutritional strategies for recovery. Shephard (1999) reported that, when left without guidance, most football players failed to ingest the necessary quantity and type of carbohydrates during the hours after exercise. Schröder et al. (2004) indicated the same trend in their study on the dietary habits and fluid intake of 55 elite Spanish basketball players. Intake of protein, fat, and vitamins exceeded the daily recommended intake, whereas intake of carbohydrates failed to meet the guidelines. Only 10% of the basketball players indicated that they consumed specific foods after competition. In their assessment of the dietary intake of female United States national soccer players, Mullinix et al. (2003) emphasised the need for education with regard to the nutrition of the players, while Schröder et al. (2004) underlined the need for professional advice from sport nutritionists. Dabinett, Reid and James (2001) reported on their efforts to educate 15 female field hockey players (mean age 24.1 years) to develop hydration strategies for the Commonwealth Games, showing that educational strategies in terms of nutrition for athletes can be successful.

Complete rest—Sleep

Pickett and Morris (1975: 49) made the following comment: "Next to the air we breathe, food and sleep are the two most crucial physical essentials for maintaining a sound and healthful state of living." Sleep is a basic human need and a healthy adult will spend about one-third of his/her life sleeping (Lee, 1997). The Japanese Ministry of Health, Labour and Welfare proposed a plan called "Health Japan 21", in which sleep was emphasised as one of the specific living habits needing improvement. Japan began a national project called "Establishing a science of sleep" in January 2001 (Tanaka & Shirakawa, 2004). It has been reported through the years that sleep is closely related to physical and mental health. Complete rest or sleep is still seen as the main means of restoring physical working capacity, as well as mental restoration (Bompa, 1999; Dale, 2004). Although sleep is seen by many as the most significant aspect of recovery, Walters (2002) stated that, with regard to athletes, it is often neglected or athletes are given brief, simplistic recommendations.

Defining sleep

Sleep is defined as "...the natural and regular state of inactivity in which consciousness ceases and the bodily functions slow down or cease" (Watson, 1976: 1042). Lee (1997) described sleep as a period of diminished responsiveness to external stimuli. Hobson (1995: 1) referred to sleep as "... a dynamic behaviour. Not simply the absence of waking, sleep is a special activity of the brain, controlled by elaborate and precise mechanisms. Not simply a state of rest, sleep has its own specific, positive functions."

The state of sleeping is physiologically very different from other states of relative inactivity such as unconsciousness, coma, or hibernation (Stores, 2001). The normal lying-down posture of sleep, eyes closed, and lack of responsiveness to stimulation does not give an indication of the active state of the brain. Measurable changes in the electrical activity of the brain are present throughout different sleep stages.

Stages of sleep

There are five distinct stages of sleep that occur during a typical night, usually divided into two main categories. Stages one, two, three and four represent the Non Rapid Eye Movement-sleep (NREM), and stage five the Rapid Eye Movement-sleep (REM). It is useful

for the athlete to understand the sequence, duration and distinct aspects of each stage to appreciate the importance of sleep as a recovery strategy. During the day beta brain waves, which are high in frequency and low in voltage, reflect a mental state that is actively aware of environmental stimuli. As one lies down to sleep, beta waves are replaced by alpha waves. This indicates a state of being awake, but relaxed. After five to twenty minutes of relaxed alpha brain wave activity, the mind and body can now enter stage one (Brassington, 2002; Nicol, 1988; Walters, 2002).

The onset of sleep under normal circumstances in normal adult humans is through NREM-sleep. This is a fundamental principle of normal human sleep and abnormal entry into sleep via REM can indicate pathological conditions (Carskadon & Dement, 1989). The four NREM stages (stages one, two, three and four) roughly parallel a continuum of depth of sleep. Stage one sleep is light sleep, marked by theta brain waves and generally persists for only a few (one to seven) minutes. Respiration becomes shallow and muscular relaxation occurs so rapidly that a physical reflex such as jerking of the arms or legs can occur. Sleep is easily discontinued during stage one by, for example touching a person lightly, softly calling his/her name, closing a door quietly. Individuals aroused during this stage often report that they were not sleeping but just resting. During stage one, humans are relatively aware of significant environmental changes and can respond quickly if aroused during this stage. A common sign of disrupted sleep is an increase in the amount of stage one sleep (Carskadon & Dement, 1989; Walters, 2002).

Some scientists argue that stage two actually marks the beginning of sleep since most individuals are blind and deaf to most external stimuli during this stage. Stage two usually lasts from 10 to 20 minutes. As one enters stage three sleep, a combination of theta and delta brain waves (high voltage, slow-waves) occurs. Theta waves become less visible and delta waves become more prominent. When theta waves completely disappear, one has arrived at stage four sleep, the deepest stage. It is difficult to wake a person in deep NREM-sleep. If the person is woken, he/she will appear disorientated and confused. Many normal functions such as blood pressure, respiration and heart rate diminish. Stage four NREM-sleep generally lasts for about 20 to 40 minutes in the first cycle. Researchers often refer to the combined stages three and four sleep as slow-wave sleep, delta sleep, or deep sleep. NREM-sleep is a dormant state of the brain with blood flow and glucose utilization decreasing by more than 40% (Carskadon & Dement, 1989; Gunning, 2001; Stores, 2001). Walters (2002: 18) said: "This is as close to hibernation as humans ever get."

After 30 to 40 minutes of delta sleep, stages three and two are retraced, but instead of returning to stage one, REM-sleep begins. The brain reactivates into a fast activity state. Blood flow, heart rate, respiration, body temperature and blood pressure all rise, and the eyes, underneath closed eyelids, dart back and forth as if scanning the environment, which may be accompanied by intermitted small muscle twitching (Brassington, 2002; Walters, 2002). REM-sleep episodes become longer as sleep progresses, with the longest REM-sleep episodes occurring in early morning. In normal adults, 20-25% of total sleep time is spent in REM-sleep (Savis, 1994; Stiller & Postolache, 2005). Dreams are often experienced during REM-sleep and REM-sleep has also been called "dream sleep" (Reisser, 2006; Siegel, 1989). REM-sleep is considered to be the state during which information may be conserved. The length of REM-sleep increases when a task is learnt. Researchers think that the chemicals required to form memories are conserved during REM-sleep. REM-sleep is thus essential when complex techniques or tactics are being learnt (Gunning, 2001). Subjects who acquired new motor skills while learning trampolining during a 13-week programme showed significantly lengthened REM-sleep (Buchegger, Fritsch, Meier-Koll & Riehle, 1991). Meier-Koll, Bussmann, Schmidt and Neuschwander (1999) also found REM-sleep to increase after the subjects explored a complex computerized maze.

In adults, cycles of NREM-sleep and REM-sleep recur within a period of 90 to 100 minutes. NREM- or slow-wave sleep makes up approximately 75-80% of this time and REM-sleep the remaining 20-25%, occurring in four to six episodes. In the young adult, slow-wave sleep dominates during the first one third of the night; REM-sleep is the greatest in the last third of the night (Carskadon & Dement, 1989; Gunning, 2001; Hobson, 1995). If sleep loss was experienced on one or more nights, slow-wave sleep will be prominent. The body has a priority for restorative, deep sleep and slow-wave sleep will therefore take precedence over any other stage of sleep during the first few nights after recovery from sleep deprivation. REM-sleep will recover only after the recuperation of slow-wave sleep. Chronic deprivation of nocturnal sleep, an irregular sleep schedule, or frequent disturbance of nocturnal sleep can result in changed distribution of sleep stages. It is most frequently characterised by premature REM-sleep: sleep onset with REM-sleep (Carskadon & Dement, 1989).

Body rhythms and sleep

The human body displays unconscious brain-based rhythms that regulate when persons sleep and wake.

The circadian rhythm

Internal clocks that control biological rhythms having periods of about the length of a day (24-hour intervals) are called circadian. It is derived from the Latin *circa*, which means about, and *dies*, meaning day (Hobson, 1995: 31). Mistlberger and Rusak (1989) wrote that most human behavioural and physiological processes are characterised by a temporal structure that matches a 24-hour day-night cycle, with daily patterns of sleep and wakefulness as the most familiar aspect. These daily rhythms are internally generated and not just reactions to alarm clocks, sunsets or external temperature changes, and persist under constant environmental conditions.

It is proposed that there is a relationship between circadian rhythms and athletic performance with peak athletic performances at a specific time of day. Disturbance of this circadian rhythmicity can influence the athlete's performance, and the timing of athletic performance is therefore important. Most performance rhythms rise to a plateau between 12:00 and 21:00, and it is seen as a time window for optimal performance. For example, long-term memory recall is higher when the material is presented at 15:00 as oppose to 09:00. This has implications for the timing of coaching instructions. Aerobic capacity peaks during the evening. Data showed that performance in swimming trials and competitions, running, shot putting and rowing was significantly better during the evening than in the morning (Winget, DeRoshia & Holley, 1985). Monk (1989) reported a well-defined peak in subjective alertness in the late morning or early afternoon.

Drust, Waterhouse, Atkinson, Edwards and Reilly (2005) did a review on circadian rhythms in sport performance. Evaluations of world record-breaking performances in sport indicated a circadian variation, with world records broken by athletes competing in the early evening, when body temperature is highest. Performances in time trials in competitive cycling were better in the afternoon and evening compared to those in the morning. Throwing, and 100-m and 400-m performances improved in the afternoon or early evening. Muscle strength peaked in the early evening, while tasks demanding fine motor control, mental arithmetic and short-term memory peaked in the morning. The authors concluded with suggesting that

the performance of skill-based sports and those requiring complex competitive strategies, decisions and recall of coaching instructions are best in the morning. Sports that require substantial physical efforts should be completed later in the day.

Smith, Guilleminault and Efron (1997) studied the win-loss records of West Coast (WC) and East Coast (EC) National Football League teams over a period of 25 seasons (1970–1994). It was found that WC-teams had won more often and by more points than the EC- teams. With the starting time of 21:00 the internal clock of the WC-teams playing on the EC would be only 18:00, a time of better athletic performance. For the EC-teams travelling to the WC, their internal clocks would be set at midnight for the 21:00-game, a time of relatively worse performance. The WC NFL teams therefore had a circadian advantage over the EC-teams because they were playing closer to a proposed peak athletic performance time of day. The players benefited when the training times were changed for a few days before departure. The researchers stated that the results supported the presence of an enhancement of athletic performance at certain circadian times of the day.

Brooks et al. (2005) summarised by saying that physical performance is maximised in the afternoon. The highest values in body temperature, strength, reaction time, pattern recognition, and heart rate occur during this time, as well as a reduced level of perceived exertion.

Sleep and light

The circadian system is acutely sensitive to environmental photic cues (Mistlberger & Rusak, 1989). Light is one of the universal environmental time cues, or *zeitgebers*. The suprachiasmatic nucleus (SCN) within the hypothalamus regulates the body's circadian system and has been established as the master circadian pacemaker or master clock. The retinohypothalamic tract is a direct neural pathway from the retina to the SCN. The visual receptors involved are independent of the classical rod and cones, and act to assess the time of dusk and dawn according to the quantity and quality of light. The SCN-cells have receptors for melatonin. As darkness falls, melatonin is secreted by the pineal gland, and its vasodilatory effect causes body temperature to fall and other physiological functions to slow down to prepare for sleep. Exposure to light therefore inhibits the release of melatonin (Reilly et al., 2005; Stiller & Postolache, 2005; Waterhouse, 2007).

Smith and Trinder (2005) confirmed this fact with their research on the effect of sunlight exposure on the circadian rhythm. Eight males (mean age 24.8 years) with normal sleep-wake patterns were studied over a five-week period. They were exposed to either two hours of bright sunlight in the morning or the evening. The study revealed that daily exposure to natural light contributes to the entrainment of the circadian system. Increased exposure to outdoor light in the morning caused a phase advance in core temperature.

In contrast to the exposure to sunlight, Harada, Matsumura and Takeuchi (2003) studied the effect of blacked-out curtains on the sleep-wake rhythm of students. Students in their fourth year of study were monitored over a period of six weeks. Blacked-out curtains that could shut out sunlight completely were installed in their bedroom windows. The shutting out of morning light had significant effects on the sleep-wake cycles, and the researchers concluded that sunlight through the window seems to have an important role as a *zeitgeber* in humans.

Sleep and body temperature

The circadian rhythm of sleeping and waking is also closely coupled to the daily rhythm of body temperature (Mistlberger & Rusak, 1989). Oral temperature follows a daily rhythm where body temperature is at its lowest in the early hours of the morning (04:00), then rises throughout the day to peak between 17:00 and 21:00 (Kräuchi, Cajochen & Wirz-Justice, 2005; Manfredini et al., 1998). Sleep onset normally occurs as distal blood skin flow starts to increase and the body temperature starts to drop. Research has shown that, when subjects are isolated from time cues, they can only fall into long periods of sleep when they are near their minimal body temperature (Gunning, 2001). Kräuchi et al. (2005) stated that evidence from physiological and neuroanatomical studies indicates that changes in body temperatures trigger brain areas to initiate sleep. REM-sleep occurs with a circadian distribution that coincides with the lowest point of body temperature, in the early morning hours. The circadian phase at which sleep occurs affects the distribution of sleep stages. If sleep is delayed until the early morning, REM-sleep will dominate and even occur at the onset of sleep (Carskadon & Dement, 1989).

Extreme temperatures in the sleeping environment will disrupt sleep (Carskadon & Dement, 1989; Glotzbach & Heller, 1989). This is often why individuals find it difficult to sleep in hot weather or after a very hot bath or shower. The body temperature may not fall due to high

external temperatures. Sleeping under very thick bedding, in lots of clothes or with a heater on high may also maintain an individual's body temperature and affect the quality of sleep (Gunning, 2001).

Napping

When the sleep-wake cycles were studied in isolation chambers where subjects were allowed to sleep whenever they wanted, it was found that subjects spontaneously took naps. Dinges (1989) studied 67 healthy young adults over a five-week period. Rectal and oral body temperatures were monitored in 2500 nocturnal sleep episodes and 500 daytime naps. These naps were relative to body temperature cycles. Longer sleep began prior to the minimum temperature, while shorter sleep or naps (*siestas*) occurred near the maximum temperature. If the 24-hour day was divided into four six-hour zones, the probability of sleep onset and wakefulness could be projected relative to the phase of the circadian temperature cycle. A high probability of nocturnal sleep was between 24:00 and 07:00. Morning wakefulness occurred between 07:00 and 13:00. A high probability of a short sleep or siesta was found between 13:00 and 18:00. Evening wakefulness occurred from 19:00. The precise hours for each zone are arbitrary and might shift relative to the temperature cycle (Dinges, 1989).

Loehr and Schwartz (2005: 60) used the term "breaking point" which refers to the time around 15:00 when individuals usually experience a high level of fatigue. This greater sleepiness in the early afternoon is also referred to as the "postlunch dip" (Stores, 2001). Vulnerability to accidents is higher in the mid-afternoon than at any other daytime period. Individuals are advised to take a mid-afternoon nap or "recovery break". Zarcone (1989) confirmed the biphasic tendency of sleep and refers to a second peak of sleepiness approximately eight hours after termination of the long consolidated nocturnal sleep. Napping at any time other than 10 to 15 minutes during this peak may have negative effects on sleep in the next consolidated sleep period of the 24-hour day. He stated that naps 10 to 12 hours after the major sleep period are particularly likely to disturb subsequent nocturnal sleep. Postolache et al. (2005: 435) referred to the two "sleep gates" as two distinct periods when it is easy to fall asleep, which usually occurs between 13:00 and 16:00, and then in the late evening. A 20-minute nap should have, according to the authors, positive effects on performance.

Numerous studies have been done on the effect of shift work on human functioning. Employees doing shift work, are at a higher risk of injuries, illnesses and accidents than day workers. Cable (2005: 29) wrote: "Humans have been hardwired to work during the day and sleep at night. When we disrupt our biological clocks, there usually is a price to pay." A 20-minute "power nap" is one of the strategies to assist the employees in their alertness and productivity. Dinges, Orne, Whitehouse and Orne (1987) showed that a nap prior to a night of sleep loss could be more important in terms of meeting performance demands than a nap for recovery from sleep loss.

Hayashi, Watanabe and Hori (1999) studied the effect of a 20-minute nap in the mid-afternoon on mood, performance and EEG activity in seven young healthy adults. Mood, performance and self-ratings of performance levels were measured every 20 minutes from 10:00 to 18:00. The subjects went to bed at 14:00 in the nap-condition and were awakened after 20 minutes from the onset of sleep stage 1. The 20-minute nap improved performance level, self-confidence and daytime vigilance level. Nicol (1988) recommended a 20-minute nap between 13:00 and 15:00, but not longer and later. Axford and O'Callaghan (2004) also referred to the possibility of daytime naps leading to insomnia if it is not well-monitored. Tanaka and Shirakawa (2004) stated that short daytime naps of less than 30 minutes are effective in preventing senility and lifestyle-related diseases in the elderly, are beneficial for brain functioning, and prevent night time insomnia among the elderly. Kaida, Nittono, Hayashi and Hori (2003) reported that a short nap (15 minutes) with self-awakening was more effective in reducing a post-lunch dip in the ten college students who participated in their study, than a nap with forced-awakening.

Walker and Stickgold (2005) reported that daytime naps can be beneficial to the learning of visual and motor skills. A midday nap of between 60 and 90 minutes can be sufficient to produce significant improvements in motor skill performance. The authors stated that, because motor skill learning is also dependent on sleep, naps may be used as a prophylactic strategy against learning deficits if the athlete expects some overnight sleep loss. With reference to athletic training, the researchers mentioned that immediate performance after awakening from a longer sleep bout (>60 minutes) might result in short-term performance impairments due to sleep inertia. It is thus important for the athlete to plan the timing and duration of the nap well. Reisser (2006) supported the idea of an effective shorter 20-minute nap for improvement in performance and alertness.

To underline the importance of a “power nap” or period of “micro-rest” for athletes, Kenttö and Hassmén (2002: 65) reserved bonus points for athletes in their *Total Recovery Method* (discussed earlier) of monitoring athletes’ regeneration actions if they had at least one nap during the day.

The role of sleep in well-being and performance

Sleep serves multiple purposes. It has been emphasised that sleep helps, for example with physical and psychological restoration and recovery, conservation of energy, memory consolidation, discharge of emotions, brain growth, and maintenance of the immune system, but the complexities of sleep are yet not fully understood. Nadler et al. (2003b) stated that sleep is essential for physical and emotional health and plays a significant role in recovery from illness and injury.

Physiological growth and repair

Although the body is continually in a process of revitalization, during sleep this process peaks in stages three and four. Physiological processes that occur during slow-wave sleep that cause this effect include the fact that metabolic activity is at its lowest, and the role of the endocrine system that increases the secretion of growth hormone (Loehr & Schwartz, 2005; Walters, 2002). Significant neuro-endocrine activity is present with the release of growth and sexual maturation hormones. More than 95% of the daily production of these hormones occurs during NREM-sleep (Gunning, 2001; Savis, 1994). In normal young adults, the 24-hour profile of growth hormone secretion consists of low levels, which is abruptly interrupted by large secretory pulses. Major secretion usually occurs shortly after sleep onset, in temporal association with the first episode of slow-wave sleep. A large pulse of growth hormone secretion occurs more than 90% of the time during the first slow-wave period, and there is a quantitative relationship between the duration of the slow-wave stages and the simultaneous amount of growth hormone secreted (Stores, 2001; Van Cauter et al., 1997). Walsh et al. (1984) studied sleep and growth hormone secretion in six female athletes by obtaining blood samples at 0.5 hour-intervals over a period of 24 hours. The secretion of growth hormone was elevated in the first hour following sleep onset, although it was not statistically different from the control group. Shapiro (1981) also referred to the greater release of growth hormone during sleep following exercise.

Godfrey, Madgwick and Whyte (2003) confirmed the pulsatile fashion of human growth hormone secretion, following a circadian rhythm. The most powerful, non-pharmacological stimuli to initiate the secretion, are sleep and exercise. To stimulate an increased secretion of exercise-induced growth hormone, the exercise must be of high intensity for a minimum of ten minutes. The elevated secretion of growth hormone is often given as one of the reasons why athletes are encouraged to sleep during the day to stimulate the release of growth hormone. This could be useful for athletes who are going to perform strength training sessions after that. NREM is considered to be the time during which the body can repair and restore itself (Gunning, 2001).

Sleep deprivation is regarded as a stressor that has significant effects on physiological growth and repair. Mostaghimi, Obermeyer, Ballamudi, Martinez-Conzalez and Benca (2005) found that sleep-deprived rats developed lesions on their paws and tails. Paturel (2006) referred to studies that have found that women who work night shifts are at a higher risk of developing breast cancer. Melatonin is secreted in darkness, and studies showed that women who are frequently exposed to long hours of light have lower melatonin levels. Scientists postulated that the lower melatonin levels due to light exposure at night, might be the culprit. It was found, on the other hand, that women with higher melatonin levels were less likely to have breast cancer. Interference with immune function through impaired cellular and hormonal influences has been noted in sleep deprived subjects. It is believed that melatonin and growth hormone, released during the sleep cycle, function to stimulate and enhance the immune system. Sleep deprivation might thus have a negative effect on tissue healing and recovery (Nadler et al., 2003b).

Cardiovascular and neuro-muscular performance

While learning new skills, athletes often believe that practice is the only prerequisite for improvement. Although correctly repeating a new task will result in learning benefits, it has been shown that the human brain continues to learn in the absence of further practice, and this delayed improvement develops during sleep (Walker & Stickgold, 2005). Walker and Stickgold (2005: 301) rephrased the old saying "practice makes perfect" to: "it's practice, with sleep, that makes perfect." The authors did a series of studies to investigate the effect of sleep on motor-sequence learning. Subjects trained on a motor sequence task at 10:00 or 22:00, and were retested at intervals across 24 hours. Subjects who trained at 10:00, showed no significant improvement when retested later the same day after 12 hours of wake

time. When retested following a night of sleep, a 20% improvement in speed and a 39% improvement in accuracy occurred. The subjects who trained at 22:00 demonstrated equally large improvements the next morning following sleep. The significant delayed learning without further practice was therefore only seen after a night of sleep and not over the equivalent period of wake time. It is suggested that optimal skill learning in athletes is dependent on sleep. Walker and Stickgold (2005) also demonstrated that if subjects were deprived of sleep on the first night after training, then took a night of recovery sleep before being retested, normal overnight improvements in learning were blocked. This indicates that sleep on the first night following training is critical, and that the sleep-dependent motor sequence learning depends on sleep within the first 24 hours after training.

Pickett and Morris (1975) studied the effects of acute sleep and food deprivation on total body response time and cardiovascular performance. Twenty male undergraduate subjects were studied over a period of eight weeks. Sleep deprivation subjects were not allowed to sleep for 30 hours prior to testing (resting heart rate, working heart rates and work time on a maximal treadmill test). Results showed that both food and sleep deprivation caused significant decrements in performance on the total body response test. Bond et al. (1986) used nine male subjects (age 18-26) to study the effects of 42 hours of sleep deprivation on performance during sub-maximal and maximal exercise, using heart rate, ventilation, VO_{2max} , carbon dioxide production, rating of perceived exertion (RPE), and worktime to exhaustion as parameters. Heart rate was significantly reduced after sleep loss during rest, exercise and recovery conditions. Exercise at workloads requiring 50% and 75% of VO_{2max} resulted in significantly greater RPE.

These findings were confirmed by Scott and McNaughton (2004) when they examined the effect of 30 hours of sleep deprivation on cardiorespiratory function. The six subjects (mean age 22 years) showed a significantly lower heart rate with sleep deprivation, but no other significant effects were found with regards to their physiological capacity to perform sub-maximal exercise. The authors concluded that sleep loss should not be considered a limiting factor in performance of sustained, moderate physical exertion, demanded by continuous multi-day endurance events such as adventure racing.

Acute sleep deprivation of 30 hours had a significant deleterious effect on the total body response time of 20 male undergraduate students (Pickett & Morris, 1975). The total body

response test was used to determine a subject's speed of movement and reaction time. Gross neuromuscular functioning was negatively influenced by acute sleep deprivation.

Thirteen students (ages 19-24 years) participated in a study to assess the influence of sleep deprivation and auditory intensity on reaction time and response force. Subjects had to respond to stimuli by pressing response keys in a simple and choice reaction task. Four sessions were performed between 19:00 and 22:00; between 23:00 and 02:00; 03:00 and 06:00; and between 07:00 and 10:00. Subjects were not allowed to sleep. Sleep deprivation significantly deteriorated reaction time and response force (Włodarczyk, Jaskowski & Nowik, 2002).

Cognitive functioning and memory

Research shows that contrary to general belief, sleep is not only about resting the body. Sleep has mostly important implications for the brain (Gillis, 1996). It is believed that sleep influences brain patterns and that, during sleep, newly formed memories are being organised in the brain resulting in better recall and more accurate memory the next day (Andrews, 2005). Stickgold (2005) referred to the familiar concept of "sleeping on a problem" and says that evidence indicates that memory reprocessing during sleep is an important component of the forming and shaping of memory. Song (2006: 83) referred to the research done by Stickgold (a cognitive neuroscientist from Harvard Medical School) and Dinges (sleep expert from Pennsylvania School of Medicine) when she wrote: "...sleep helps consolidate memory, improve judgment, promote learning and concentration, speed reaction time and sharpen problem solving and accuracy."

Relationships between sleep-wake patterns and academic performance have been found. O'Brien and Mindell (2005) concluded from a study involving 388 adolescents, that higher levels of sleep problems were related to academic performance as well as significantly higher levels of risk-taking behaviour. Students with more consistent week and weekend wake times had better sleep quality and academic performance. Students who got eight hours of sleep, but shifted their sleep schedules by two hours, reported greater depressive symptoms, lowered sociability and more frequent attention and concentration difficulties (Brown, Buboltz & Soper, 2006).

Nilsson et al. (2005) studied the effect of one night's sleep deprivation on the executive functioning of 22 healthy volunteers. Executive functioning refers to "prefrontal cortex functions related to decision-making, monitoring performance, updating of information and planning and therefore relates to memory of when events occurred and how you go ahead with doing things" (Nilsson, personal communication, February 14, 2006). The test battery for executive functioning consisted of items like verbal working memory, story-telling, arithmetic calculations, object naming, and delayed recall. The sleep-deprived subjects performed significantly worse than the control group on the executive test. The sleep-deprived group was significantly more mentally fatigued and also sleepier than the control group. The researchers stated that executive functioning depends largely on the activity in the prefrontal cortex. The prefrontal cortex is affected negatively by acute sleep deprivation, and cognitive work tasks might therefore be impaired. Young adults who had their sleep restricted to 33% below their habitual sleep duration (to an average of 4.9 hours per night) for seven consecutive nights, showed significant decreases in memory and serial-addition tests performance (Dinges et al., 1997).

Forty healthy adults took part in a study comparing the effect of a period of 24-hours of sustained wakefulness and a 0.08% blood alcohol level on the speed and accuracy of psychomotor performance (Maruff, Faletti, Collie, Darby, & McStephen, 2005). The researchers concluded that the fatigue-related cognitive impairment was greater than that detected for 0.08% blood alcohol levels. Scott, McNaughton and Polman (2006) reported that subjects (n=6) who were deprived of sleep for 30 hours and performed five hours of intermittent moderate aerobic exercise during that period, were more vulnerable to impairment in simple and two-choice reaction times, implicating a reduced capacity to respond quickly.

Emotional well-being

Emotional well-being has an effect on every aspect of life. Haack and Mullington (2005) wrote that it has been shown that being optimistic, sociable, and happy can protect individuals against stroke and cardiovascular disease, accelerate wound healing, increase resistance to infectious illnesses, is associated with lower levels of bodily pain, and higher pain tolerance. The researchers studied the effect of sleep restriction on the emotional and physical well-being of 40 healthy subjects aged 21-40 years (average 26 years), over a period of 16 days. After comprehensive screening, subjects were included if they had for

instance, no current or past history of psychiatric, neurological, immune, cardiovascular, or sleep disorders, and had an average sleep time between seven and nine hours per night. Subjects were randomly assigned to an eight-hour sleep opportunity per night or a four-hour sleep opportunity per night. Mood (*Profile of Mood States*) and pain-related symptoms (*Symptom Check List*) were assessed by means of computerised visual analogue scales directly after awakening, and every two hours during the waking periods. Optimism-sociability decreased significantly over the period of sleep restriction, with the lowest values at awakening and at the end of the day. Bodily discomfort (ratings of generalised body pain, stomach pain, backache, headache, joint pain and muscular pain) increased. The authors stated that, because optimism and positive mood states are associated with better mental and physical health, it might be that chronic insufficient sleep could be involved in lowering psychosocial functioning and positive outlook. Insufficient sleep might also contribute to a high prevalence of localised and generalised pain.

Brassington (2002) referred to numerous studies that have been done on the effect of poor sleep on emotional well-being and concluded that mood is strongly affected by sleep deprivation, and poor sleep is associated with depressed mood and reduced motivation. A reduced ability to deal with emotions is of the first symptoms associated with sleep deprivation. Sleep-deprived subjects consistently show increased levels of depression, stress, anxiety, worry, frustration, irritability, and difficulty coping with new environmental stressors. Youngstedt (2005) also stated that disturbed sleep is a risk factor for the development of depression. It seems as if REM-sleep specifically is necessary for hypothalamic functioning, because these are hypothalamic-related symptoms (Lee, 1997). With even minimal sleep loss, perceived exertion is increased and the threshold for containing anger is lowered. Lack of sufficient sleep adds to the emotional challenges inherent in competition (Walters, 2002).

Scott et al. (2006) studied the effect of sleep deprivation and exercise on the participants' mood (measured by the *POMS*), and also whether mood was a predictor of cognitive and motor performance. Six subjects were deprived of sleep for thirty hours and performed five hours of intermittent moderate aerobic exercise during the period of sleep deprivation, as well as sleep deprivation without any exercise. The researchers found that sleep deprivation was associated with significantly greater disturbances to vigour, fatigue and depression. Compared to those subjects who have been deprived of sleep alone, individuals that performed the intermittent exercise were more vulnerable to negative mood disturbances. There were also significant correlations between the performance of motor tasks and

negative mood disturbances, therefore indicating that subjective measures of vigour and fatigue could be predictors of changes in performances with sleep deprivation.

The potential health impact of insomnia has received increasing attention, and Taylor, Lichstein and Durrence (2003) described insomnia as a serious health-risk factor. The authors did an extensive review of literature and concluded that insomnia is a strong risk factor for depression, anxiety disorders, the development of alcohol and substance abuse problems, and suicide. Sixteen healthy young adults had their sleep restricted to 33% below their habitual sleep duration to 4.9 hours per night for seven consecutive nights. Subjects were assessed three times each day for subjective sleepiness and mood (*POMS*). Sleep restriction resulted in significant effects on fatigue, confusion, tension, as well as total mood disturbance (Dinges et al., 1997).

The sleep-wake patterns of college students, with the effects on their lives, have received considerable attention. Jean-Louis, Von Gizycki, Zizi and Nunes (1998) investigated the relationship between mood states, sleepiness and falling asleep, among college students. The researchers mentioned the reduction in total sleep time, delayed bedtime and increased nap episodes in this population. Sleep deprivation or fragmented sleep can lead to a disturbance in mood states in healthy persons, with an increase in negative mood states, tension, confusion and depression. A sample of 294 students participated in the study. General mood states were assessed with the use of the *POMS*. Students who fell asleep in classes experienced greater negative mood states than those who did not. The researchers mentioned that falling asleep in class could be used as an index characterising students who are likely to manifest maladaptive behaviour or experience psychological difficulty. Students who fell asleep also reported greater use of alcohol and smoked more than those who did not fall asleep.

The effects of sleep-wake patterns on psychological distress among university students were also studied by Asaoka, Fukuda and Yamazaki (2004). The data of 196 students were used in the study. Second- and third-year students who reported earlier bedtimes were in a healthier psychological state — which strengthens the notion that earlier onset of sleep is associated with a better mood. Blagrove (1996) found that individuals who had not slept for 21 hours, scored lower on the *POMS* with regard to the vigour and confidence scales than the control group. Sleep-deprived individuals had a reduced cognitive ability and motivation to discriminate and detect discrepancies between original and misleading information.

Hobson (1995: 4) wrote: "Taken to an extreme in 'brainwashing', sleep deprivation can cause heroically patriotic citizens to denounce their own nations and ideals, to sign patently false declarations, and to join political movements that have been lifelong anathemas to them."

In contrast to studies on the effect of sleep deprivation, Kamdar, Kaplan, Kezirian and Dement (2004) investigated the impact of extended sleep on daytime alertness, vigilance and mood. Fifteen healthy college students (mean age 20.1 years) were allowed to sleep as much as possible during a sleep extension period of seven days, without compromising their ongoing work and social commitments. The authors referred to previous studies showing the progressive deterioration in daytime alertness, performance and mood due to the cumulative effect of sleep reduction over consecutive nights. It has been shown that mood and vigilance levels can be improved by even small increases in total sleep. Subjects participating in the study of Kamdar et al. (2004) were encouraged to maintain their habitual sleep schedule, but within the limits of no less than six hours and no more than nine hours. Subjects had three daytime *Multiple sleep latency tests (MSLT)* (five trials each at two-hour intervals), a reaction-time test sensitive to daytime fatigue 10 minutes after the *MSLT*, and the *POMS* on the *MSLT*-days. The sleep extension significantly improved *MSLT*-scores, reaction-time measures, and mood scores.

A regular sleep-wake rhythm might also be important in optimal efficiency during wakefulness, and not only obtaining a normal amount of sleep. Ferrara and De Gennaro (2001) referred to studies where delayed bedtimes produced changes in REM-sleep and mood, resembling those of depression. Dale (2004: 37) stated that a greater amount of deep sleep occurs earlier in the night, and there is truth in the expression: "an hour before midnight is worth two after."

Tanaka and Shirakawa (2004) reported from their studies involving 467 elderly subjects (age 65+ years) that people who got better sleep had higher levels of morale and satisfaction with regard to their own roles in society, higher levels of activity in their daily life, fewer illnesses, strong subjective feelings of health, and confidence in their own life as well as being confident that they have the trust of others.

The amount of sleep needed

Ferrara and De Gennaro (2001: 155) wrote: "For a lot of people, the body's need to sleep is treated as a waste of time. In our 24-hour society, we often steal night time hours for daytime activities, depriving ourselves of precious sleep." The question can be asked: Is there a fixed amount of sleep that needs to be obtained?

Adolescence is the phase of life where major changes in body form and size occur. These changes are the body's response to the sex and growth hormones that are released in pulses during slow-wave sleep. The strain of social, sexual and intellectual challenges may affect adolescent sleep patterns. Adolescents tend to stay up later at night and sleep later in the morning, with sleep bouts on weekends (Hobson, 1995). Carskadon (2005) stated that young people live in a nearly constant state of chronic insufficient sleep. He pointed out that more and more adolescents have "arousing" activities available at all hours in their bedrooms, such as television, play stations, internet connections and cellular phones. He also referred to part-time employment, consumption of alcohol and caffeine, and often lengthy athletic practices. Carskadon reported that students with short nights and irregular sleep patterns perform poorly academically and in other aspects of their lives, including a tendency for a depressed mood. Most teenagers might be getting less sleep than required on most school nights and compensate by oversleeping on weekend days.

Young adults (age 18 to 30 years) enter a life-long period of declining sleep length and depth, although they would not notice it at this stage. Courtship, marriage and family life may lead to the emergence of sleep problems during this stage of life. The average sleep time for young adults, according to Zarcone (1989), is seven hours. During the middle part of the life span (age 30 to 45 years), most people will notice a shallowing and shortening of sleep, with an increase in the number of awakenings during the night (Park, Matsumoto, Seo, Kang & Nagashima, 2002; Park, Matsumoto, Seo, Shinkoda & Park, 1998). There will be a greater sense of fatigue and decreased sleep length and depth. There is also a marked and normal drop in the amount of deep, stage-four sleep (Hobson, 1995; Nicol, 1988). The quantity of sleep might vary considerably between individuals. For example, there are indications that too much sleep can lead to irritability, depression, headaches and sleepiness during the day (Nicol, 1988).

The average length of sleep for people in the developed world has reduced quite dramatically over the years. According to Ferrara and De Gennaro (2001), the number of nocturnal hours of sleep for healthy adults has fallen from 8-8.9 hours per night in 1959 to 7-7.9 hours per night in 1980. About 27% had only 6-6.9 hours of sleep per night. Axt and Axt-Gadermann (2005) also mentioned the decline in sleep from 9 hours in 1910, to 7 hours 40 minutes in 2005. Hicks and Pellegrini (1991) analysed data from published studies over a 20-year period and noted that the average hours of sleep among college students dropped by one hour from 7.75 hours per night in 1969 to 6.75 hours in 1989. Hicks, Lucero-Gorman, Bautista and Hicks (1999) assessed the average self-reported sleep duration among four ethnic groups of university students (n=963). African Americans slept 6.94 hours per night; Asians slept 6.86 hours per night; Hispanics for 7.10 hours per night, and Euro-Americans for 7.18 hours per night. The researchers also observed that none of the groups had a good knowledge of sleep hygiene.

The 2005 the *Sleep in America Poll* (National Sleep Foundation, 2005) showed that individuals older than 18 years tend to sleep an average of 6 hours 40 minutes during the week and 7 hours 15 minutes over weekends. Fifty percent of the respondents reported that they felt tired and not up to par during wake time. Seventy-five percent reported sleep problems, with 27% of respondents using alcohol, over-the-counter sleep aids or prescription medicine to help with their sleeping problems. A desire for more sleep is often expressed by subjects participating in sleep research and studies often reveal evidence of recovery oversleeping during weekends (Ferrara & De Gennaro, 2001).

Kamdar et al. (2004) stated that every human being needs a specific amount of sleep in order to meet the daily homeostatic sleep requirement. Ferrara and De Gennaro (2001) reported that a mean of 7-8 hours of daily sleep should be enough for most people. When subjects were placed in isolation without exposure to clocks and natural light, they slept 7-8 hours out of every 24 hours (Loehr & Schwartz, 2005). Reisser (2006: 1) wrote: "Sleep research has consistently shown that most adults actually *do* need the proverbial eight hours of sleep a night in order to perform at their best and avoid general tiredness, daytime drowsiness, and even fatigue-related illnesses".

Studies have compared the amount of sleep of student athletes with a general student population and found that athletes sleep less than non-athletes and they have increased difficulty sleeping prior to competition. Bompa (1999) believes that athletes require 9 to 10

hours of sleep, 80-90% of it during the night. The balance may be completed by naps during the day. Calder (2003) supported this belief in saying that adolescents experiencing heavy training and a growth spurt might need up to 10 hours per night. Bonnet and Arand (1995) suggested that the best way to determine the individual's sleep need is to go to bed when tired and sleepy and get up in the morning when feeling refreshed, without any alarm.

Factors affecting sleep patterns

Various factors could make it difficult for athletes to sleep as well as they would like. They might not be totally sleep deprived, but may feel the consequences of "fragmented sleep" where the quality of their sleep is adversely affected by various factors (Sivas, 1994: 112).

Arousal in the sleep setting

Many factors can lead to arousal in the sleep setting. Some of the factors relate to psychological stressors, for example, deadlines, examinations, job crisis or marital conflict. Athletes are often under pressure to keep up with the demands of work and/or study, family commitments and training, social life, which can all affect the quantity and quality of sleep (Bompa, 1999).

Some athletes are "worriers" and sleep poorly because of future concerns in their minds. Carney and Waters (2006) mentioned worry as a major contributor to pre-sleep cognitive arousal, leading to interfered sleep. They studied the effect of cognitive intervention on the treatment of the problem of pre-sleep cognitive arousal. Thirty-three college students were divided into two groups. Participants in the "constructive worry group" recorded possible solutions to worries, while the "worry group" recorded worries and completed worry questionnaires for five nights. The constructive worry group (recording solutions) had decreased pre-sleep cognitive arousal relative to the worry group and to baseline scores.

Others factors might not be related to any particular psychological stressor, but might still be major sources of excitation; for example, someone working on a task related to his/her occupation right up to the moment he or she turns off the lights prior to sleep. Another person could continue a review of the previous day's events and try to decide on action plans for the next day while he or she is half awake (Zarcone, 1989).

Higuchi, Motohashi, Yang and Maeda (2005) studied the effects of playing computer games at night on sleep patterns and sleep quality. Male adults (mean age 24.7 years) played exciting computer games with a bright or dark display between 23:00 and 01:45, went to bed at 02:00 and slept until 08:00. Heart rate was significantly higher after playing games than after the control conditions, and was also significantly higher after using the bright display than after the dark display. Sleep latency was significantly longer after playing games and REM-sleep was significantly shorter after playing the games. The researchers concluded that playing the exciting computer game affected sleep quality.

De Valck, Cluydts and Pirrera (2004) studied the effect of cognitive arousal on sleep latency, somatic and cortical arousal in 14 subjects (mean age 27 years). The arousal condition consisted of the visit of a television camera crew who supposedly was producing a documentary film. Subjects were asked if they were willing to participate. Experimentally-induced cognitive arousal resulted in statistically significant increases in sleep latency and induced an acute insomnia-like state in the normal sleepers. The anticipation of a stressful situation as well as active involvement in the situation lead to the arousal.

Environment

Adults are sensitive to their sleep environment and might find it difficult to fall asleep in a strange setting. The effect of a change in environment on sleep is recognized by researchers when they almost always discard the first night when research subjects are studied in a sleep laboratory. Delayed sleep onset and frequent awakenings occur (Lee, 1997). Spruyt, O'Brien, Cluydts, Verleye and Ferri (2005) attempted to describe the prevalence and predictors of sleep problems in school-age normal children. Data from 3045 children were used and the researchers concluded that sleep-onset latency and a noisy, not well-darkened room are predictive towards sleep problems. They also state that parents and children should be informed of the importance of good sleep-wake hygiene. Bedtime rituals are recommended, such as drinking warm milk, quiet reading in bed, prayer, and an age-old method—counting sheep (Lee, 1997).

Noise affects sleep by causing awakening or making the sleep shallower. Kawada and Suzuki (1995) studied the effect of passing truck noise on sleep in eight male students (19 to 20 years old) for 12 nights. The researchers observed shallowing or changes in REM-sleep with the passing truck noise with no habituation to the noise exposure. They also referred to their

previous studies on the effects of noise where they found a decrease in total sleep time and REM-sleep. Eighteen subjects (average age 22.8 years) participated in the study by Öhrström and Skånberg (2004) to assess the effect of road traffic and ventilation noise on sleep. Subjects were exposed to noise from traffic, noise from ventilators, and a combination, when they slept six consecutive nights in a sleep laboratory and six consecutive nights at their homes. Noise exposure started at 22:30 and continued until 07:30. The traffic noise was more disturbing for sleep quality than the ventilation noise, giving support to the notion that intermittent and fluctuating noise such as road traffic noise disturbs sleep more than an even noise. The researchers recommended that the individual should rather select a bedroom next to the courtyard (even if there is ventilation equipment) rather than one that is located next to the road.

Axt and Axt-Gadernann (2005) advocated that the bedroom should be the quietest room in the house. The bed should be comfortable with a high-quality mattress (Nicol, 1988). Temperature in the room higher than 24°C and lower than 10°C could decrease the quality of sleep (Axt & Axt-Gadernann, 2005; Nicol, 1988). The dominating colour in the room might also affect the individual's mood. Niehaus (2005) referred to the records from ancient Egypt and the temple of Heliopolis where patients were treated in rooms designed to break up the rays of the sun into different colours—specific ailments dictated the colour of the room the patient needed to lie in. Niehaus (2006) suggested that the main colour in the room should not be yellow, because of its stimulating effect.

Fitness, and exercise

There has been a belief that fitness and exercise promote sleep. Ancoli-Israel (2001) stated that this notion can even be traced back to Biblical times. Youngstedt (2005) referred to a survey in Finland in which 1190 respondents indicated exercise as their most important behaviour to promote sleep. Shapiro et al. (1984) studied the effect of improved fitness on sleep onset latency, wake time during sleep and sleep efficiency in army recruits over a period of an 18-week training programme. It was found that slow-wave sleep as a percentage of total sleep time increased significantly between the commencement of the measurements and the measurements at 9 and 18 weeks. With increases in fitness, sleep onset latency and wake time during sleep decreased.

Higher levels of habitual physical activity are associated with greater sleep quality. Exercise increases the percentage of slow-wave sleep and total nighttime sleep, while sleep onset latency and awake time during the night decrease, therefore leading to a deeper, more restful sleep (Brassington, 2002; Walters, 2002). Shapiro (1981) also mentioned the variety of changes of sleep patterns that may occur following exercise, such as an increase in sleep duration, decrease in sleep onset latency, decrease in movement during sleep, and an increase in slow-wave sleep.

The effect of daytime physical exercise on the quality of objective and subjective sleep was assessed by Sasazawa, Kawada and Kiryu (1997). Five male students (aged 10 to 20 years) who were doing karate four days a week were observed. Subjects trained for three hours, from 17:00 - 20:00 on exercise days, went to bed at 23:00, and were awakened at 07:00. Sleep efficiency increased after exercise days as compared with non-exercise days, caused by decreasing sleep onset latency. Exercise days also lead to a lower percentage of waking from sleep during the night.

Relatively more fit individuals might have better sleep quality in general, but what is the quality of sleep following an acute bout of exercise? Youngstedt, Kripke and Elliot (1999) examined the influence of prolonged vigorous late-night exercise on sleep among sixteen highly fit cyclists. They cycled for three hours at 65 - 75% of their heart rate reserve, with exposure to bright light. Bedtime followed 30 minutes after the exercise. Sleep was assessed through sleep onset latency, wakefulness after sleep onset, total sleep time, as well as subjective assessments in the morning. No significant differences in objective or subjective sleep variables were found between treatments.

The influence of low- and moderate-intensity exercise, performed up to 30 minutes before normal bedtime, on sleep and core body temperature was investigated by O'Connor, Breus and Youngstedt (1998). The researchers suggested that night-time is a practical time to exercise for many individuals. They stated that it might be possible that late-night exercise could be positively associated with neuromuscular and self-reported relaxation after the training. Sleep initiation could also be more likely to occur when core body temperature is rapidly declining after it was elevated through exercise. Eight healthy, young (average age 20.8 years), moderately active males participated in the study. Ninety minutes before their self-reported bedtimes, in randomised order and on separate days, the subjects completed one hour of either: seated cycling exercise at 60% of VO_2 -peak (moderate intensity); or

seated cycling exercise with zero pedal resistance (low intensity); or seated reading in a cushioned chair. Late-night cycling shortly before bedtime did not significantly influence sleep onset latency, the number of awakenings, total sleep time or sleep efficiency in young, healthy, moderately active males.

Driver, Rogers, Mitchell, Borrow, Allen, Luus and Shapiro (1994) studied the effect of exercise duration on sleep following exercise. Eight fit male athletes (mean age 30 years), training for an ultra-triathlon, participated in the study. Each athlete's sleep was recorded on four separate occasions: following a day when no strenuous exercise was performed, after a 15-kilometre run day, after a 42.2-kilometre run day, and after a day of canoeing (21 kilometres), cycling (96 kilometres) and running (42 kilometres). Despite the differences in exercise intensity between the 15-kilometre run and the 42-kilometre run, the sleep of these fit athletes was not affected and did not differ from the no-exercise condition. Participation in the ultra-triathlon reduced REM-sleep to a third of the no-exercise level. There was a 40% increase in wakefulness and stage-one sleep in the first six hours of recordings. The researchers concluded that mild to moderate exercise did not affect the sleep of fit male athletes, while the ultra-triathlon led to a decrease in REM-sleep.

Youngstedt (2005) concluded that there is little support for the common assumption that late-night exercise disrupts sleep. Exercise completed within four hours of sleep onset increased total sleep time, decreased wake time after sleep onset, and slightly delayed sleep onset latency. Light-intensity exercise of less than 1 hour has negligible effects on sleep, while high-intensity exercise is associated with increases in amount of wake time after sleep onset. Athletes often have to train twice daily, and the evening might be a practical time to exercise, but with a consideration of the intensity and duration of the exercise session.

In contrast to the effect of exercise on sleep, Hague, Gilbert, Burgess, Ferguson and Dawson (2003) were interested in the effect of a sedentary day on sleep in trained athletes. Sixteen individuals (mean age 21.7 years) performing high levels of aerobic type exercise on a daily basis (average 1.87 hours per day), participated in the study. The sedentary condition consisted of a 36-hour supervised laboratory period. Slow-wave sleep decreased and REM-sleep increased significantly. Core temperature was also significantly higher in the sedentary condition. The authors concluded that, because a decline in core temperature acts as a physiological trigger for sleep, the temperature differences prior to, and early in, sleep could be underlying the sleep changes. Athletes and their trainers should therefore plan effective

tapering periods that will not adversely affect pre-competition sleep. Manipulating skin and core temperature could be an option to promote sleep (Cole, 2005).

Caffeine, nicotine, and alcohol

Caffeine is considered the most widely used central nervous system stimulant with coffee being the most common source (Van Dongen et al., 2001). Caffeine has a deleterious effect on sleep, producing increased wakings and decreases in total sleep time during nocturnal sleep. Sensitivity to the effects of caffeine can last as long as eight to fourteen hours. An average cup of coffee contains 100 mg of caffeine, whereas a strongly brewed cup of coffee contains 200 mg. Tea and cola drinks contain between 50 mg and 75 mg, depending on the type. Any person consuming more than 500 mg caffeine per day should be encouraged to discontinue caffeine to see what the effect is on nocturnal sleep and daytime anxiety associated with caffeine ingestion (Zarcone, 1989).

Van Dongen et al. (2001: 813) studied the effects of caffeine on sleep inertia, which they describe as "grogginess, cognitive performance impairment, and a tendency to go to sleep immediately after awakening." Twenty-eight healthy male subjects (mean age 29 years) participated in the study. Subjects underwent 88 hours of wakefulness, with a total of seven two-hour naps every twelve hours. Subjects received either caffeine (a quarter cup of coffee or 0.3 mg/kg caffeine) or a placebo (n=13) every hour, except during naps. Sleep inertia after awakening from nap sleep was not evident in the relatively low-dosed caffeine condition. Caffeine reached its peak blood plasma concentration within half an hour after intake, because caffeine passes the blood-brain barrier almost immediately. According to the researchers, this might be the reason why many people habitually drink caffeine-containing beverages, such as coffee, after awakening. The researchers found evidence that NREM-sleep onset was delayed, but not consistently suppressed by the caffeine intake. No difference between the two groups was detected for psychomotor vigilance, which indicated that the caffeine's effect was specific to sleep inertia.

Studies indicate that nicotine has much the same effects as caffeine on nocturnal sleep. Moderate or heavy smokers can titrate the effects of ethanol and/or caffeine with nicotine and this combination of caffeine and nicotine arousal and ethanol sedation can be disturbing to nocturnal sleep (Zarcone, 1989). Riedel, Durrence, Lichstein, Taylor and Bush (2004) studied the relationship between smoking and sleep in a sample of 769 individuals. Light

smokers (fewer than 15 cigarettes per day) were more likely to report chronic insomnia than non-smokers. Light smoking did not differ significantly from heavier smoking in self-reported chronic insomnia. The authors suggest that highly variable smoking patterns may be more detrimental to sleep than heavier, but more consistent smoking patterns.

The acute ingestion of ethyl alcohol, even at relatively low doses in normal subjects, leads to changes in sleep. Hobson (1995: 181) stated that alcohol has profound short- and long-term effects on the quality and quantity of sleep. Ethanol is commonly self-prescribed to initiate sleep and presumably helps a person "sleep better". Blood alcohol levels below 10 mg/dl may be associated with increased total sleep time and reduced awake activity. More than 10 mg/dl will cause a decrease in REM sleep, particularly during the early part of the night. Between three and eight drinks will lead to disturbed sleep. Awakenings from intense dreaming activity with sweating might occur. The awakenings are part of the sympathetic arousal that occurs along with catecholamine secretion following even moderate doses of ethanol near bedtime. Ethanol is metabolised at approximately the rate of one drink per hour. The sympathetic arousal can persist for as long as two to three hours after the blood concentration returns to zero. Chronic ingestion of alcohol will cause a loss of slow-wave sleep and disruption of sleep patterns.

Sierra, Jimenez-Navarro and Martin-Ortiz (2002) investigated the sleep quality of Spanish university students, as well as the effects of alcohol, caffeine and tobacco consumption on sleep quality. They concluded that the subjects who drank between two and four alcoholic drinks daily, or between two and four cups of coffee, or who daily smoked between 20 and 30 cigarettes, had a poor sleep quality, greater sleep latency, a greater number of sleep disturbances, and a greater daytime dysfunction.

Drug ingestion

Carskadon and Dement (1989) stated that many common drugs, including those that are typically prescribed for sleep disorders, will affect the distribution of sleep stages. Some commercially available hypnotics tend to inhibit, rather than increase, slow-wave sleep, while others will suppress REM-sleep (Carskadon & Dement, 1989; Hobson, 1995; Van Cauter et al., 1997). Nicol (1988) referred to the fact that, although sleeping pills actually interfere with the sleep stages and quality of sleep, a relative large percentage of the adult population uses these drugs to enhance sleep. She advocated addressing the reason for the insomnia

and not the symptoms. Axford and O'Callaghan (2004) also warned against the use of night-time sedatives, because of the disruptive effect it might have on sleep patterns. Acute ingestion of marijuana produces a reduction of REM-sleep, while chronic ingestion produces a long-term suppression of slow-wave sleep (Nicol, 1988; Nicholson, Bradley & Pascoe, 1989; Zarcone, 1989).

Sexual activity

Sztajzel, Periat, Marti, Krall and Rutishauser (2000) referred to the very limited scientific information available on the psychological and performance effects of sexual activity in high-level athletes, due to the difficulty in monitoring sexual behaviour among humans. Persistent opinions, based on anecdotal evidence, surround the topic of sexual activity and athletic performance. Mohammad Ali reportedly abstained from sexual activity for six weeks before a fight. It was suggested that abstinence could help athletes concentrate better. Some coaches would claim that abstinence before important competitions could lead to frustration, therefore increasing aggression, which is rooted in the frustration-aggression hypothesis (Anshel, 1981; Lovgren, 2006; Thornton, 1990). Fischer (1997) found that football (n=83) and baseball (n=73) players from three universities abstained from sex before a game because they believed that abstinence helped them by conserving strength and increasing energy.

Studies on the effect of sexual activity on athletic performance mostly showed that sexual activity did not have too much of a detrimental influence on the athlete's performance. Thornton (1990) wrote that intercourse is a relatively undemanding physical activity, and research has shown that the energy required for sexual activity is well within the tolerance levels of most myocardial patients. Sztajzel et al. (2000) showed that sexual intercourse had no effect on the maximal workload achieved and mental concentration of the athletes (n=15), although sexual intercourse two hours before competition could affect the recovery capacity of the athlete.

Anshel (1981) wrote that intercourse in itself did not decrease performance, but the accompanying late-night socialising, sleep loss, and reduced level of concentration on the sports task might have a detrimental effect. Refinetti (2005) found that most sexual encounters in a university student population (n=38) occurred later at night, around

bedtime, between 23:00 and 01:00. Coaches therefore may be favouring abstinence because they want to make sure that athletes get enough sleep (Lovgren, 2006).

The effect of sexual activity on sleep in humans has been poorly studied. Relaxation, quiescence of the body, reduced tension, a hypnotic effect, sleepiness and sleep are often stated as after-effects of an orgasm (Anshel, 1981; Brissette, Montplaisir, Godbout & Lavoisier, 1985; Thornton, 1990). Brissette et al. (1985) measured the effects of masturbation on sleep latency and sleep structure in five men and five women (mean age 25.1 years). Results showed that masturbation with or without an orgasm at bedtime had no effect on nocturnal sleep. The researchers did acknowledge the fact that coitus shows physiological and psychological differences from orgasm obtained by masturbation.

Vazquez-Palacios, Bonilla-Jaime, Retana-Marquez and Velazquez-Moctezuma (2002) stated that, although it is often believed that sexual activity could increase the need to sleep, the relationship between copulatory activity and sleep had been poorly studied. The researchers studied the sleep-wake patterns of male rats immediately after different conditions of copulatory activity. The results showed that the rats slept significantly more following sexual activity. Increased percentages of time were spent in slow-wave sleep and the latency to the first slow-wave sleep episode was shorter than the control or baseline conditions. Male rats that were not able to copulate in spite of the presence of a female, showed stress or anxiety, which altered the sleep stages. Sexual activity can be arousing or sedating, depending on the individual. If sexual activity is arousing, it should occur at a different time of day than the hour preceding the major sleep period (Zarcone, 1989).

Researchers reported that an athlete's belief in his or her training regimen, whether it is physiologically and psychologically sound or not, may have a placebo effect and improve the athlete's performance. Likewise, some athletes might therefore believe in abstinence and the notion of "heroic purity", while others might find intercourse to be relaxing and "a natural anti-anxiety drug" (Thornton, 1990: 148, 154).

Travel

Long journeys usually cause tiredness in athletes. This might be due to cramped conditions, dehydration as a result of low humidity on board a plane, air turbulence, reduced barometric pressure, vibration, noise, flight anxiety, and whole-body stiffness due to relative inactivity

while travelling. The athlete might also feel stressed due to the generally high level of activity surrounding any long trip, transport arrangements at departure and arrival and control checks when crossing national borders. Mood states may also be negatively affected by the abovementioned factors. These symptoms of travel fatigue can be reversed relatively quickly once the athlete reaches his or her destination and usually do not persist beyond the first 24 hours after landing (Graeber, 1994; Reilley, Waterhouse & Edwards, 2005).

A bigger problem becomes evident when the athlete has to cross multiple time zones rather than covering the same distance in a northerly or southerly direction. Some of the symptoms that the athlete might experience include an inability to sleep at the local time, bowel irregularities, increased incidence of headaches, irritability and moodiness, fatigue, reduced cognitive skills, and poor psychomotor co-ordination (Brooks et al., 2005). The athlete's circadian rhythms are disturbed by the trans-meridian travel, when the time in the new environment no longer matches the body's internal circadian rhythm. This psychophysiological impairment of well-being and performance is known as circadian dysrhythmia or jet lag (Dale, 2004; Graeber, 1994; Reilley, Waterhouse & Edwards, 2005).

The severity of jet lag is directly related to the direction of flight (worse after flying eastwards compared to westwards), and the number of time zones crossed. Graeber (1994) mentioned that travellers in general adjust at a rate of about 1 hour 30 minutes a day after westward flights and at 1 hour a day after eastward flights. Reilley, Waterhouse & Edwards (2005) pointed out that the rate of adjustment was traditionally seen as one day for each time zone crossed, but great inter-individual variations in this rate became evident.

Apart from the effects of jet lag on athletic performance, Reilly et al. (2005) also mentioned some health concerns associated with long journeys. Deep-vein thrombosis might be a problem, caused by remaining in a restricted position for a long period of time. Preventative measures could include becoming periodically active, by walking in the plane, doing isometric exercises, and performing gentle stretches. Compression stockings can also prevent blood from pooling in the legs. An increased risk of infection has been associated with long-haul flights due to the quality of the circulated air. Changes in immune function accompany sleep disruption. The increased risk of infection is caused by reduced defence mechanisms and not so much just by increased exposure. Loss of appetite and constipation are also characteristics of jet lag. The researchers emphasised that the managers and technical staff accompanying athletes must remember that performance in their occupational tasks will also

be affected by jet lag. People at risk for cardiovascular disorders must be cautious in the period of resynchronization, because it seems that by the time body temperature has readjusted to the new time zone, blood pressure responses have not yet returned to normal.

Coping with jet lag has been dominated by problems with the sleep-wake cycle, with the focus on how to improve nocturnal sleep, how to eliminate sleep disturbances, and how to promote adjustments of the body clock. Reilly et al. (2005) provided some ideas on how to cope with jet lag from the perspective of a behavioural approach. Management staff should plan the itineraries for athletes to arrive in sufficient time for the body clock to adjust before competitions. Steenland and Deddens (1997) studied the effect of travel and rest on the performance of professional basketball players. Data from games over eight seasons (1987 – 1995) from the National Basketball Association (NBA) were analysed, which comprised 8 495 observations. Data were analysed for teams playing after three situations: a team could not have travelled, or travelled within a time zone, or travelled across one or two zones. The researchers concluded that performance with only one day between games was negatively affected. Performance for both home and visiting teams improved with more than one day between games, peaking with three days between games, and tailing off with four days or more between games.

Waterhouse et al. (2002) also emphasised the importance of optimum flight arrangements to try and minimise the effects of jet lag. A mixture of athletes, their coaches and academics attending a conference (n=85) was studied during two flights from the United Kingdom to Australia, and for six days after arrival. The researchers recommended that management staff should try to arrange for flight times to be such that the amount of time spent before being able to take a full night's sleep at the new night time is made as short as possible. Brooks et al. (2005) advised athletes to make eastbound flights during daylight hours with an earlier start for the longer flights. Westbound flights should be late in the day to arrive as close to the athlete's sleep time as possible.

In-flight activity can get some attention with the planning of activities focusing on the local time at the destination. Graeber (1994) described research on jet lag countermeasures with regards to eastward flights, involving soldiers from America being deployed in Europe. The military aircraft's light-dark schedule and meal schedules were changed to destination time. Watches were reset as a group and rest-activity cycles were controlled in accordance with destination time.

The athlete's dietary programme during and after flight has received some attention in an attempt to apply dietary countermeasures to jet lag. Reilley, Waterhouse and Edwards (2005) advised athletes to focus on fluid ingestion during flight over and above their normal intake. It is often advised that the macronutrient content of the diet can be manipulated to promote circadian resynchronization. A breakfast high in protein is suggested to raise plasma tyrosine levels, which could stimulate the synthesis and release of dopamine and norepinephrine. This activates the body's arousal system, making the individual feel alert. Caffeine, as a central nervous stimulant, can also increase alertness. An evening meal high in carbohydrate can raise plasma tryptophan levels, promoting the synthesis and release of serotonin, a precursor of melatonin. The individual would then feel drowsy and inclined to sleep (Reilley, Waterhouse & Edwards, 2005; Winget et al., 1985), although Waterhouse (2007) stated that the effect of such a dietary intervention seems to be small. Appropriate times of exposure to, and avoidance of bright light might be better alternatives. Axt and Axt-Gademann (2005) advised individuals to eat food like bananas, pasta, eggs, nuts, lamb, poultry, soya beans and pineapple in the afternoon and evening, because it will stimulate the production of melatonin. Graeber (1994) also suggested that tryptophan, obtained in the diet or capsule form, might be beneficial for sleep after transmeridian flights.

A structured sleep schedule can improve nighttime sleep after eastward flights. Athletes often go to bed after arriving on an overnight flight. They will then fall asleep, but for a relatively short time, because they tend to awake at a time corresponding to late morning at their own home. Graeber (1994) advised athletes to limit sleep to no more than two hours after arrival to time the wakeful period to end around the normal local time for sleep.

In an attempt to cope with jet lag, travellers, athletes and managers might want to follow a pharmacological approach to ease the effects. Amphetamines are often used to increase alertness after waking and sustain mental performance, while hypnotics induce drowsiness and promote sleep. These drugs might be unacceptable for travelling athletes because they might be on the list of banned drugs. In a position statement on the use of sleeping pills and melatonin, the British Olympic Association concluded that the use of sleeping pills was unnecessary for its athletes and support staff, and counselled against use of these substances (Reilly, Maughan & Budgett, 1998).

Melatonin is a hormone produced by the pineal gland in the brain in response to darkness ("the hormone of darkness"), and suppressed by exposure to bright light (Stores, 2001: 29).

Melatonin is made available when tryptophan is converted to serotonin and then enzymatically converted to melatonin. Serum levels are low during the day, with peak levels occurring from 02:00 to 04:00 (Lee, 2006). Melatonin has hypnotic properties, and is marketed commercially for the relief of jet lag and insomnia. Doses of melatonin varies from 5 mg daily for the relief of jet lag to 75 mg daily for chronic insomnia (Lee, 2006). Although Greaber (1994) stated that results from different studies on the use of melatonin are inconclusive to recommend it as a regular treatment, Lee (2006) wrote that melatonin generally is regarded as safe for short-term use. Stores (2001) also stated that, although melatonin has achieved popularity as an agent to promote sleep, its use remains contentious. Common adverse effects include fatigue, dizziness, headaches, irritability, and sleepiness. The hypnotic response caused by melatonin intake is linked to immediate reductions in short-term mental and physical performance. Depending on the dose, these effects might still be apparent on cognitive performance three to five hours after administration, but effects on physical performance seem to be shorter.

Carskadon (2005) mentioned that natural daylight or bright artificial light, when appropriately timed, is more effective at phase resetting than melatonin. Greaber (1994) supported this viewpoint by saying that a less intrusive way of manipulating melatonin levels is to manipulate exposure to sunlight. Melatonin is produced at night and suppressed by daylight. Exposure to daylight might enhance the phase adjustment process and lessen the jet lag experience. The researcher refers to a study where it was found that more severe jet lag was experienced by a group confined to hotel room after a transatlantic flight than in a parallel group that was allowed outdoors. Postolache and Oren (2005) warned against indiscriminate exposure to light, because of the alerting properties of light. They advocate appropriately timed light exposure and light avoidance to be effective in the treatment of jet lag symptoms.

Behaviours that promote sleep

Sleep is a vital part of the regeneration process. A lack of sleep can cause a decrease in work capacity, reduced arousal and increased feelings of fatigue. This can decrease performance and reduce the effectiveness of a training programme or competitive results (Gunning, 2001). It is therefore crucial for athletes to sleep well and be optimally rested and ready to perform on a particular day at a particular hour. Athletes must be able to fall asleep, either at night or when taking a nap, as planned. Athletes might choose to use hypnotic

medication, but it can, as mentioned previously, actually interfere with the sleep stages and negatively affect sleep quality. Cole (2005) mentioned that hypnotics can also produce negative hangover effects on performance, and athletes might prefer to use nonpharmacologic methods for promoting sleep onset.

Cole (2005) described conditions that might impair sleep, namely, an upright posture, excessively hot or cold temperatures, bright light, noise, and stress. This suggests that the opposite conditions might promote sleep: lying down comfortably, appropriately warm or cool temperature, motor relaxation, sensory withdrawal, and cognitive relaxation. Walters (2002) also discussed the optimal sleeping environment, but adds that the individual must identify the amount of sleep that is needed, and that a regular sleep schedule must be kept. The individual must go to bed when tired and sleepy and sleep until he or she awakes without the use of an alarm clock. It can take up to two weeks for the athlete to establish his/her "genetic sleep need", because sleep debt is often being repaid during the first week. The amount of sleep each night is recorded and the average calculated after two weeks. Inconsistent sleep patterns disrupt the internal biological clock, and tend to increase the amount of time it takes to fall asleep. Adjustments to earlier or later sleep than the regular schedule should not exceed 30 minutes. Changing the schedule for more than two days or sleeping one hour longer on weekends disrupts the biological clock. It usually takes four to five days to adjust to a particular bedtime. The individual should get up in the morning at the same time, even if he or she experienced low quality sleep the previous night, and therefore establish consistent sleep and wake-up times (Nicol, 1988; Reisser, 2006).

Walters (2002) highlighted four factors with regards to the bedroom: it must be quiet, dark, cool, with a comfortable bed. In preparation for the 2006 Winter Olympics, deliberate efforts were made to improve the sleeping conditions of the athletes. Michaelis (2005) wrote: "If speedskater Apolo Anton Ohno is standing atop the medal podium at the 2006 Winter Olympics, he might feel compelled to credit soft lighting, muted wall colouring and a plush-top mattress." Dr Rosekind was consulted for the improvements, and said: "Most of our data show that when people don't get enough sleep their performance can be degraded literally to the level where it's as if they are drunk." Some changes he suggested included darker curtains, full-size beds, soft lighting and relaxing wall colours. The results from the 2006 Winter Olympics in Turin, Italy show that Apolo Anton Ohno has won the gold medal in the 500 m event (Winter Olympics, 2006).

Kräuchi et al. (2005) explained that the readiness in humans to fall asleep is correlated with distal vasodilation, where blood flow to the skin increases. Sleep onset might be promoted by manipulating skin temperature. Sleep latency can be shortened by taking a warm bath before bed, or warming the feet in a footbath (Cole, 2005). Alexandru et al. (2004) showed that a hot bath may be an effective and practical method of promoting sleep. Their study with nine subjects (mean age 38.8 years) revealed that a hot bath significantly increased REM-sleep, and also significantly improved the scores on the *POMS*, especially decreasing confusion, anger and hostility. Nadler et al. (2003b) reported that subjects who had low back pain and were given a warm bath had significantly increased sleepiness at bedtime, with increased slow-wave and stage four sleep. Subjects with insomnia showed significantly increased slow-wave sleep after warmer baths (40°C to 40.5°C) compared to cooler baths (37.5°C to 38.5°C).

It is advised that individuals go to bed only if they are tired. If they are still awake after 30 minutes, they should go to another room. Caffeine within six hours of bedtime should be discouraged. Hot milk or a herbal drink might aid sleep (Dale, 2004; Gorman, 2005; Nicol, 1988). The importance of avoiding bright light and caffeine prior to sleep was highlighted by Wright, Myers, Plenzler, Drake and Badia (2000) in their research among women on the acute effects of bright light and caffeine on night time melatonin and temperature levels. The authors mentioned that their previous research showed that a combination of caffeine ingestion and bright light exposure reduced night time melatonin levels and increased core temperature levels in male subjects. The results from the study on women showed that the combination of bright light and caffeine enhanced night time temperature levels to a greater extent than did either caffeine or bright light alone. Melatonin levels were reduced throughout the duration of bright light exposure for all the women, but caffeine ingestion had little effect on melatonin levels for the oral contraceptive users (n=32).

Athletes are to be encouraged to follow a bedtime ritual and develop a "winding down routine" that serves as a cue to the mind and body to get ready for sleep (Reisser, 2006: 9). Zarcone (1989) mentioned that a period of as little as ten minutes can be effective. He gives some ideas on simple techniques of stress management, for example, making a list of the psychological stressors that occurred and some plans to deal with it the next day, assuring oneself that doors are locked and that the sleep environment is safe, seeing that pets are where they belong, and reading entertaining material. Looking at a clock will heighten an arousal state, because an easily visible clock can be an arousing stimulus (Zarcone, 1989).

Most people have an awareness that a period of relaxation is needed between the concerns and psychological stressors of the day and their major or nocturnal (night) sleep. Hobson (1995) found that postural immobility reliably preceded the first sign of sleep by a fixed time period of about 7.5 minutes. He stated that this finding reaffirms the recognition of the role of postural relaxation in facilitating sleep onset. An individual will often adopt a posture that was found to be particularly favourable to sleep onset. Hobson (1995: 106) calls it the "sleep launch position".

Muscle relaxation is one of the critical factors in falling asleep that can be voluntarily controlled. One's posture should be supported to allow complete muscle relaxation and physical stillness. Voluntary breathing techniques can produce a feeling of calm. Athletes can use cognitive relaxation techniques to reduce cortical arousal (Cole, 2005). It has been known that music has psychological effects on humans, and music has been used to create a relaxing environment. Ogata (1995) investigated the psychophysiological effects of music on human EEG. While listening to classical music, the subjects (n=8) reported that they felt pleasantly relaxed or comfortable. Axt and Axt-Gadermann (2005: 110) referred to their own work where they used music to promote sleep and relaxation. Western classical music that was found particularly suited for relaxation were the "Largo pieces" from Antonio Vivaldi, Frederic Chopin, Franz Schubert, Wolfgang Amadeus Mozart, Georg Frederic Händel, and Johann Sebastian Bach. The authors do acknowledge that individual preference might play a role. Individuals should choose music with a tempo slower than heartbeat to induce a calming and relaxing effect.

Physical strategies

Various forms of cold, heat and contrast temperatures have been used in sports medicine and rehabilitation for the treatment of acute injuries, and injury management. These modalities are now increasingly being used for recovery in sport due to the supposed physiological and psychological benefits for the athlete.

Cryotherapy

A survey of literature shows that the lowering of temperature of human tissue through different means and for various reasons has been practised through the centuries. The Greek noun *cryos* is used to refer to cold (Licht, 1972a). Knight (1995: 5) defined cryotherapy as “the therapeutic application of any substance to the body that results in the withdrawal of heat from the body, thereby lowering tissue temperature.” In athletic training, cryotherapy refers to the application of local cold for therapeutic purposes. Cryokinetics refers to the combination of cold and exercise in therapy (Denegar, Saliba & Saliba, 2006; Knight, 1995; Lehmann & De Lateur, 1990b).

Cryotherapy can be accomplished by several means. Warren, McCarty, Richardson, Michener and Spindler (2004) mentioned that ice is often considered to be one of the most common modality choices to treat physical disorders. Although artificially made ice was unknown before 1750, and became commercially available in the United States in 1885, snow, natural ice, cold spring water and snowcooled water were used by the ancients in various ways (Licht, 1982). Nadler, Prybicien, Malanga and Sicher (2003) did a survey amongst 905 athletic trainers at high-school, college and professional levels, and at physical therapy clinics. The researchers found that ice was the most commonly used modality for therapeutic use. Other modalities for cryotherapy can include the following: vapocoolant sprays, ice massage, cold water circulating units, cold water baths and showers, running cold water over a burn, whole-body hypothermia prior to organ transplant surgery, and cryosurgery to freeze and destroy tissue (Denegar et al., 2006; Knight, 1995). According to Hubbard, Aronson and Denegar (2004), the majority of research on the effect of cryotherapy focused on tissue temperature, blood volume, swelling, postoperative measures, and to a lesser degree, functional performance.

Cryotherapeutic techniques have been traditionally used for immediate care after an injury, rehabilitation during various musculoskeletal pathologies, joint disorders, and during surgical procedures (King, 1993; Salcido, Musick & Erdman, 2003). Arguments for the use of cryotherapy as part of the recovery process in sport rely on the benefits of cold for injury management in athletes, such as decreases in pain, muscle spasm, swelling, and decreased metabolism limiting secondary hypoxic or ischemic injury (Hubbard et al., 2004; Knight, 1995).

Cryotherapy has become a popular and frequently used recovery method amongst coaches. Coutts and Sirotic (2004) stated that cryotherapy can reduce the initial stages of micro injury, and reduce inflammation and swelling after matches. De Roubaix, head coach for the South African swimming team for the World Cup Swimming Series in 2005 said in an interview: "Usually swimmers will lie in a big drum full of ice for about five minutes. This helps muscles recover quicker. The cold lessens the inflammation of the muscles, which is caused by high intensity activities, and helps the swimmer to function optimally" (Rippenaar, 2005: 8). Most of the cryotherapy treatments in athletic training are supposed to be relatively inexpensive and easy to apply.

To date there are few studies that have focused on the effectiveness of cryotherapy for post-exercise recovery. Rob Duffield, academic from Charles Sturt University, Australia (personal communication, December 12, 2006) indicated that the practice of cold water immersion is very popular in many Australian sports, from club to elite level, although there is currently little published research on the effects and benefits for athletes.

Methods of cooling

Although tissue temperature can also be reduced by convection and evaporation, conductive cooling is the most widely used method in cryotherapy (Licht, 1972b). Denegar et al. (2006: 106) described conduction as "the transfer of heat through direct contact between a hotter and a cooler area." The primary physiological response of tissue to cold applications is a decrease in the temperature of the tissue to which they are applied. All other changes occur in response to the temperature decrease (Knight, 1995).

Ice packs or ice bags

One of the most simple methods for therapeutic cooling is an ice pack or ice bag. Crushed ice in a waterproof bag is placed or wrapped on the skin to cool tissues. Jackins and Jamieson (1990) recommended treatment times with cold packs or ice packs between 20 and 30 minutes. Crushed ice is preferred to commercial cold packs. The cold packs stored in a freezer may be considerably colder than the crushed ice at 0°C. The greater temperature difference between the cold pack and the skin may result in cold injury or frostbite to the skin (Denegar et al., 2006). An insulating layer of plastic or cloth should therefore be used between commercial ice packs and the skin for protection (Knight, 1995; Stamford, 1996).

Although a protective wrap is often used between the skin and an ice pack, research tends to show that the protective material might interfere with the effectiveness of cryotherapy. Janwantanakul (2004) studied the cooling times and magnitude of cooling temperature during ice bag treatment with and without a damp towel wrap. Thirty females (mean age 21.1 years) participated in the study where they were exposed to a randomised sequence of three 20-minute applications of three modalities, 24 hours apart. The three cold modalities, which were placed on the anterior thigh, were chipped ice in a plastic bag, chipped ice in a plastic bag wrapped in a damp cotton towel, and a plastic bag containing room temperature water as control. Skin surface temperature was recorded every minute. The lowest skin surface temperature (5-7°C) occurred after five minutes of direct application of the ice bag. The wrapped ice bag lead to a lowest temperature of 9-12°C after eight minutes.

Chesterton, Foster and Grad (2002) studied the effects of a 454 g packet of frozen peas, and a flexible frozen gel pack on skin temperature response applied to the anterior thigh. Surface skin temperatures were measured in 20 subjects, at baseline and 10 and 20 minutes after cryotherapy. The researchers found that the application of the frozen peas produced the lowest skin temperature adequate to induce local skin analgesia, to reduce nerve conduction velocity, and to reduce metabolic enzyme activity. The flexible frozen gel packs did not cool the skin sufficiently to achieve the same effect. Kanlayanaphotporn and Janwantanakul (2005) also compared the effect of different cryotherapy modalities on skin surface temperature. An ice pack, gel pack, a bag with frozen peas or a mixture of water and alcohol was randomly applied for 20 minutes to the skin on the right quadriceps femoris muscle in 50 women (mean age 20.6 years). The ice pack and mixture of water and alcohol showed significantly lower skin surface temperatures than the gel pack or frozen peas.

The trend of wrapping ice bags to the legs while training to use the benefits of deep tissue cooling was studied by Bender et al. (2005). Left triceps surae intramuscular and skin temperatures were measured in 16 physically active subjects (mean age 21.6 years). Once an ice bag was applied, the subject would either remain prone or walked on a treadmill for 30 minutes. The researchers found that the ice packs could effectively decrease intramuscular temperature at rest. Intramuscular temperatures continued to decrease while the subjects rested, but no cooling took place during walking. The authors suggested that cooling for deeper tissues should be performed while resting.

Cold water circulating units

Cold water circulating units or cryocuffs are similar to ice packs in that a cold surface is placed on or near the skin. Warren et al. (2004) involved twelve subjects (mean age 26 years) in their study on the effects of an ice bag and a cryocuff on intra-articular knee temperature changes. A thermocouple probe was inserted intra-articularly into the suprapatellar pouch, and a second probe was placed on the skin. The cryocuff device was applied to the subject's right knee, while the plastic bag filled with crushed ice was secured to the left knee, both for one hour. Suprapatellar pouch and skin temperature were recorded every minute for two hours. The ice application showed significantly lower skin and intra-articular temperatures at 30 minutes. Intra-articular temperature could be lowered to 30°C within 30 minutes. The researchers stated that joint temperatures of 30°C or lower resulted in a decrease in enzyme activity during synovitis and inflammatory joint disease, therefore decreasing the cartilage breakdown. Tolerance was recorded by a 10 cm visual analogue scale, which revealed ice to be more painful than the cryocuff at 30 minutes and 60 minutes.

Cooling jackets

Cooling jackets are used to apply cold to the torso of an individual to lower tissue temperature. The effect of wearing an ice cooling jacket on repeat sprint performance was studied by Duffield, Dawson, Bishop, Fitzsimons and Lawrence (2003). The researchers attempted to simulate the intermittent, repeat sprint activity that occurs in team sports. Seven male first- grade field hockey players (mean age 20 years) participated in the study. Three testing sessions, separated by seven days and randomly assigned, were conducted. The exercises consisted of an intermittent repeat sprint cycling protocol for 80 minutes, consisting of four 15-minute quarters, and 5-minute rest periods or a 10-minute half time break. The experimental and control sessions were identical, except for the ice cooling jacket

that was worn over the training clothes during the rest periods. The following measurements were taken: performance on a stationary track cycle, blood lactate concentrations, skin and rectal temperatures, sweat loss, rating of perceived exertion, thermal comfort, rating of thirst, and fatigue/vigour from the *POMS*. Although not significant, trends were found for lower lactate concentrations, sweat loss, and mean skin temperatures in the cooling trial. Significantly lower values were found for chest temperature, rating of thermal comfort, and rating of thirst. The researchers concluded that the application of a cooling jacket at halftime might help suppress feelings of fatigue and exertion during the second half of a match. They also suggested the inclusion of ice towels to the head to assist with greater body cooling and possible significant effects on performance and other parameters.

Hornery, Papalia, Mujika and Hahn (2005) also studied the effect of a 10-minute halftime cooling with a cooling jacket on, physiological parameters and performance benefits. Fourteen subjects completed two randomised one-hour cycling trials, consisting of 30 minutes high-intensity cycling, 10 minutes cooling by application of a cooling jacket or 10 minutes passive recovery, followed by a 30-minute high-intensity exercise bout. Halftime cooling resulted in greater aerobic performance. Heart rate during the fifth minute of maximal effort, blood lactate concentration at six minutes post-exercise and ratings of perceived exertion at 20 minutes post-halftime recovery, differed significantly between the two conditions, revealing a tendency for enhanced aerobic performance following the cooling application.

Ice massage

For ice massages, water can be frozen in a paper or foam cup and used for cooling and massages (Denegar et al., 2006). Waylonis (1967) found ice massages to be an effective, safe, and inexpensive way to use cold for managing acute neuromuscular pain problems, although ice packs reduced skin and muscle temperatures more. Brisk, sweeping strokes are used directly over a muscle, usually over relatively small areas. A massage should be discontinued when the individual experiences a feeling of superficial numbness (Jackins & Jamieson, 1990). Licht (1972b) recommended five to seven minutes of ice massage to be effective for most bodily areas. Areas with considerable fatty subcutaneous tissue (thigh or buttocks) require a longer period of ice massage. Very lean athletes might require a shorter ice massage period (Stamford, 1996). According to Jackins and Jamieson (1990), an ice massage is one of the least likely cooling methods to cause frostbite.

The effect of ice massages on exercise-induced muscle damage was studied by Howatson and Van Someren (2003). Nine males (mean age 23.3 years), accustomed to resistance training, performed an exercise protocol designed to induce muscle damage in the dominant or non-dominant arm, in random order, on two occasions, separated by two weeks. Subjects were randomly assigned to either an ice massage or a control group. Treatments were undertaken immediately after exercise, and again at 24 hours and 48 hours post-exercise. For the ice massage, a 250 ml thermal polystyrene cup was filled with water and frozen to form an ice ball. A qualified sports masseur applied the ice ball directly to the skin, and performed circular and stroking motions for 15 minutes. The control group was "treated" with the use of an ultrasound machine for five minutes with the power output set to zero. Measures of concentric one-repetition maximum (1 RM), plasma creatine kinase (CK), perceived muscle soreness (DOMS), limb girth, and range of movement (ROM) were taken pre-exercise, immediately post-exercise, 24 hours, 48 hours, and 72 hours post-exercise. It was found that the ice massage significantly reduced blood plasma concentrations of CK at 72 hours post-exercise, but failed to affect any of the other signs and symptoms associated with muscle damage.

Cold- or ice-water immersion, and cold whirlpools

Cold water immersion and cold whirlpools are also used to administer cryotherapy. Casa et al. (2007) reported that a person cools four times faster in water than in air of the same temperature. Consistent guidelines in terms of cryotherapy protocols are difficult to find. Knight (1995) referred to a study in which the recommended duration and frequency of cold application were assessed in over 30 published protocols, with only two of the recommendations the same. The area of the body exposed to the cold, amount of subcutaneous fat, and activity level of the individual before cryotherapy affect the length of application. Coutts and Sirotic (2004) recommended a two-minute ice bath at 12-15°C for team-sport athletes at the end of a recovery session. Wilcock, Cronin and Hing (2006b: 758) cautioned against sudden severe cold immersion of a large portion of the body when they wrote: "... care should be taken when using cold immersion on athletes. Very cold temperatures may be best only in a localised manner to treat acute injuries and reduce inflammation, rather than being used as a recovery strategy."

A limb or body part that must be treated can be immersed in a bucket of ice and water with a temperature near 0°C. Immersion in a tank can be at water temperatures from 10°C (Jackins & Jamieson, 1990), while temperatures between 12.8°C and 18.3°C can be used in

a whirlpool (Kuligowski, Giannantonio, Lephart & Blanc, 1998). According to Denegar et al. (2006), immersion of a limb in 4-10°C water or a 10-15°C whirlpool will cool tissue as effectively as an ice pack. Warmer water is used in the whirlpool because the movement of the water breaks down the boundary layer of water (thermopane) around the limb, that is warmer than the cold bath. Loss of thermopane results in tissues cooling more rapidly.

In a study comparing the cooling and rewarming effects of 20-minute treatments of crushed ice-packs and cold whirlpool cryotherapy, Myrer, Measom and Fellingham (1998) found ice packs to be superior in decreasing temperature. Thirty-two college students participated in this study. Subcutaneous and muscle tissue temperatures were measured with microprobes into the gastrocnemius muscle. A 1.8 kg ice pack was placed over the triceps surae muscle group for 20 minutes. Cold whirlpool immersion consisted of a leg immersed into a whirlpool with the water temperature maintained at 10°C. Intramuscular and subcutaneous temperatures were recorded every 30 seconds as well as for 30 minutes post-treatment. No significant differences were found in the decrease in intramuscular temperatures between the two treatments. The ice pack treatment significantly decreased subcutaneous temperature more than the whirlpool. The rewarming rate of the ice pack group was significantly faster than the whirlpool group. The authors concluded that this is important when returning an athlete to play after receiving cryotherapy, because any possible deficit in neural or muscular function due to the cold will be eliminated faster.

Clements et al. (2002) wanted to compare the cooling rate of immersion in ice water with immersion in cold water in runners with exercise-induced hyperthermia. Seventeen highly trained runners (mean age 28 years) ran a hilly trail run of approximately 19 kilometres on three occasions, one week apart. The random, crossover design included the distance run with a 12-minute ice-water immersion (5.15°C); the distance run with a 12-minute cold-water immersion (14.03°C); or the distance run with a 12-minute mock treatment. Immersion took place two minutes after completion of the run with subjects being immersed from the shoulders to the hips in a tub. Results showed that ice-water immersion and cold-water immersion cooling rates were similar to each other. The authors concluded that, given the similarities in cooling rates and rectal temperatures between the two treatments, either mode of cooling could be recommended for treating hyperthermic athletes.

In an athletic team setting, ice is normally put in a container such as a plastic container filled with water, in which athletes will stand to immerse their legs. Wilcock et al. (2006b)

mentioned that the duration of immersion in performance research on cryotherapy varies from 15 to 20 minutes, but in a field setting immersion time may be as little as 30 seconds. The authors stated that this immersion method might be impractical for team sports, because of the time required to treat all the athletes.

Sellwood et al. (2007) wrote that the most commonly used ice-water immersion protocol in Australia involved one minute ice-water immersion, followed by one minute out of the water, for a total of three cycles, applied immediately after a bout of exercise. The researchers wanted to evaluate the efficacy of this ice-water immersion protocol for the prevention of DOMS. Forty non-athletes were randomly divided into a control (mean age 20 years) and an intervention group (mean age 21.4 years). The eccentric exercise protocol to induce DOMS consisted of seated leg extensions performed by the non-dominant quadriceps. Immediately after the exercise, participants in the intervention group stood submerged to the level of the anterior superior iliac spine in melting iced water at 5°C, while the control group were immersed in tepid water at 24°C. Participants remained in the bath for one minute, followed by one minute out of the bath, repeated three times. Pain and tenderness in the exercised leg, swelling, functional performance (one-legged hop-for-distance- test), and serum creatine kinase were recorded at baseline, and at 24, 48 and 72 hours after the eccentric exercise protocol. The researchers concluded that the ice-water immersion did not show any benefit for pain, swelling, or isometric strength and function.

Vapocoolant sprays

Vapocoolant sprays result in very superficial, rapid cooling. According to Denegar et al. (2006), there is virtually no temperature change below the epidermis. Vapocoolant sprays briefly numb an area and may be effective in the management of tender trigger points.

Cryochambers

In preparation for the Rugby World Cup Tournament in France in 2007, it was reported in a South African newspaper that consideration was given to the possibility of the Springbok rugby team training in Poland (Cronjé, 2007). The cold and “miracle-ice” of Poland is seen as a magic cure for sore muscles. The players could supposedly also train harder and recover faster. Jake White, coach of the Springbok rugby world champions in 2007, also wrote about his plans to send some players to a training camp in Poland before the World Cup, because of the reports from other teams indicating that the cryotherapy there “helps the body

recover quickly by applying extreme cold to destroy damaged tissue in the body” (White & Ray, 2007: 284).

This method of whole-body cryotherapy is mostly found in Poland, namely the use of cryochambers (also called cryocabins or polaria). The Polish cryochambers were developed in 1983 (Strnad & Forytkova, 2006). The temperature inside the chamber is between -110°C and -140°C. A pre-chamber of -60°C is first entered for 30 seconds, before moving into the main chamber for a maximum of three minutes. A small swimsuit, woolly hat, thick gloves, socks, and mouth and ear protection is worn. It is believed that treatment in a cryochamber can reduce pain, increase muscle strength and performance, decrease anxiety and irritability, increase decision-making skills, and increase emotional control (Douglas, 2006; Emerald rugby, 2006).

Although no research articles could be found on the use and benefits of the cryochambers, numerous references to the use of cryochambers by athletes are found in newspapers. Bech (2007) reported on the Irish team visiting the cryotherapy centre in Spala, Poland, as part of their preparation for the Rugby World Cup. Ireland head coach also mentioned that the players could train harder, and recover more quickly (R. Killworth, personal communication, July 16, 2007). The Scottish rugby team visited Spala in Poland before the 2003 Rugby World Cup. The fitness coach stated that players could train hard three to four times a day without suffering any delayed onset muscle soreness (BBC Sport, 2003).

Effects of cooling

Cooling and rewarming skin

With the application of cold, the skin temperature drops rapidly (Lehmann & De Lateur, 1990a). Knight (1995) found that the rate of cooling slows and finally levels off after a few minutes at a few degrees above the temperature of an ice pack or ice bath. A similar pattern of rewarming occurs. An initial rapid rise in temperature is followed by a more gradual return to the original temperature. Skin temperature can remain below pre-application levels for over an hour following 30 minutes of cold application. When cooling is followed by physical activity, rewarming occurs more rapidly (Denegar et al., 2006).

Cooling and rewarming deeper tissues

Deeper tissues cool more slowly and to a lesser extent than the skin. Muscle tissue temperatures also continue to drop for several minutes after the removal of ice packs. The drop of muscle temperature depends largely on the thickness of sub-cutaneous adipose tissue (Lehmann & De Lateur, 1990a). Research has shown that with less than one centimetre of subcutaneous fat, there is a significant reduction of muscle temperature after 10 minutes of cold application to a maximal depth of two centimetres into the muscle. With more than two centimetres of fat, muscle temperature hardly drops after 10 minutes of ice application. It will take at least 10 minutes to begin to cool muscles in a lean individual, and about half an hour in a more obese individual (Lehmann & De Lateur, 1990b). Ice massage often affects only the skin.

Otte, Merrick, Ingersoll and Cordova (2002) found a direct relationship between adipose thickness and required cooling time. The researchers used a 750 g crushed-ice bag to the anterior thigh of 47 subjects to assess the time required to decrease intramuscular temperature by seven degrees from baseline. The authors concluded that a 25-minute ice pack treatment may be adequate for an individual with a skinfold of 20 mm or less; 40-minute application for individuals with skinfolds between 21 and 30 mm; and a 60-minute application for individuals with skinfolds 30 to 40 mm. Once a muscle is cooled, the layer of fat will assist in insulating the cooled muscle and prolong the effect (Jackins & Jamieson, 1990). Knight (1995) found changes in rectal temperature during whole-body immersion to be related to subcutaneous fat percentage.

Intra-articular temperature

Changes in intra-articular temperature follow the same pattern as observed in muscle, although there is a greater temperature decrease in the joint than in the surrounding muscle. Cold water immersion results in greater cooling of the intra-articular space than an ice pack due to the greater surface area exposed to the cold (Denegar et al., 2006; Knight, 1995). Deep tissues rewarm very slowly. Knight (1995) reported that the rewarming of muscle and intra-articular spaces at rest can exceed two and a half hours. With application of ice directly to the skin, a rewarming period of at least twice the cooling period is recommended (Knight, 1995). When cryotherapy is followed by exercise, deep tissue temperatures return to normal more rapidly (Myrer, Measom & Fellingham, 2000).

Blood flow and acute inflammation

Cooling lowers the metabolic activity and oxygen demands of cells. Localised cooling leads to vasoconstriction and decreased local blood flow in superficial and deep tissues. Lehmann and De Lateur (1990b) wrote that blood flow decreased as temperatures decreased to 18°C, but increased again at temperatures below 5°C. This opening of blood vessels in spite of cooling occurs on and off to maintain a minimum safe temperature level to prevent tissue damage. Warren et al. (2004) did not find this reflex vascular vasodilation, even beyond the one-hour treatment time in their study, as mentioned previously. It supports the findings by Knight, Bryan and Halvorsen (1981) that blood flow in the forearm decreased significantly by 56% during cold pack application and immersion in 5°C and 10°C water, and 75% during immersion in 15°C water, without vasodilation.

The added use of an ice pack or cold during acute inflammatory response can control pain, limit swelling, and minimise secondary tissue injury. Secondary injury or secondary ischemic injury refers to tissue death due to inadequacies in oxygen, fuel substrates, and waste removal (Knight, 1995; Merrick, 2002). During an acute inflammatory response, disruption of capillaries and congestion due to oedema decrease oxygenation of healthy cells close to the tissue damage, and this hypoxia leads to further cell death. The cooling of tissue lowers the metabolic activity and reduces oxygen demand. When oxygen demand is lowered through cooling, more cells can survive a period of hypoxia, there is less tissue damage, and more rapid recovery (Merrick, Rankin, Andres & Hinman, 1998).

Nervous system

Cold application also affects the nervous system. Cold initially stimulates cold and pain receptors, but after several minutes of cold, sensation is diminished because the cooling of nerve fibers slows the conduction of neural impulses (Hardy, 1982). Impulses cannot be effectively transmitted from the periphery to the sensory cortex, and cryotherapy therefore result in pain relief (Denegar et al., 2006; Lehmann & De Lateur, 1990b). Cold reduces muscle spasms by directly affecting the muscle spindle. Muscle spindles are less sensitive when cooled, the muscle relaxes and spasms can be relieved (Lehmann & De Lateur, 1990a; Lehmann & De Lateur, 1990b; Licht, 1972b; McMaster, Liddle & Waugh, 1978). Kawahara, Kikuchi, Stone, Brucker and Edwards (2005) found cryotherapy to be a useful method for treating exercise-associated muscle cramps. The researchers induced muscle cramps through electrical stimulation to assess the effect of a 30-minute ice bag treatment in 18 subjects

(mean age 24.9 years). Local cooling of the right flexor hallucis brevis decreased the susceptibility to electrically induced muscle cramps.

Muscle function, and exercise performance

Cryotherapy is used extensively in the immediate care of musculoskeletal injuries. Knight (1995) stated that treatment must be within the first hour after injury to be most effective. Studies on the application of cryotherapy techniques in uninjured individuals showed that muscle performance and motor activity could be reduced by local cooling. When muscle tissue is cooled below 15°C-18°C, maximum isometric and isotonic strength and rate of force development are reduced (Hatzel, Kaminski & Horodyski, 1998; Knight, 1995; Lehmann & De Lateur, 1990b). Studies on the effect of cooling on muscle endurance showed that duration of muscle contraction was shortened at temperatures below 27°C. A bath temperature of 18°C corresponds to approximately 27°C intramuscular temperature. A bath temperature below 18°C led to a sharp decrease in the muscle tension that could be exerted (Lehmann & De Lateur, 1990b; Licht, 1972b). Handgrip strength decreased significantly following forearm immersion for 30 minutes in baths with temperatures below 15°C (Knight, 1995).

Pre-exercise cooling impaired high-intensity running performance in a study by Mitchell, McFarlin and Dugas (2003). It is assumed that physical performance can be impaired by elevations in core temperature, particularly during prolonged endurance exercise. Various cooling procedures are employed during and prior to exercise. The purpose of the investigation by Mitchell, McFarlin and Dugas was to determine the effect of pre-exercise cooling on high intensity, moderate duration treadmill running performance in a hot environment. Eleven endurance trained males (mean age 24.1 years) with competitive running backgrounds participated in the study. Core temperature was determined with an oesophageal probe, and skin temperatures were measured by surface thermistors at four sites on the body. Cooling consisted of standing for 20 minutes in an environment of 22°C with a fan cooling the subject and water spraying anteriorly and posteriorly on the body. Two treadmill runs to exhaustion at 100% of maximal aerobic power, with and without cooling, were done on separate days. Results showed that the 20-minute pre-exercise cooling impaired performance, despite significant reductions in core, skin and body temperatures in the cooling condition. The researchers concluded that some aspect of neuromuscular function could have been impaired, and suggested that exercise intensities at or near maximal levels might be impaired by pre-exercise cooling.

Schniepp, Campbell, Powell and Pincivero (2002) also found that 15 minutes of cold water immersion at 12°C impaired maximum-effort sprints in cycling. Ten well-trained cyclists participated in the study to examine the effects of cold water immersion on power output, heart rate, and time to peak power on a computerised stationary trainer. Subjects performed two maximal-effort sprints, separated by either 15 minutes of cold water immersion up to the level of the iliac crest, or 15 minutes of quiet sitting. All subjects participated under both conditions in a counterbalanced design. Tests were separated by two days. Time to peak power did not differ between the two conditions. Maximum and average powers declined by 13.7% and 9.5% for the cold water immersion-condition, but only 4.7% and 2.3% for the control condition.

Yeargin et al. (2006) found that body cooling between endurance type activities enhanced running performance. Fifteen subjects (mean age 28 years) participated in the random, crossover design. Subjects ran 90 minutes at a self-selected pace on uneven terrain in a hot environment before 12 minutes of either cold water immersion (13.98°C), ice water immersion (5.23°C), or a mock treatment (sitting in a tub with no water). Cold water immersion (13.98°C) resulted in significantly faster performance times in the 2-mile race that followed the treatment.

Cross, Wilson and Perrin (1996) raised concern about the depressive effects of cryotherapy on motor activity. They examined the effects of ice immersion on three functional performance tests, namely a shuttle run, a 6-metre hop test, and a single-leg vertical jump. Twenty soccer and football players were randomly assigned to either an experimental or control group. The experimental group performed the functional performance tests before and after the application of a 20-minute ice immersion (13°C) of the lower leg. Vertical jump scores and shuttle run times decreased in the experimental group, while the 6-metre hop test values were not affected. Leavy, Siemann and Surgent (1998) also found that a 20-minute icing of the knee had an adverse effect on functional performance. Nineteen subjects were tested before and after treatments on a 6-metre single leg hop test with the dominant leg, a 23.4-metre carioca run, and a 24.4-metre shuttle run. Experimental treatments consisted of an ice pack applied to both the anterior and posterior surfaces of the knee for 20 minutes, while subjects sat for 20 minutes during the control treatments. The results revealed that icing had no significant effect on the hop test, but did produce significantly slower times on the carioca run and the shuttle run. Results from the effects of cryotherapy on muscle and motor performance strengthen the statement by Licht (1972b) that an athlete

should rewarm muscle tissue through exercise before returning to activities that require maximal muscular efforts.

Five ice packs (three to the shoulder and upper arm, and two to the elbow and lower arm) were applied to the arms of ten male volunteers (mean age 29 years) as part of an interval cryotherapy to assess the effect on fatigue during repeated weight lifting (Verducci, 2000: 423). The researcher changed the time period from the minimum of 20 minutes used by “most investigators” to three-minutes of cryotherapy between the arm-pull sets. Results showed an increase of 14.1% more total work, 14.5% more arm pulls, more sets, and higher velocities during the cryotherapy condition. Verducci (2001) also did a study on baseball pitchers, using the same cryotherapy protocols. He wrote that most baseball pitchers believe that ice can decrease recovery time, and many baseball pitchers ice their shoulders and arms for a minimum of 20 minutes after completing a game, as well as between games. His study showed that the three-minute interval cryotherapy resulted in a significantly higher number of innings pitched (showing a significantly delayed onset of fatigue), and increased velocity of pitching.

Yanagisawa et al. (2003b) stated that repeated stress during baseball pitching led to an increase in the muscle cross-sectional area of the rotator cuff muscles, as well as a reduction in range of motion (ROM) of the shoulder muscles. The researchers wanted to assess the effect of either ice treatment, light shoulder exercise, or ice combined with light shoulder exercise on shoulder range of motion and muscle cross-sectional area of the rotator cuff muscles. Seven highly skilled baseball pitchers (mean age 23 years) took part in a pitching protocol similar to a single game situation, where they threw 98 pitches over a period of approximately 70 minutes. Ice treatment consisted of an ice bag with crushed ice placed on the subject’s dominant shoulder for 20 minutes. Light shoulder exercise was performed using an Upper Body Cycle ergometer, doing front and back revolutions for 20 minutes. Ice treatment had no effect on decreasing muscle cross-sectional area of the rotator cuff muscles, suggesting that the cooling effect did not reach the rotator cuff muscles, covered by more superficial muscles. The combination of ice and light shoulder exercises was the most effective mode for changing shoulder ROM and muscle cross-sectional area of the rotator cuff muscles, therefore making it an appropriate therapeutic mode for baseball pitchers.

Many investigations have attempted to alleviate or prevent exercise-induced muscle damage and its associated symptoms. Recent research has focused on the role of cryotherapy on indices of muscle damage. Delayed-onset muscle soreness (DOMS) and associated decrements in muscular function are seen as one of the most commonly reported sport-related injuries (Bailey et al., 2007). The role of cryotherapy as treatment for sport-related injuries has been well documented, but its specific application to exercise-induced muscle damage remains, according to Bailey et al. (2007), predominantly anecdotal. In their study on the effects of various therapeutic measures on shoulder strength and muscle soreness after baseball pitching, Yanagisawa et al. (2003a) found ice, combined with light shoulder exercises, to be the optimal treatment against decreased shoulder strength and increased muscle soreness from repetitive baseball pitching.

The effects of cryotherapy on the symptoms of exercise-induced muscle damage following strenuous eccentric exercise was the focus of the study by Eston and Peters (1999). Fifteen females (mean age 22 years) were divided into a control and a cryotherapy group. Immediately after performing the damage-inducing eccentric exercise, the subjects in the cryotherapy group immersed the exercised arm in cold water (15°C) for 15 minutes, and then every 12 hours for 15 minutes, until seven sessions were completed. Relaxed elbow angle, muscle tenderness, plasma creatine kinase activity, isometric strength, and swelling in the upper arm were measured before and for three consecutive days after the eccentric exercise. Cryotherapy resulted in a greater relaxed elbow angle and lower creatine kinase activity on the second and third days following the eccentric exercise, suggesting that muscle stiffness and post-exercise muscle damage were reduced when compared to the control group. No effect from cryotherapy was found on the perception of tenderness and strength loss.

Bailey et al. (2007) wanted to assess the effects of a single administration of cryotherapy on recovery from the effects of strenuous intermittent shuttle running. Twenty healthy men (mean age 22.3 years) completed the Loughborough Intermittent Shuttle Test (LIST), designed to replicate the demands associated with intermittent activity found in team sport. The following assessments were also done: ratings of perceived exertion every 15 minutes during the LIST; heart rate every 15 seconds; core body temperature; and nude body mass before and after exercise. A venous blood sample was taken immediately after exercise, and then 1, 24 and 48 hours after exercise to determine serum creatine kinase activity and myoglobin concentration. Participants were randomly assigned to either a control or a

cryotherapy group. The cryotherapy group immersed their lower limbs immediately after the exercise into a cold-water bath (10°C) for 10 minutes. The water was regularly agitated to avoid the formation of a warmer boundary layer. Participants in the control group remained at rest in the same long-seated position as the cryotherapy group. Ratings of perceived muscle soreness were assessed using a visual analogue scale, before, immediately after, and 1, 24, 48, and 168 hours after exercise. Vertical jump height, maximal voluntary isometric contractions of the knee extensors and flexors, and sprint performance were also assessed. The researchers reported that individuals who received the cryotherapy treatment reported a diminished perception of muscle soreness up to 48 hours later, a lower decrement in maximal voluntary isometric contractions at 24- and 48-hours post-exercise, and reduced serum myoglobin response one hour after exercise. The authors suggested that cryotherapy was effective in reducing muscle injury, rather than facilitating removal of exercise-induced accumulation of by-products.

Balance, proprioception, and postural stability

Studies on the effect of cryotherapy on balance, proprioception, and postural stability are inconclusive. Lehmann and De Lateur (1990b) mentioned that scores on knot tying, block stringing, typing and manipulation tests dropped sharply after total body cooling or local cooling. Dover and Powers (2004) studied the effect of cryotherapy on shoulder proprioception. Thirty subjects (mean age 23.7 years) received 30 minutes of ice bag application to the dominant shoulder. Cryotherapy did not impair shoulder joint position sense. Miniello, Dover, Powers, Tillman and Wikstrom (2005) studied the effects of 20-minute cold-water immersion of the lower leg on muscle activity and dynamic stability in 17 women. It was concluded that lower leg cold immersion did not impair dynamic stability during a jump-landing task. Local cooling also did not affect the proprioceptive acuity in the quadriceps muscles of subjects assessed by Tremblay, Estephan, Legendre and Sulpher (2001). Twenty physically active subjects (mean age 22.1 years) had to perceive small differences in weight (proprioceptive acuity) after a 20-minute application of a crushed ice pack to the quadriceps muscle group. The results indicated that the perception of force signals required for weight discrimination was not affected by the local cooling of the quadriceps muscle group.

Knight (1995) gave a summary of studies from which it can be concluded that a 20-minute cold application (immersion or ice pack) has no effect on proprioception. According to Evans, Ingersoll, Knight and Worrell (1995) agility tests (shuttle run and carioca) were unaffected

by ankle immersion for 20 minutes in 1°C ice water in 24 male athletic subjects. Atnip and McCrory (2004) determined the effect of cryotherapy on subtalar and ankle joint kinematics in 21 healthy athletes. The researchers stated that the deleterious effects of limb cooling, such as decreased nerve and muscle function, slowed sensation and inhibition of normal reflexes might put an athlete at increased risk of injury during athletic events. Retro-reflective markers were placed on the subject's shank and foot. Six high-speed cameras were used to collect the kinematic data while the subjects performed a 45-degree sidestep cut prior to and after a 10-minute icing treatment. The results indicated that the icing treatment did not have an effect on either the movement patterns or angular velocities.

Mood states

There is currently a lack of published research on the effects of various cryotherapy modalities on mood states. Kerperien et al. (2005) mentioned that athletes often make subjective comments by stating that cold water immersion helps them to "feel better". The researchers therefore wanted to determine the effect of cold water immersion on mood states. Twenty subjects (mean age 20.95 years) were divided into a control group and cold water immersion-group (CWI). The CWI subjects received 20 minutes of cold water immersion at 15°C at the umbilical level on four consecutive days. The control group remained seated in the laboratory for 20 minutes. The *POMS* was completed on the first day and again on the fifth day, without any treatment. Mood states were therefore not assessed directly after cold immersion, but rather the effect over the course of the five-day treatment. The cold water immersion did not significantly improve total mood disturbance, increase vigour, or decrease tension, depression, anger, fatigue, and confusion. The researchers mentioned a tendency for lowered tension, depression and confusion, although not significant.

Apart from determining the effect of a 10-minute halftime cooling on physiological parameters, Hornery et al. (2005) also assessed the psychological state of the subjects by means of the Positive and Negative Affect Schedule (*PANAS*) at three stages during the test. Results showed that the two variables "scared" and "ashamed" were higher when participants were in preparation for the second bout of exercise without cooling. The authors stated that the short duration cooling application "served to decrease feelings of apprehension toward the exercise task ahead" (Hornery et al., 2005: 24). Significantly higher levels of "proudness" and "alertness" were observed in the cooling trial, and the subjects perceived themselves as more enthusiastic and excited. Although the participants were

physically fatigued and exhausted, the cooling trial led to a positive mental and emotional response.

Cautions and contraindications

Lehmann and De Lateur (1990b) wrote that severe adverse effects of cold application are rare. Some side effects due to cold application are the result of cold hypersensitivity and intolerance (Licht, 1972b). Nadler et al. (2003) concluded from the responses from 905 athletic trainers on their use of therapeutic modalities, that the complications most commonly associated with cryotherapy included allergic reactions, burns, intolerance or pain. Some side effects are skin manifestations such as itching, sweating, and/or a facial flush and puffiness of the eyelids. Gastrointestinal symptoms are associated with gastric hyperacidity and can include abdominal pain, diarrhea, and vomiting. Individuals with Raynaud's disease (a condition in which the blood vessels in the fingers, toes, ears, and nose constrict dramatically when exposed to cold) show a pathological increase in arterial tone at 23°C with closure of the digital arteries at 18.5°C (Lehmann & De Lateur, 1990b; Stamford, 1996). Frostbite is a possibility, but rare, and usually not severe (Jackins & Jamieson, 1990). Stamford (1996) stated that cryotherapy should be applied with caution to diabetic individuals. According to *The Erdman Therapy*, therapeutic heat and cold modalities should not be applied at random to everybody. This therapy basically states that individuals respond to heat versus cold on the basis of arterial tone. According to the hypothesis, only five to ten percent of the population would benefit from cold therapy in the treatment of a variety of clinical conditions (Salcido, Musick & Erdman, 2003).

Licht (1972b) proposed that cooling over an excessive period of time may retard healing, which he linked to the reflex vasoconstriction. Cases have been reported in which ice application around the knee joint resulted in peroneal nerve damage with footdrop (Lehmann & De Lateur, 1990b). Some large nerves emerge from deep tissue and pass just below the skin and fatty layer, resulting in less tissue to insulate the nerve. These cold-induced nerve palsy can be caused by cold or pressure during ice pack application. Nerves most susceptible are the ulnar nerve at the elbow, the peroneal nerve at the knee, and the lateral femoral cutaneous nerve (Denegar et al., 2006). Lehmann and De Lateur (1990b) mentioned special precautions to be taken to prevent nerve damage: limit ice application to 20 minutes, avoid compression on the nerve, and avoid gel packs which produce temperatures below freezing. Barnett (2006) mentioned in his review article on recovery

modalities that there are some indications that cryotherapy might have negative effects on adaptation to training.

Thermotherapy

Licht (1982: 1) wrote: "Heat has been used to appease aches and pains ever since man first experienced what the heat of the sun could do for him. Of the many therapeutic agents used in ancient times, few has been used as continuously through the past into the present and, except for exercise, none has continued to be used more extensively and in more different forms than heat." Licht referred to the use of heat in therapy as almost "instinctual". Artificial heat was first used therapeutically to burn, and the word *cautery* comes from the Greek word *to burn*. The oldest written record of the use of cautery is believed to have been written about 3000 B.C. Numerous references to cautery is found in Egyptian, Asian, Greek and Roman medical writings. Crystal balls through which the rays of the sun have passed were used as burning glasses prior to 420 B.C. The oldest known sources of therapeutic heat were those which occurred naturally, like heated sand, oil, water, grain, and thermal waters (Licht, 1972a; Licht, 1982).

Heat is generally available, relatively inexpensive and safe, and, when used effectively, gives almost immediate relief. The various types of heating modalities used in therapy can be divided into those that heat the superficial tissues (skin) and those that heat the deeper structures. Superficial heating modalities include hot packs, paraffin baths, whirlpools, and moist air. These modalities have little or no effect on the temperature of deeper tissues (Denegar et al., 2006; Lehmann & De Lateur, 1990a). Denegar et al. (2006) stated that superficial heat is commonly applied in athletic training, because its primary benefits are linked to pain control and relief of muscle spasm, although the mechanisms responsible are yet not well understood. Deep heating modalities include ultrasound and diathermy.

Most of the arguments in favour of heat as therapeutic modality, focus on the effect of heat in increasing the extensibility of collagen tissue and increasing muscle elasticity, decreasing joint stiffness, producing pain relief, relieving muscle spasm, increasing local blood flow, causing local vasodilation, and assisting in the resolution of oedema (Cochrane, 2004; Lehmann & De Lateur, 1990a). It is often stated that optimal thermal effects occur when

peak tissue temperatures of between 40°C to 45°C are maintained for at least five minutes (Garrett, Draper, & Knight, 2000).

Methods of heating

Heat pack

Licht (1982) referred to the use of flat earthenware dishes filled with boiling water or hot oil used by Hippocrates as therapeutic agents for superficial heating. Denegar et al. (2006) stated that the most common form of superficial heat is a moist heat pack, usually called a hydrocollator. The heat pack is filled with silicate gel that absorbs and holds water with a high heat content. With application, the highest temperatures are found in the skin, with a rapid drop of temperature to the subcutaneous fat. Although Jackins and Jamieson (1990) wrote that the depth of heat penetration when using a hot pack, was between two and ten millimetres, Draper et al. (1998) reported a temperature increase to a depth of one centimetre with the use of a hot pack in their study with 21 subjects (mean age 23.7 years). They advised an application time of 15 minutes for hot packs to be effective. A rubber hot water bottle or an electric heating pad can also be used for heat application (Lehmann & De Lateur, 1990a).

According to Sumida, Greenberg and Hill (2003), the pain relief associated with thermal treatments is due to the activation of cutaneous warmth receptors stimulated by the hot pack. The stimulation of the receptors in the skin overlying the sore muscles is thought to decrease the perception of muscle pain, and the effect of the heat on the cutaneous thermoreceptors last for 15 to 20 minutes after removal of the hot pack. Sumida et al. (2003) wanted to determine whether the pain of delayed-onset muscle soreness (DOMS) could be reduced by applying a superficial hot or cold gel pack. Seventy-one participants (age between 21-30 years) were randomly assigned to one of four treatments: hot-pack treatment, cold-pack treatment, room-temperature treatment, or no treatment. The pain of DOMS was assessed with a visual analogue scale before the 20-minute application of the treatments, and 30 minutes after its removal. Results indicated that pain was attenuated 30 minutes after the hot-pack treatment, but not after the cold-pack treatment when compared with pre-treatment levels. The researchers referred to studies indicating that heat and cold applied to the skin for a short time period have only transient effects in reducing musculoskeletal pain, due to the shallow penetration depth of heat and cold, and the relative short time of the effect. The researchers also concluded that the attenuation of the pain of

DOMS after the hot pack removal could be due to a placebo effect of heat on pain. Participants could have expected that the heat, because of its soothing effect and feelings of comfort, would relieve pain. According to the authors, hot-pack treatments might not enhance the recovery process, but might motivate an individual to participate in continuous treatments, which could facilitate the recovery process.

Warm water immersion, and whirlpool

Pools, tanks, and other containers have been specifically devised for the use of water in therapeutic heat. Warm water whirlpools are popular forms of superficial heat commonly used, also in a sport setting, because it permits heating around an entire limb or body. Licht (1982) reported on the ancient Romans who sent their soldiers to warm mineral springs for all kinds of musculoskeletal problems. Underwater exercise in warm water was highly recommended around 1898, and the first whirlpool bath was designed before World War I. Wilcock et al. (2006b: 749) referred to thermotherapy as "immersion in water that raises the core body temperature. This increase in core temperature occurs in water with a temperature $>36^{\circ}\text{C}$." Kuligowski et al. (1998) suggested that warm whirlpool therapy can be administered at temperatures between 35°C and 43.3°C .

Superficial heating in a whirlpool permits passive and active range of motion exercises. It is suggested that active motion increases lymphatic drainage, which can reduce swelling (Denegar et al., 2006). McCulloch and Boyd (1992) also stressed the importance of active muscle contraction when immersed in a whirlpool. When an athlete sits with the lower extremities in the gravity-dependent position and does not contract the calf muscles, gravitational forces tend to favour oedema formation. Forty healthy subjects (mean age 24.3 years) participated in this study to assess the response of the leg to whirlpool treatment and the dependent position. Subjects were exposed to all three treatment protocols in random order, with two to three days between assessments: seated with a leg in the whirlpool with water temperature of 40°C for 20 minutes, seated with a leg in the whirlpool without water for twenty minutes, and supine lying on a treatment table for 20 minutes. Subjects were instructed to minimise leg movement during all the treatment sessions. Subjects seated in the gravity-dependent position showed significant increases in volume compared to volume decreases in subjects who rested in the supine position. The greatest changes occurred when subjects received whirlpool treatment that combined the heat and the dependent position. The authors concluded that therapists should be aware of the potential for lower

extremity swelling during whirlpool treatment, and a nondependent position of the extremities could be considered.

Treatment in a hot whirlpool can stress the body's ability to dissipate heat, because the skin's vasodilation response to the heating does not serve to transfer heat from the core to the outside, but rather picks up more heat from the surrounding water bath. The larger the portion of the body immersed in the whirlpool, the greater the heat stress. For partial immersion, for instance a limb, temperatures up to 46°C can be applied. Water temperatures above 40°C should not be used with total body immersion (Lehmann & De Lateur, 1990a). Caution is advised if a whirlpool is situated in a poorly ventilated area. Bacteria thrive in warm, moist environments and whirlpools should therefore be cleaned and disinfected after each use (Denegar et al., 2006; Wilcock et al. (2006b) wrote that numerous athletic teams perform thermotherapy after training, although little research has been conducted on the physiological or performance effects of hot water immersion.

Sauna (dry heat)

Sauna bathing has been a tradition in Finland for thousands of years, and has become increasingly popular in training environments. Peräsalo (1988) wrote that Finns have used sauna for centuries to clean themselves, to maintain their health, and even to help in treating a variety of illnesses. According to the authors, the longevity and effects of saunas in Finland are linked to the view of the sauna as a holy place. Hannuksela and Ellahham (2001) described the requirements for a sauna: a wood-panelled room of at least 3 m² to encourage the correct balance between heat, humidity, and ventilation, with temperatures of 80°C to 100°C at face-level and 30°C at floor-level. Humidity can be temporarily increased by throwing water on hot rocks in the sauna heater. A usual ritual consists of several short stays of five to twenty minutes in the sauna, interspersed with cooling-off periods.

Benefits attributed to the use of saunas are: stimulation of the release of growth hormone (Bompa, 1999), relaxation, a feeling of well-being and alleviating psycho-emotional stress (Bompa, 1999; Helamaa & Aikäs, 1988; Sudakov, Sinitchkin, & Khasanov, 1988), sleep improvement, improvement in local and general blood flow, and promotion of the excretion of toxins (Bompa, 1999; Solonin & Katsyuba, 2003).

Opaszowski, Busko and Blachnio (2001) wanted to assess hormonal responses to a one-hour bathing in a sauna, and to evaluate a possible modulatory effect of rehydration (water) on

these responses. Eight male physical education students (mean age 23.1 years) took a Finnish sauna twice a week. The temperature of the sauna was 90°C, and the total time of the bathing was divided into four 15-minute exposures, separated by two- to three-minute breaks. On one day of the experiment, subjects drank no water during the bath, while they drank one litre of non-carbonated mineral water, divided into five 200 ml portions on the other day. The exposure to the heat led to a significant increase in growth hormone and testosterone, and to a significant reduction in cortisol. This effect was more pronounced in the rehydrated condition. The authors stated that a sauna is used for biological recovery. Moderate use of a sauna may therefore affect the circadian rhythm of growth hormone secretion beneficially and thereby affect the regeneration processes.

Solonin and Katsyuba (2003) studied the effect of short-term exposure to extreme temperatures on thermoregulation and blood circulation in unathletic adults (mean age 43 years). Sauna temperature was 110°C. After exposure to the extreme temperatures (2°C for the cold intervention), the researchers concluded that short-term exposures of unathletic adults to extreme temperatures caused protective physiological mechanisms typical of acute stress. A number of researchers indicated that, although sauna bathing causes various acute, transient cardiovascular and hormonal changes, it is safe and well tolerated by most healthy adults (Hannuksela & Ellahham, 2001; Kauppinen, 1997). Uninjured athletes are cautioned to wait at least between six and eight hours after a training session or competition before introducing heat (Bompa, 1999).

Saunas seem to be part of many gymnasiums and health centres, and there are references to the use of saunas and some supposed benefits, but a lack of research in terms of athletic populations in Western countries was found.

Effects of heating

Superficial heating can increase skin temperature several degrees. Although the temperature of deeper tissues such as large muscles and deep joints rises insignificantly with superficial heating, Denegar et al. (2006) mentioned that heat is still commonly applied in athletic training due to the clinical benefit of pain control and relief of muscle spasms.

Lehmann and De Lateur (1990a) reported that the therapeutic temperature range of tissue is relatively narrow, with a range between 40°C to 45.5°C. A minor change in tissue

temperature produces a major change in the degree of the body's physiological response, with the margin of effectiveness and safety narrow. Tissue temperatures fall fairly rapidly following thermotherapy, with superficial tissues cooling more rapidly than deeper tissues. Any stretching or manual therapies should therefore be performed immediately following thermotherapy. Blood flow is increased as a result of temperature elevation (Denegar et al., 2006; Lehmann & De Lateur, 1990a). Higgins and Kaminski (1998) suggested that heat can facilitate soft tissue repair through accelerated cellular metabolism.

It is suggested that superficial heat does have an analgesic effect. Two-hundred and nineteen subjects suffering from acute non-specific low back pain participated in a study by Nadler et al. (2003a) to assess the effect of a continuous low-level heat wrap. Subjects were randomised to one of the following groups: heat wrap, oral placebo, oral ibuprofen[®], or unheated back wrap. The heat wrap provided significant therapeutic benefits, with greater pain relief, less muscle stiffness, and increased flexibility. Nadler et al. (2003b) also evaluated the efficacy and safety of the continuous low-level heat wrap during sleep for the treatment of acute low back pain in 76 subjects. Overnight use of the heat wrap provided effective pain relief throughout the next day, reduced muscle stiffness and disability, and improved trunk flexibility. Heat wraps were more effective than placebo medication or ibuprofen. The positive effects were sustained for more than 48 hours after treatments were completed. The researchers also suggested that the heat wrap therapy could provide benefits for the individuals in terms of more comfortable and restorative sleep.

It is reported that fibrous tissues in tendons, joint capsules, and scars yield more readily to stretch when heated, with heat therefore leading to increased tissue elasticity. Heat application markedly decreased joint stiffness, and also reduced muscle spasms (Denegar et al., 2006; Lehmann & De Lateur, 1990a).

Application of superficial heat relaxes the smooth musculature of the gastrointestinal tract, seen in the decrease in peristalsis, which is the basis for relief of gastrointestinal cramps. It has been reported that external cold application increased free and total gastric acid secretion, while heating the skin of the abdominal wall, reduces gastric acidity (Lehmann & De Lateur, 1990a; 1990b). Application of superficial heat also relaxes the smooth musculature of the uterus, which reduces menstrual cramps (Lehmann & De Lateur, 1990a).

In terms of the psychological effects associated with heat, it is suggested that superficial heat can assist with relaxation. Denegar et al. (2006) mentioned that superficial heat applied for 20 to 30 minutes often has a calming effect. Immersion in a warm water whirlpool environment also produced a significant reduction in anxiety (Becker, 2004).

Cautions and contraindications

Skin burns are the primary risk of superficial heating. Nadler et al. (2003b) stated that heat-producing physical modalities for therapeutic use often produce temperatures exceeding the threshold of 45°C for tissue damage. Adequate insulation around heat packs and controlling whirlpool temperatures can minimise the risks (Denegar et al., 2006).

Heat stresses the cardiovascular system. Although it is rarely a problem in athletic training, heat stress from superficial heating combined with a warm, humid environment can be a high risk for an individual with coronary artery disease or medical problems.

Ultrasound is a safe therapeutic modality with few contraindications. Therapeutic ultrasound and diathermy should not be applied near the abdomen during pregnancy. Ultrasound and diathermy have been reported to promote growth of malignant cells and should not be used near tumours, and should also not be applied over an infection (Denegar et al., 2006; Lehmann & De Lateur, 1990a). Bompa (1999: 106) suggested that uninjured athletes should wait at least between six and eight hours before introducing any form of heat after a training session or competition.

Contrast temperature therapy

Contrast therapy or bathing consists of alternating applications of heat and cold (Denegar et al., 2006; Wilcock et al., 2006b). It is suggested that contrasting hot and cold showers, or using a warm spa or whirlpool with a cold plunge pool or shower can be an effective way to administer contrast temperature therapy (Calder, 2000a). Temperatures between 40.6°C to 43.3°C (hot) and 15°C to 20°C (cold) are advocated. Therapy usually starts with immersion in hot water for five to ten minutes, then into the cold bath for one minute, and then cycles of four minutes in hot water and one minute in cold water, until a total of 30 minutes has elapsed, ending again with hot water (Bompa, 1999; Jackins & Jamieson, 1990; Lehmann and De Lateur, 1990a; 1990b). Calder (2000a) suggested alternating between temperatures

of 39°C to 40°C for four minutes and 10°C to 12°C for one minute when using a spa or bath and a cold shower or cold plunge pool. This should be repeated three times. If only showers are used for contrast therapy, 30 seconds should be spent with hot temperatures, and 30 seconds with cold, repeated three times. A cold-to-warm ratio of 1:3 minutes or 1:4 minutes is thus applied (Denegar et al., 2006). Higgins and Kaminski (1998) wrote that contrast therapy treatments are typically 20 to 30 minutes in length. They also stated that there is no evidence to suggest that ending with either heat or cold is more effective. The authors mentioned that they use contrast therapy in their clinic as a transition between early cryotherapy and subsequent thermotherapy treatments.

Calder (2000b; 2003) referred to an unpublished study from the University of Canberra which measured the effect of contrast water immersion, active recovery, and passive recovery on lactate recovery in high-performance hockey players after a series of Wingate tests. Athletes first had a shower, then alternated between a hot pool (39°C-40°C) for three minutes and a cold plunge pool (10°C-15°C) for 30 to 60 seconds. Results indicated that lactate levels were recovered equally fast by using either the active recovery protocol or the contrast water immersion protocol.

It is believed that pain can limit range of motion and prevent an athlete from performing prescribed exercises or activities. Delayed onset of muscle soreness (DOMS) is often used as a model of injury and pain to study the effects of various modalities. Eastep et al. (1998) compared the effectiveness of a cold whirlpool and contrast therapy on symptoms associated with DOMS in 27 subjects (mean age 21.5 years). Subjects received either a control treatment, contrast bath, or a cold whirlpool for 20 minutes. The researchers concluded that there did not appear to be any benefit in using the cold whirlpool or contrast therapy to control the pain, loss of range of motion, and strength associated with DOMS. Kuligowski et al. (1998) also studied the effect of various treatment modalities on DOMS. Fifty-six gender-matched volunteers (age between 19-25 years) were, after induction of DOMS, randomly assigned to one of four treatment groups for 24 minutes: warm whirlpool, cold whirlpool, contrast therapy, and control. No significant differences were found between the cold whirlpool or contrast therapy for any of the dependent variables, namely degrees of resting and active elbow flexion and extension, perceived soreness, and maximal voluntary isometric contraction. Results suggested that a cold whirlpool and contrast therapy were more effective than the warm whirlpool or no treatment in alleviating DOMS.

In their study on the effect of contrast water therapy on symptoms of delayed onset muscle soreness, Vaile, Gill and Blazeovich (2007) compared the effectiveness of contrast water therapy versus passive recovery in reducing and improving the recovery of functional deficiencies that resulted from DOMS. Thirteen recreational athletes (mean age 26.2 years) participated in DOMS-inducing exercises. Subjects performed one of two recovery strategies 45 seconds after completion of the exercise protocol. In the passive recovery session, subjects sat for 15 minutes with minimal movement. For the contrast-water condition, subjects alternated between immersion for 60 seconds in cold water (8°C-10°C) and immersion for 120 seconds in hot water (40°C-42°C). Subjects were immersed to the level of the anterior superior iliac spine, and alternated between the two baths for 15 minutes. The effects of the exercise were assessed through the measurement of isometric squat force, a jump squat for peak power, creatine kinase concentration, thigh volume, and perceived muscle soreness on a visual analogue scale. Results showed that the contrast therapy was associated with less muscle force generating capacity loss, a smaller reduction in, and faster recovery of, power production during the jump squat, and a smaller increase, and faster reduction, in thigh circumferences compared to passive recovery. The researchers discussed possible mechanisms that could explain the results, such as hydrostatic pressure associated with immersion, vasodilation from the warm-water treatment, and an increase in sympathetic nervous system activity. It was concluded that strength, power, and symptoms of DOMS were improved by cold-water therapy compared to passive therapy.

Gill et al. (2006) examined the effectiveness of either contrast water therapy, active recovery, a lower body compression garment, or passive recovery on the rate and magnitude of muscle damage recovery in rugby players. Twenty three elite male rugby players (mean age 25 years) were monitored before, immediately after, 36 hours after, and 84 hours after competitive rugby matches. The players were well-trained and represented their province in the New Zealand National Provincial Championships. Four competition weeks were monitored and subjects were randomly assigned to one of four post-match recovery sessions. Contrast water therapy consisted of immersion up to the anterior superior iliac spine, alternating between one minute in cold water (8°C-10°C) and two minutes in hot water (40°C-42°C), for nine minutes. It was concluded that undertaking low-impact exercise, wearing a compression garment, or carrying out contrast water therapy after the rugby matches enhanced creatine kinase clearance more than passive recovery.

The effectiveness of contrast therapy and active recovery on blood lactate removal and repeated sprint performances in rugby players was compared by Hamlin (2007). Twenty junior representative rugby players (mean age 19 years) were given either contrast-temperature water therapy or active recovery after performing a repeated sprint test. The sprint test consisted of ten 40-metre sprints with 30 seconds between sprints. Active recovery consisted of slow jogging for six minutes. In the contrast-temperature water therapy, subjects were immersed to hip-height in cold water (8°C-10°C) for three one-minute sessions, alternated with three one-minute sessions in a hot water (38°C) shower. Blood lactate concentrations and heart rates were measured throughout the testing, while the sprint test was repeated after one hour. One week later, the groups were reversed and the testing was repeated. The results showed that, compared to active recovery, contrast-temperature water therapy decreased blood lactate concentration and heart rate, but had little effect on the players' subsequent repetitive sprinting performance.

Myrer, Draper and Durrant (1994) wanted to assess if significant fluctuations in muscle temperatures could be produced by contrast therapy to gain the physiological benefits attributed to this modality. Twenty-eight subjects immersed their right leg into a hot whirlpool of 40.6°C for four minutes, followed by a cold whirlpool of 15.6°C for one minute, repeated four times. No significant differences were found in intramuscular temperature of the gastrocnemius muscle.

Myrer, Measom, Durrant and Fellingham (1997) investigated the effect of a 20-minute cold- and hot-pack contrast therapy treatment on the subcutaneous and intramuscular tissue temperature of the right calf in 16 subjects. The control group had a 1.8 kg ice pack on the triceps surae muscle group for 20 minutes. Treatment in the experimental group consisted of alternating hot- and cold-pack applications for five minutes each, for a total treatment time of 20 minutes. Treatment started with the hot-pack application. The researchers reported that the contrast therapy was incapable of producing any significant physiological effect on the intramuscular tissue temperature one centimetre below the skin and subcutaneous fat. The researchers concluded that oedema reduction requires the removal of extravascular fluid and proteins from the injury site through the lymphatic system, not the circulatory system, and circulatory changes would therefore have little effect on lymph flow. Denegar et al. (2006) added by writing that the brief exposure to cold, and the fact that superficial heating has a minimal effect on deep blood flow, would suggest that there is little vascular response to contrast therapy.

Twenty subjects (mean age 20.9 years) participated in a study by Higgins and Kaminski (1998) to measure the change in the gastrocnemius intramuscular tissue temperature during contrast therapy treatment. The control group was subjected to a 31-minute warm whirlpool treatment, while the experimental group was subjected to a 31-minute contrast therapy treatment. Each subject in the experimental group spent the first 10 minutes with the treatment leg immersed in a warm whirlpool of 40°C, followed by immersion in a cold whirlpool of 15°C for one minute. Cycles of four minutes warm and one minute cold followed until the completion of four cycles after 31 minutes. Intramuscular tissue temperature was measured in both groups every 30 seconds. Results showed that the contrast therapy did not cause a fluctuation in tissue temperature at a depth of four centimetres, with the temperatures actually increasing.

Fiscus, Kaminski and Powers (2005) examined the change in arterial blood flow in the leg during warm- (40°C), cold- (13°C), and contrast-water therapy (same temperatures, with four minutes hot and one minute cold), and a control condition (empty whirlpool). Twenty four sedentary men (mean age 23 years), with midcalf circumferences between 24 and 45 cm, volunteered to participate in the study. Lower limb blood flow was measured using a strain gauge plethysmograph. Subjects were exposed to all the treatment conditions over four consecutive days, with each session lasting 20 minutes. Blood flow was recorded at a ratio of three minutes inflation time and one minute off, throughout the treatment session, while subjects sat quietly in the whirlpool with their legs immersed in the water. A significant change in blood flow from baseline was observed across the entire warm water treatment condition. The warm water treatment condition resulted in a significant increase in blood flow when compared with both the control and cold water condition. Submersion in 13°C water did not decrease blood flow in the midcalf region significantly, and it was nearly equivalent to the blood flow during the control condition at all time points. The authors stated that the gravity-dependent position could have an effect on increased volume from gravity. A significant increase in blood flow from baseline was observed during each warm-water phase of the contrast therapy, but not during the cold water phase of the contrast therapy. When the cold water phases of the contrast therapy were compared with the corresponding time points of the cold water treatment, no differences were observed. A significantly greater change in blood flow in the warm therapy was observed when compared to the warm water phases of the contrast therapy. Results showed a significant fluctuation in blood flow of the lower leg during the 20-minute contrast condition. It appeared that the decrease in blood flow during the cold phases of the contrast therapy was a return to

baseline only, and that continued vasoconstriction did not occur to support the "pumping theory".

It is a popular belief that contrast therapy causes cycles of local vasoconstriction and vasodilation, thereby creating a "pumping" action that would enhance removal of oedema (Knight, 1995). Numerous ratios (minutes of heat versus minutes of cold) such as 4:1, 3:1, and 3:2 have been recommended for contrast baths. Knight (1995) and Wilcock et al. (2006b) stated that vaso-pumping seemed to be unlikely due the slow frequency of only two to five "pumps" over a period of two to ten minutes, or 15 pumping cycles per hour, during contrast therapy. The authors mentioned that the increased removal of wastes from the body might be due to hydrostatic pressure caused by immersion in water. Knight (1995) wrote that lymphatic pumping, and not vascular pumping, is the need during rehabilitation processes.

Another hypothesis for the use of contrast bath therapy is that it might decrease sensation (including pain) and therefore facilitate active exercise. Rehabilitation could then also begin sooner. Cotts, Knight, Myrer and Schulthies (2004) investigated the effect of contrast bath therapy on sensation. Twenty four track athletes (mean age 22.9 years) were randomly assigned to one of the four treatment orders (control, contrast, both bath, and cold bath). Subjects had their right leg immersed in the whirlpool for 20 minutes. Treatments were performed with hot temperatures kept at 41°C, and cold temperatures at 13°C. Contrast bath conditions consisted of a hot bath for three minutes followed by a one-minute cold bath, repeating the cycle five times. The study did not support the idea that contrast bath therapy affects sensation of pressure. Other research involving the same body part showed that the major difference might be the temperature and time of exposure during contrast bath therapy (Knight, Han, Rubley, & Brucker, 2002; Rogers, Knight, Draper, & Schulthies, 2001). Cotts et al. (2004) referred to pilot work from their laboratory indicating that a 15-minute cold application of 1°C increased numbness. The researchers concluded that the brief applications of cold and heat in contrast bath therapy counter each other and prevent net intramuscular temperature changes.

Another reason why contrast baths might be applied is suggested by Knight (1995). According to the author, the body often accommodates sensory stimulation so that the effects of the stimulation are diminished. If the body accommodates the application of cold

so that it no longer removes pain and allows exercise, a change in stimulation might be beneficial.

Hydrotherapy

Water immersion as a recovery method or as part of other recovery methods has become increasingly popular amongst the athletic population. The therapeutic and rehabilitative benefits attributed to water have been acknowledged throughout the centuries. Humans have resorted through the ages to healing waters, thermal baths, and pools for the soothing and healing properties it possessed. According to De Vierville (2004: 1) soaking in baths and pools, and "healing water rituals" played an important role in Mesopotamia, Egypt, India, and China, as well as the ancient Greek, Hebrew, Roman, Christian, and Islamic cultures. Bathing played an important role in individual and social regenerative processes. Social bathing was seen as "a receptive, relaxed, and restorative activity that enhances wellness for the whole being and embodies the broad ideal of total regeneration" (De Vierville, 2004: 2).

The ancient Greeks and Romans believed that bathing after exercise had therapeutic value. Greek bathing arrangements as early as 334 BC consisted of individual tubs set in a line or a circle (De Vierville, 2004). The Romans had multiple rooms and pools (*thermae*) with varied temperatures, with a suite of baths comprising a cold plunge bath (*frigidarium*), a bath of tepid heat (*tepidarium*), a hot bath (*caldarium*), and a sweating-room (*sudatorium*) (Dal Maso, 1974; Cunliffe, 1985). Cunliffe (in Bath Archeological Trust, 1985: 31) wrote: "After taking exercise the bather would first acclimatise himself to the warm heat of the *tepidarium* before making his way to sit and sweat in the *caldarium*. Here he would be oiled and scraped and possibly massaged before finishing his treatment with a quick plunge in the cold bath." Russian culture combined hot baths with cold plunges. The history of aquatic traditions in Europe and America is also lengthy: institutes and medical colleges built for the practice of cold water bathing, warm swimming pools built for physical therapy exercises, and the use of water for its psychotherapeutic effects (De Vierville, 2004). The belief in the therapeutic effects of water continues today. The 21st century brought extensive new designs in the functional use of water: home relaxation showers, whirlpool baths, herbal hot tubs, and many more.

According to Wilcock et al. (2006b) water immersion *per se* is the easiest method of application in the field, with no resources needed for heating or cooling the water. Temperatures used for this mode ranges from cool to thermo-neutral (16°C-35°C). Other modes of water immersion with the focus on recovery include immersion in cold water, immersion in hot water, and alternating-temperature immersion, as discussed in the previous sections. The difference between these types of recovery methods is the temperature of the water. An important aspect of water immersion *per se* is the hydrostatic pressure associated with water immersion, and also buoyancy. Most research articles on the benefits of water immersion for recovery do not indicate whether the possible benefits resulted from the water temperature or from hydrostatic pressure, with limited research on the effect of immersion in water which is neutral in relation to body temperature (Wilcock, Cronin, & Hing, 2006a).

Water immersion affects the human body and all of its homeostatic systems, with the effects being both immediate and delayed. Immersion in water creates the force of buoyancy, which progressively takes the weight off the immersed joints. Becker (2004) stated that immersion to the umbilicus resulted in an off-load of approximately 50% of body weight, while the load on the anti-gravity muscles is reduced to 10% when the body is immersed up to the shoulders (Takahashi, Ishihara & Aoki, 2006). Dowzer, Reilly, Cable and Nevill (1999) emphasised the benefits of running in deep water (29°C, up to chin level) to decrease the orthopaedic trauma linked with running on land, where the athlete will experience high impact forces. The antigravity effect caused by buoyancy may reduce the perception of fatigue in athletes and aide energy conservation (Wilcock et al., 2006b).

When a body is immersed in water, hydrostatic pressure as a compressive force is exerted on the body, with the pressure varying relative to the depth of immersion. This external pressure can be related to blood pressure measurement: for every one centimetre depth of immersion, the pressure increases by 0.74 mmHg. An upward squeezing action on the body is caused. A person standing in water experiences compression on the body acting inwards and upwards. Displacement of fluid from the lower extremities into the thoracic region is caused during hip-level immersion. During head-out immersion, hydrostatic pressure on the central cavity reduces residual air volume of the lungs, increasing displacement of fluids into the thorax. The movement of these fluids may enhance the ability of an athlete to recover from exercise (Wilcock et al., 2006b).

The circulatory system also reacts to water immersion. Heart rate has a tendency to decrease by approximately 4% to 6% when the body is immersed in thermo-neutral water to the level of the hips. According to Becker (2004) heart rate drops approximately 12% to 15% at 25°C. Immersion in cold water (15°C) produces a period of slowed heart rate that begins to return toward baseline at around ten minutes of immersion time. Warm and hot water immersion (40°C-41.5°C) produces a significant rise in heart rate. Regardless of the heart rate response, the individual's stroke volume will increase, causing an increase in cardiac output. These changes are temperature dependent, with cardiac output rising with increasing water temperatures (Becker, 2004; Wilcock et al., 2006b). Srámek, Simecková, Janský, Savliková and Vybíral (2000) examined the effect of hydrostatic pressure, and water at different temperatures, on hormone and cardiovascular functions in a group of young men. Participants were immersed for one hour in a head-out position in water of 32°C (thermo-neutral), 20°C, and 14°C. The researchers listed a number of effects on rectal temperature, metabolic rate, heart rate, blood pressure, and plasma cortisol and aldosterone activity. It was concluded that physiological changes induced by water immersion were mediated by humoral control mechanisms, while responses induced by cold water immersion were mainly due to the increased activity of the sympathetic nervous system.

It is suggested that the effects of water immersion on the musculoskeletal system are due to water compression, as well as reflex regulation of blood vessel tone. Blood lactate has an increased clearance rate when subjects have been partially immersed in water, indicating that blood flow through the muscle beds increase. Hydrostatic pressure may also aid the reduction of exercise-induced oedema, which might improve nutrient delivery and speed recovery from exercise that has induced muscle damage (Becker, 2004; Wilcock et al., 2006b).

Relief from the symptoms associated with DOMS has also been researched in hydrotherapy. Vaile, Halson and Gill (2007) assessed the effect of hydrotherapy on delayed onset muscle soreness in 38 strength-trained males. Each subject completed two experimental trials, separated by eight months. One trial involved passive recovery, while the other trial consisted of one of three hydrotherapy protocols to which the subjects were randomly assigned. The hydrotherapy intervention consisted of either of the following: cold-water immersion (15°C), hot-water immersion (38°C), or contrast-water therapy (15°C/38°C). After the DOMS-inducing exercise protocol (eccentric leg press with load of 120% of RM), and at 24, 48, and 72 hours post-exercise, subjects performed one of two recovery

interventions (passive or hydrotherapy). In the passive recovery session (control), subjects were seated with minimal movement for 14 minutes. Cold-water and hot-water sessions consisted of subjects being immersed in water up to their necks, with their whole body in an upright position (Vaile, 2007, personal communication) for 14 minutes. For the contrast-water therapy, subjects alternated between hot- and cold-water exposure for one minute each, for a total of 14 minutes (seven cycles). Recovery assessments included isometric squats, squat jumps, blood markers, thigh circumference, and perceived soreness. Results showed that all three hydrotherapy interventions improved the recovery of isometric force compared to passive recovery. Cold-water and contrast-water therapy significantly enhanced the recovery of dynamic power, as well as reduced the degree of post-exercise swelling of the thigh when compared to passive recovery. The only post-exercise reduction in creatine kinase response was found at 24- and 72-hours following cold-water immersion, and at 48-hours with hot-water immersion. It was suggested that hydrostatic pressure played a role in recovery following damaging exercise. Immersion in the cold water could have decreased blood flow, which might have affected oedema.

Takahashi et al. (2006) studied the effect of aqua exercise on recovery of the lower limb muscles after high-intensity eccentric exercise. Ten male long-distance runners (mean age 20 years) were divided into an aqua exercise group and a control group. All participants completed a questionnaire on muscle soreness, as well as assessments for serum creatine kinase activity, muscle power, flexibility of the legs, whole body reaction time, and muscle stiffness, pre- and post-intervention (three consecutive days after the exercise protocol). Three sets of five-minute downhill running exercise on a treadmill were performed at a speed corresponding to the runner's best time for a 5000 metre race. The aqua-exercise group performed combined exercises of walking forwards and backwards, jogging, and jumping in 29.2°C water (1.3 metre deep) for 30 minutes. The control group rested passively. The researchers found that the aqua exercise promoted recovery of muscle power, muscle soreness (calf muscles), and muscles stiffness (calf and thigh), and tended to promote recovery of whole-body reaction time more quickly than in the control group. It was suggested that the hydrostatic pressure of the water, the massaging effect of movement in the water, and the lack of eccentric work in the water could play a role in the recovery from the effects of high-intensity eccentric exercise. The massaging effect of the water could also relate to the feelings of relaxation in water immersion.

The effect of water immersion on pain perception has also been studied extensively. According to Becker (2004), a rise in pain threshold is found with an increase in water temperature and water turbulence. Plasma dopamine levels, correlating positively with an athlete's mood state, have been noted to increase during immersion (Becker, 2004).

Wilcock et al. (2006a: 203) did a review of literature to assess the effect of post-exercise water immersion on exercise performance and concluded by stating that athletes who underwent intense exercise sessions that caused prolonged muscle fatigue (muscle damage) benefited from water immersion. Benefits were also observed with athletes who performed multiple bouts of strength and plyometric exercise and water-recovery sessions. The beneficial effects of water immersion from a single-repeat, short-duration exercise were found to be trivial to small. Because the effect of water temperature on recovery is still unclear, the authors suggested that benefits from water immersion might be due to the hydrostatic pressure. Whether water immersion provides greater recovery benefits than active recovery is also unclear. Wilcock et al. (2006a) concluded by writing: "Therefore the best practice might be to use water immersion and associated water temperature according to the personal preference of the athlete. One should be aware that there are many limitations in the research... Performance parameters, exercise mode and intensity, water temperature, immersion duration, immersion depth, recovery timelines, and longitudinal effects of water immersion on performance are a few areas that require research."

Touch therapy—Massage

McGilvery et al. (2002: 100) wrote: "The sense of touch is a powerful and highly sensitive form of communication. It is a natural reaction to reach out and touch, whether to feel the shape and texture of something, or to respond to other persons, perhaps by comforting them. A mother cuddles her baby, family pets are stroked, sexual partners caress, and if we accidentally knock a limb we instinctively rub it better." The Western world is experiencing a revival of interest in many arts placing great importance on touch. These include massage, aromatherapy, reflexology, and shiatsu amongst others.

The development of massage

History shows that the Chinese were among the first to recognise the healing value of massage with the first mention of massage appearing in the oldest existing medical work, *Huang Di Nei Jing*, written in 2598 BC. This is one of the earliest documented references to massage as a health-promoting treatment (Goats, 1994a; Ward, 2004). Early Egyptians also made references to the benefits of massage. The word massage derives from the Arabic *mass*, meaning to press (Holey & Cook, 2003: 6), while *massage therapy* has a Greek origin (McGilvery et al., 2002; Ward, 2004). Greek philosophers and physicians prescribed it for its restorative powers for treating sports or war injuries, and for general preservation of the body and mind, with the art of massage becoming part of a daily ritual of relaxation (Goats, 1994a; McGilvery et al., 2002; Ward, 2004). Galen (130 – 200 AD), a physician to prominent Romans, wrote in detail about the massage methods used by the *anointers* (so called because they used oils) in their treatment of athletes, as well as other benefits of massage (Benjamin & Lamp, 1996).

The emergence of therapeutic massage in the West is attributed to French missionaries in the early nineteenth century who brought with them Chinese medical writings dating from about 2700 BC. Massage became popular throughout Europe as a result of the work of Per Henrik Ling (1776 – 1839), a Swede who developed his own system of massage from the Chinese works and pioneered the modern massage techniques (Holey & Cook, 2003; McGilvery et al., 2002; Ward, 2004). Swedish massage is the most common type of massage used in the West, which has been adopted by physiotherapists, the alternative healing professions and practitioners of recreational massage (Vickers, 1996).

Massage is a popular therapeutic technique described as “hand motions practised on the surface of the living body with a therapeutic goal” (Goats, 1994a: 149), or “... the therapeutic manipulation of soft tissue” (Vickers, 1996: 18), or “... the manipulation of the soft tissues of the body by a trained therapist as a component of a holistic therapeutic intervention” (Holey & Cook, 2003: 6).

Almost all cultures throughout history appear to have used massage as a form of health care, such as cardiac massage, massage of carotid sinus, treatment of various musculo-skeletal disorders, and for general feelings of well-being, to bring about specific and non-specific effects in the individual (Vickers, 1996). Athletes and the general public turn to massage therapists for many reasons. It is believed that massage can be used in the

treatment of a variety of conditions, such as musculo-skeletal injuries, cancer care, asthma, arthritis, constipation, headache, insomnia, anxiety and depression. It is also stated that massage improves circulation of blood and lymph, reduces muscle tightness, reduces muscle soreness and delayed onset of muscle soreness, reduces adhesions, and reduces pain. Subjectively it is often mentioned that massage just "feels good" (King, 1993; Ward, 2004: 196). Massage is widely used by the athletic population for a variety of purposes, such as injury prevention, recovery from fatigue, relaxation, and to increase performance (Hemmings, 2001). With reference to recovery, Calder (2000a: 5) wrote: "Sports massage ... is regarded as one of the most effective means of recovery."

Various applications of massage

Basic massage

Therapeutic, basic or general massage is described as "a physical therapy method that incorporates a selection of well-documented manual techniques which have been developed to improve certain ailments and conditions, and in particular musculo-skeletal problems" (Ward, 2004: 199). Lewis and Johnson (2006: 147) wrote that massage is "a group of systematic and scientific manipulations of body tissues best performed with the hands for the purpose of affecting the nervous and muscular systems and the general circulation." Massage has been adapted to also place emphasis on the psychological and spiritual aspects of treatment. Rather than just concentrating on for instance stiff joints and blood circulation through vigorous massage strokes, practitioners focus on calmness, relaxation, and feelings of being connected and more in touch with the body through more gentle and flowing treatments in a peaceful atmosphere (Vickers, 1996).

Clinical massage treatment environments are usually comfortably warm, private, and have a sufficiently spacious and relaxing environment, usually equipped amongst others with a treatment couch, towels, blankets, pillows, paper tissues, oils and lotions, and running water (Ward, 2004). Massage media that are used may include various types of oils, creams, lotions and balms to reduce skin friction during strokes. Massage oils are used for various reasons: it makes gliding and flowing movements possible, it assists in superficially warming muscles, and essential oils might add to the relaxation effect. Dry lubricant powders can be useful for clients who dislike the feel of oil or cream, or if the therapist wants to have more control and no slipping with a specific massage technique (Ward, 2004).

The fundamental massage techniques are effleurage, petrissage and tapotement, with kneading (circular compression), vibration (shaking) and friction (small range intensive stroking) that can also be added to the basic techniques (Calder, 2000a; Goats, 1994a; Ward, 2004). Effleurage is rhythmic stroking along the length or longitudinal axis of the muscle, and is often the first technique used to apply massage oil, provides initial treatment contact, gently palpates superficial tissues, relaxes the client and warms the muscles, and is also used at the end of a session. Petrissage is a kneading technique with deeper pressure applied across a muscle, where the muscle is lifted and rolled, wringed or squeezed across the longitudinal axis, and usually follows effleurage. Tapotement is a percussive technique involving rapid, light alternating strikes or chopping movements, and is generally used in massage to stimulate, tone and energise the body, and is used when finishing a section of the body, and often before and during a competition (Vickers, 1996; Ward, 2004; Micklewright, Griffin, Gladwell & Beneke, 2005b; Weerapong, Hume & Kolt, 2005). Modifications of this basic technique include hacking (using the ulnar border of the hand along the long axis of tissue), and pounding (using tightly closed fists) (Goats, 1994a). Vibrations and shaking are delivered by trembling both hands held firmly in contact with the skin. This type of massage is often used in chest physiotherapy to disperse mucus and improve respiratory function (Goats, 1994a). In a typical massage session, the therapist will use a combination of the various techniques. It should, however, be noted that Solodkov and Povareshchenkova (2006) reported that different massage techniques applied in their study, differed in their effects on neuromuscular system parameters, with some techniques having a rapid effect, while other techniques had a delayed influence.

The time allocated for an individual treatment session depends upon a particular situation and the requirements of the client. A full routine maintenance session will usually take from 45 to 90 minutes (Holey & Cook, 2003; Ward, 2004).

Sports massage

Ward (2004: 198) defines sports massage as "the systematic manual manipulation of the soft-tissues, designed to produce specific responses in the athlete and ultimately improve performance" and has been developed to help athletes prepare and recover from their training and competition. King (1993: 7) uses the term performance massage for sports massage and describes it as "the application of creative and intuitive touching skills to enhance expressive movement and athletic performance."

Sports massage is performed on people who generally have good knowledge and awareness of their bodies, who engage in regular physical activity, are fit, with toned and well-trained bodies (Benjamin & Lamp, 1996; King, 1993; Ward, 2004). It is designed to focus on improvement of athletic performance, and treatments are administered during all phases of training. Athletes can be taught to apply self-massage techniques as part of the warm-up routine. Compression, friction and percussion can easily be self-administered. Partner massage in the sport setting has the advantage that areas of the body can be reached more easily, for example the upper back.

Sports or performance massage for athletes differs from traditional therapeutic massage in terms of the following aspects: clothing stays on (bathing suit, running shorts, sweat suits or track suits), making it accessible to athletes in any location (training and locker rooms, or on-site at sporting events); no skin lubricant is needed; it is of shorter duration than most massages (30 minutes or less); and fundamental techniques can be learned by anyone, including athletes (Benjamin & Lamp, 1996; King, 1993). In comparison to a general massage, sports-massage treatments will often take place in non-ideal conditions.

Five major applications of massage in sports are often listed: recovery or restorative massage after training or competition to enhance the athlete's physical and mental recovery; maintenance massage to help the athlete maintain optimal health; remedial massage; massage as part of rehabilitation after an injury; and massage related to a specific competitive event (pre-event, inter-event, and post-event) (Benjamin & Lamp, 1996; Calder, 2000a; Ward, 2004).

Pre-event massage

A massage before exercise, performance, or competition is given as an adjunct to, but not a substitute for, the physical warm-up. Pre-event massage can be used within four hours preceding an event to assist the athlete in achieving optimal physical and psychological readiness (Benjamin & Lamp, 1996; King, 1993). A massage as part of the warm-up phase can be given for 15 to 20 minutes, 30 to 45 minutes before competition (Calder, 2000a; King, 1993). Apart from physiological reasons why massages might be administered, it may also reduce pre-competition anxiety, provide stimulation or arousal to the apathetic athlete, or be used as part of the athlete's preparation ritual. Hiskins (2001) mentioned that pre-event massage lends itself to the application of self-massage techniques, where athletes can focus on the prominent muscle groups they tend to use during the sporting event. Massage

duration should be short, and pressure applied should be light to moderate with brisk movements and not over-vigorous and deep. Emphasis should be placed on the muscles to be used for the particular activity (Benjamin & Lamp, 1996; Ward, 2004).

Inter-event massage

Massage during the event is very similar to pre-event massage. It may take place during intervals at competitions, between heats at an athletic meeting, or within training sessions. The aim is to keep the athlete in a prepared state, to reduce discomfort, to offer psychological encouragement, and accommodate high training loads (Calder, 2000a; Ward, 2004).

Post-event massage

Post-event massage normally takes place half an hour to two hours after the activity. It is mentioned that the massage should not take the place of an adequate active cool-down. Post-event massage is generally a relaxing treatment and aimed at reducing muscle tension and fatigue and lower stress levels. It is also useful as a hands-on identification of minor injuries and muscle spasms. King (1993) wrote that a post-event massage as part of the cool-down process is often seen by athletes as a reward in itself. Typical techniques used in post-event treatments include effleurage, petrissage, stroking, shaking and vibrating. Post-event massage is deeper than the pre-event massage and of slower frequency, because the emphasis is on relaxation and recovery. Techniques are focused on the main working muscles and joints of the preceding activities. At a sports event, it is not always possible for the athlete to be clean and showered for the massage. The therapist will therefore quite often work through clothes or towels, without applying oils, creams and lotions (Calder, 2000a; King, 1993; Ward, 2004).

Maintenance massage

The aims of maintenance massage are to help in the prevention of injuries, aid recovery from intensive training, improve mobility, tone and responsiveness of the body, and help improve body awareness. Athletes often like this type of massage best. It is performed in a one to one, relaxed environment, and attends to the athletes' current concerns, needs, aches and pains. The treatment session usually takes the form of a standard routine, covering the major muscle groups, or focusing on a specific body area such as the back or legs. Techniques used in the maintenance massage include effleurage, petrissage,

tapotement, frictions, stroking, soft tissue release, electro-massage, and thermal therapy (King, 1993; Ward, 2004).

It is suggested that elite or professional performers will benefit from at least two full body massages per week, or every other day in periods of hard training and competition. Sessions should be scheduled at a regular time each week to encourage massages as being an essential component of a training regime (King, 1993; Calder, 2000a; Ward, 2004).

Benefits of massage

Abundant testimonials and anecdotal evidence exist about the benefits of massage and its use in athletic training and competition. Vickers (1996) wrote that much of the data on sports massage are contradictory and many of the claims made are unsubstantiated. The majority of the studies on massage have methodological and statistical limitations, with small sample sizes, lack of control, differences in types of massage and strokes employed, varied time scales, and number of massages underwent (Vickers, 1996; Holey & Cook, 2003). Benjamin and Lamp (1996) wrote that it is a challenge to specifically explain why massage seems to enhance athletic performance.

Ward (2004) stated that massage can have two basic types of effect on the body, namely mechanical or reflexive. Mechanical effects occur directly as a result of the stretching, stroking, pressing and kneading of tissues, which lead to pumping circulation, stretching of soft tissue, breaking scar tissue, increasing microcirculation, and improving tissue permeability (Hemmings, 2001). Reflex effects occur indirectly where a chain of reactions is set up that leads to a change in function. Massage has potential physiological and psychological effects, which may directly or indirectly benefit the systems of the body (Ward, 2004). Benjamin and Lamp (1996: 9) referred to a "constellation of primary and secondary effects" produced by massage. The authors stated that sports-massage techniques lead to a chain reaction. Improved blood circulation induced as a primary effect can bring about a secondary effect such as better cell nutrition and faster recovery, optimising positive performance factors such as allowing for longer and more intense practice, thereby ultimately increasing performance potential.

A number of claims are made about the physiological benefits of massage. These include increased blood circulation, increased lymph flow, improvement in muscle tone and

flexibility, sedation of the nervous system, physiological relaxation, removal of soft adhesions, relieving pain, and effects on skin, bone, fatty tissues and the internal organs (Ward, 2004).

Skin and muscle temperature

Superficial skin friction increases local heating, and it might be that skin and muscle temperature could be increased through massage techniques. Drust et al. (2003) evaluated the effect of different durations of massage, and ultrasound treatment, on the temperature of the vastus lateralis muscle in males. Seven healthy males (mean age 28 years) attended the laboratory on four separate occasions, following a six-hour fast and no exercise 24 hours prior to the trials. Each participant was subjected to three massage sessions (5, 10 and 15 minutes), and a five-minute period of ultrasound. Trials were completed in a randomised order and conducted one week apart, at the same time of day to avoid the circadian variations in physiological variables. Intramuscular temperature of the vastus lateralis was assessed using a needle thermistor, inserted into the muscle to an initial depth of 3.5 centimetres. Deep effleurage massage was performed by a certified, experienced massage therapist for either 5, 10 or 15 minutes. Heart rate was recorded continuously. Ultrasound was applied continuously for five minutes during the ultrasound treatment. Results indicated that changes in muscle temperature at 1.5 and 2.5 centimetres were significantly greater following massage than ultrasound. No significant differences were noted between massage treatments and ultrasound when intramuscular temperature was measured at 3.5 centimetres. Heart rate and thigh skin temperature also increased significantly compared to ultrasound, irrespective of the massage duration. The researchers concluded that massage and ultrasound did not increase deep muscle temperature (deeper than 2.5 centimetres) and therefore have limited effects on deep muscle temperature.

Blood and lymph flow

It is assumed that massage enhances muscle recovery from intense exercise due to the supposed ability to speed muscle blood flow, thereby making more oxygen, nutrients and bloodborne factors accessible to damaged tissue, which might enhance tissue healing and lactate removal (Shoemaker, Tiidus & Mader, 1997; Tiidus, 2000). Techniques to determine blood flow are complicated and often inaccurate, leading to contradictory findings (Hemmings 2001). Tiidus and Shoemaker (1995) tested the effect of effleurage massage on muscle blood flow in nine healthy volunteers over the course of four days. The quadriceps

muscles of one leg on subjects were massaged for 10 minutes, three days before and immediately after quadriceps eccentric exercise, and repeated on day two and three after the eccentric exercise. Leg blood flow was determined by femoral artery and vein mean blood velocities via pulsed Doppler ultrasound velocimetry. Results indicated that massage of the quadriceps muscle did not significantly elevate arterial or venous blood velocity above resting levels, while light quadriceps muscle contractions did. It should be noted that the ultrasound only detected changes in the large artery and vein, but did not detect microcirculation in the muscles that could be affected by massage (Weerapong et al., 2005). Vickers (1996) wrote that there is evidence indicating that massage might increase local and systemic blood flow, although the massage techniques used play a major role in the effectiveness. Significant increases in blood flow were recorded after hacking, while kneading caused statistically insignificant increases in blood flow. Shoemaker, Tiidus and Mader (1997) investigated the effect of types of massage on limb blood flow, using sensitive Doppler ultrasound velocimetry as measuring instrument. Ten healthy subjects were exposed to effleurage, petrissage and tapotement on both the right forearm and quadriceps muscles, administered by a certified massage therapist. The order in which the massage techniques were administered to a given limb and the order of limbs receiving treatments were counterbalanced. Values were obtained at 5, 10, and 20 seconds and 5 minutes following the onset of massage, and then compared with values obtained prior to the massage treatment. Data from the study showed that manual massage did not elevate total limb blood flow irrespective of massage techniques on a large (quadriceps) or small (forearm flexors) muscle group. When light voluntary exercise was performed, blood flow was significantly elevated. The researchers concluded that, if elevated blood flow is the desired therapeutic effect, then light exercise would be beneficial whereas massage would not.

Weerapong et al., (2005) stated that there is a lack of confirming evidence that massage does anything significant for the blood flow physiological response, with most high-quality studies showing no change in total muscle blood flow. Tiidus (2000) also wrote that recent studies determining arterial and venous blood flow have failed to support any increment in muscle blood induced by any type of massage in large or small muscle groups. Some evidence exists as to the ability of massage to influence skin limb flow, but, because of measurement difficulties, the effect of massage on lymph flow has yet to be demonstrated convincingly (Tiidus, 2000; Vickers, 1996).

Blood lactate removal

It is suggested that accumulated lactate, and the associated hydrogen ions, are partially responsible for slowing recovery from fatigue (Gupta et al., 1996), and blood lactate is therefore used as a marker for fatigue and recovery. While the majority of lactate accumulated during exercise is removed by direct oxidation and through conversion to glycogen (Gupta et al., 1996), considerable research has been done to look for various methods of recovery to assess if oxidation can be enhanced (Hemmings, 2001).

Robertson, Watt and Galloway (2004) examined the effects of a leg massage compared with passive recovery on lactate clearance after repeated high-intensity cycling exercise. Nine healthy male games players (ages between 20-22 years), who regularly took part in rugby, hockey or football, participated in the study. Dietary intake and exercise intensity were well controlled. Subjects were in the laboratory on three separate occasions one week apart and at the same time of day. After a 15-minute rest period on arrival, a baseline blood sample was drawn. Subjects then performed a standardised light warm up, followed by six standardised 30-second high-intensity bouts of exercise on a cycle ergometer. Subjects then undertook five minutes of active recovery and then the 20-minute intervention. The intervention was either 20 minutes of passive supine rest or 20 minutes of leg massage, assigned in a randomised crossover fashion. The researchers aimed to complete a leg massage that would commonly be used during recovery periods in track and field events. Capillary blood samples were drawn at rest, after six initial high-intensity bouts, at 10 and 20 minutes of intervention, and three minutes after the Wingate test. It was concluded that no measurable effect of leg massage was observed on lactate clearance after repeated bouts of high-intensity cycling. A period of active recovery was included, because the researchers stated that, given that the beneficial effects of active recovery after intense exercise are well established, research on the effect of massage should include active recovery of some sort. The researchers stated that the lack of an observed effect on lactate clearance with massage compared to passive rest implies that there was no change in muscle blood flow and/or lactate efflux during the massage intervention or that lactate removal from the circulation was unaffected by massage.

Martin et al. (1998) examined the comparative effects of sports massage, active recovery, and rest in promoting blood lactate clearance after maximal anaerobic leg exercise. Ten competitive male cyclists (age 21-34 years) performed three successive 30-second supramaximal Wingate cycle tests on a Monark cycle ergometer, with two-minute rest

intervals between each. Venous blood samples were taken before exercise, immediately after each Wingate cycle test, five minutes after the final test, and at five-minute intervals throughout each 20-minute experimental condition. During the active recovery session, subjects pedalled for 20 minutes at an intensity of 40% VO_{2max} . During the passive condition, they remained lying in a supine position for 20 minutes, while the massage condition consisted of a 20-minute massage of the legs using techniques to promote increased blood flow. The results of the investigation support the use of active recovery in accelerating the decrease of metabolic acidosis following high-intensity anaerobic exercise. Active recovery produced significant decreases in measures of blood lactate concentration, while no significant difference was found between a sports massage and rest for changes in blood lactate concentration.

The findings of Martin et al. (1998) were substantiated in a study by Monedero and Donne (2000) who investigated the effect of four 15-minute recovery interventions on lactic acid removal after maximal exercise, and subsequent performance after recovery. The subjects, 18 trained male cyclists (mean age 25 years), were tested on six separate occasions over a period of three weeks. Each subject performed two five-kilometre maximal cycling efforts on a King-cycle trainer/tester unit and on the cyclist's own bicycle. Following the first five-kilometre test, the subjects remained stationary on the bicycle for one minute, after which the different recovery interventions took place. The second five-kilometre test was performed after the recovery interventions. Performance time for the tests, blood lactate (during the tests and at three-minute intervals during recovery), and heart rate were recorded. During passive recovery, the subject sat at rest on a chair for 15 minutes. Active recovery consisted of cycling at 50% of VO_{2max} , while massage consisted of effleurage, stroking and tapotement applied to the lower extremities. Combined recovery consisted of pedalling at 50% of VO_{2max} for 3.75 minutes, followed by massage for 7.5 minutes, and finally cycling again for 3.75 minutes. Results showed that active exercise was better than passive rest or massage at removing blood lactate at 9 and 12 minutes.

Studies have demonstrated that massage does not increase the rate of post-exercise blood lactate clearance (Barnett, 2006), while mild exercise can significantly speed up its removal. Findings therefore suggest that active warm-down strategies may be more efficient than massage at removing lactate in the recovery phase following exercise (Hemmings, 2001; Tiidus, 2000).

Delayed onset of muscle soreness (DOMS) and musculoskeletal pain

Athletes who engage in a sudden increase in intensity of training often experience muscle soreness from predominantly eccentric muscle actions. Soreness usually begins 24 hours after exercise, peaks 48 to 72 hours after the activity and continues for several days after activity, hence the term delayed onset of muscle soreness (DOMS) (Jönhagen, Ackermann, Eriksson, Saartok & Renström, 2004; Mancinelli et al., 2006). Massage has long been used as a means for alleviating the after-game or post-event muscle soreness. Reaburn (2003: 38) wrote: "Masseurs are invariably found waiting at finish lines of fun runs or triathlons and in tents at major sporting competitions with all athletes believing that the post-event massage will take away the aches and pains the next day."

Hilbert, Sforzo and Swensen (2003) wanted to investigate the physiological and psychological effects of massage on delayed onset muscle soreness. Eighteen participants (mean age 20.4 years) underwent baseline tests consisting of POMS, range of motion for the hamstring, five maximal eccentric contractions with the hamstrings, and two sets of 12 descriptor items that measure both the intensity and unpleasantness of soreness. A blood sample (5 ml) was then taken by a venipuncture. Subjects were then randomly assigned to a massage intervention group or a control. Experimental treatment for each subject consisted of a isokinetic warm up protocol, followed by six sets of 10 maximal eccentric contractions with the hamstrings, with one minute rest between the sets. Each subject then completed five more maximal eccentric contractions. Subjects returned two hours later and peak torque was again measured. Subjects then received 20 minutes of massage or control treatment. Massage treatment consisted of five minutes effleurage, one minute tapotement, 12 minutes petrissage, and two minutes of effleurage. The control treatment consisted of a placebo lotion applied to the legs by the therapist, who then instructed the subjects to rest for 20 minutes while listening to the same audiotape heard by the massage group. After the treatment, subjects completed a POMS questionnaire. At six hours and 24 hours post-exercise, subjects returned to the laboratory for measurements of mood states, range of motion, peak torque, soreness, and neutrophil levels. Final data collection occurred 48 hours post-exercise. Results showed that massage conducted two hours after strenuous eccentric exercise did not alter the circulating neutrophil count, peak torque, or range of motion. It was also stated that the effects of massage might be more psychological than physiological, because the massage lowered soreness intensity at 48 hours post-exercise. The researchers stated possible explanations for the decreases in muscle soreness, being improved sleep

patterns, increased endorphin and serotonin levels, and decreased levels in stress hormones following treatment.

Jönhagen et al. (2004) examined the potential ability of sports massage to reduce DOMS. Sixteen subjects, eight men and eight women (mean age 28 years), participated in the study. All subjects were recreational athletes who exercised two to three times per week. Subjects were seated in a Kin-Com dynamometer, and the quadriceps muscles of each leg performed 300 maximal eccentric contractions. The exercise session lasted 30 minutes. Within ten minutes after the exercise, subjects were treated with sports massages by an experienced sport physical therapist, using massage oil during the treatment. One leg was randomised to massage, while the other leg did not receive any treatment. The massage started with four minutes of effleurage and was completed with eight minutes of petrissage. Massage was also given once daily for another two days. The subjects rated the pain and discomfort of both legs on a visual analogue scale. Subjects had to indicate the pain before and after exercise, as well as before and after the massage sessions. The study demonstrated that the sports massage given did not have any local effects in reducing DOMS of the quadriceps muscle.

Twenty-two NCAA Division I women basketball and volleyball players (mean age 20 years) participated in a study by Mancinelli et al. (2006) to determine if post-exercise massage had an effect on DOMS. Measures were taken on the first day of pre-season training, and then repeated on day four that was predicted as the day of peak soreness (two days after the first intense training session). Pressure pain threshold of the anterior thigh was evaluated using pressure algometry. Subjects also provided their perception of muscle soreness using a 10-point visual analogue scale. Subjects were randomised into a treatment group (n=11), receiving a thigh massage using effleurage, petrissage and vibration by two licensed massage therapists, or a control group (n=11) who rested, without any stretching or activity. Each 17-minute massage session around the knee and anterior and medial thigh followed the following routine: four minutes of effleurage, six minutes of petrissage (kneading), two minutes of vibration, two minutes of petrissage (pressing and rolling), and then culminated with three minutes of effleurage. A tape recording was played to announce the changing of strokes. The researchers found that massage decreased perceived soreness in the experimental group, as well as a significant change in algometry measures of the left leg.

It has been pointed out that massage is an instinctive response to pain—one of the first responses to injury is to rub the affected part. Vickers (1996) wrote that, although practitioners claim that massage relieves pain, there is almost complete absence of reliable evidence regarding the effect of massage on pain. The potential of repeated massage therapy interventions to influence recovery of quadriceps and hamstring muscle soreness, recovery of quadriceps and hamstring muscle strength, and reduction of upper leg muscle swelling was evaluated by Dawson, Dawson and Tiidus (2004).

The researchers wanted to assess the ability of massage to enhance recovery after running a half marathon road race. Twenty reasonably well-established runners (mean age 35.2 years) with a mean running experience of 65.7 months participated in the study. Ninety-one percent of the runners were not using massage therapy as part of their training regime, while 58% of the runners had never used massage previously. All the participants indicated that they were using the typical post-race strategies of stretching and icing. The CYBEX II isokinetic dynamometer was used to measure quadriceps and hamstring strength. Thigh circumference was measured to assess leg swelling. An adapted Graphic Ratings Scale (GRS) was used to assess soreness perception. Each participant had one leg randomly massaged, while the non-massaged leg served as the control. Two registered massage therapists administered the 30-minute treatment. Treatment began with effleurage (five minutes), followed by petrissage (15 minutes), then passive stretching movements (five minutes), petrissage to the lower back (three minutes), and finished with effleurage (two minutes). On days 1, 4, 8, and 11 post-race assessments of pain, strength, and leg circumference were performed. During each of the post-race test days, the participants were measured first for circumference of the upper thighs, then tested on the CYBEX, and finally massaged for 30 minutes. Results indicated that the massage leg did not return to baseline measures of strength, soreness, or leg circumference any faster than the control group. The researchers concluded by stating that therapeutic massage post race did not alleviate physiological symptoms of endurance activities such as muscle strength loss, swelling or soreness faster than the no treatment condition. A qualitative review of the participants' comments indicated that the massaged leg felt more relaxed, felt looser when running, felt better while weight lifting, felt better when walking downstairs. The researchers mentioned that massage might have positive effects on perceptions of recovery, and that the subjective perception of recovery following massage and how it might influence other holistic aspects of post-race recovery should be investigated (Dawson et al., 2004: 42).

Barnett (2006) argued that, if massage leads to a higher perception of recovery and a reduced perception of soreness, athletes might attempt training loads beyond their current capacity. Lewis and Johnson (2006) did an expanded review of randomised controlled clinical trials and experimental studies on the effectiveness of therapeutic massage for the symptomatic relief of musculoskeletal pain in healthy subjects. Although the researchers identified about 7000 titles in their initial search of electronic databases, only 20 full published reports (1341 participants) were relevant, and matched the inclusion criteria. Lewis and Johnson (2006: 156) concluded that "the available evidence of the effectiveness of massage for the relief of musculoskeletal pain is inconclusive and not convincing."

Myofascial release through adapted massage techniques is becoming popular in the management of musculoskeletal pain, with an attempt to manipulate connective tissue and stretch fascia bonding which is either stretched/contracted ('locked long') or shortened/contracted ('locked short') (Holey & Cook, 2003; Myers, 2001).

Performance benefits

Frequent claims are made in sports literature that massage can enhance athletic performance. Studies on massage in this area typically used performance times and muscle force parameters as variables to assess the effects of massage on athletic performance.

Twelve male subjects participated in a study by Cafarelli, Sim, Carolan and Liebesman (1990) to determine the effect of vibratory massage on recovery from repeated sub-maximal contractions. Repeated, static contractions of the quadriceps at 70% maximal voluntary contraction were performed until the subject could no longer produce the required 70%. This was repeated three times and the rate of fatigue was calculated. Rate of fatigue was also calculated during static exercise following 30 minutes of cycling at 75% VO_{2max} . During the control conditions, subjects rested for five minutes between each of the three series of contractions, while subjects in the experimental condition received four minutes of percussive vibratory massage and one minute of rest. Results showed that there was no significant difference in the rate of fatigue in either static or following dynamic exercise between the control and vibrated conditions. It was concluded that short-term recovery from intense muscular activity was not augmented by percussive vibratory massage.

Hemmings, Smith, Graydon and Dyson (2000) investigated the effect of massage on perceived recovery and blood lactate removal, and also examined the effects of massage on

repeated boxing performance. Eight amateur boxers completed two performances on a boxing ergometer on two occasions in a counterbalanced design. After the first performance, the boxers received a massage or a passive rest intervention. Perceived recovery ratings were given before completing a second performance. Heart rates, blood lactate and glucose levels were also assessed before, during and after all performances. Results showed that the massage intervention significantly increased perceptions of recovery compared to the rest intervention. No differences in blood lactate or glucose levels following massage or passive rest interventions were found. A decrement in punching force between the first and second performance on the boxing ergometer was found. It was concluded that the findings provided support for the psychological benefits of massage, but raised questions about the benefit of massage for physiological restoration and repeated sports performance.

Mancinelli et al. (2006) did not only determine if post-exercise massage had an effect on DOMS, as reported previously, but also wanted to assess the effects of massage on physical performance. Twenty-two NCAA Division I basketball and volleyball players underwent baseline measurements which included height, weight, vertical jump displacement, shuttle run times (speed and agility), quadriceps femoris length, and pressure-pain threshold. Baseline measures were followed by randomisation and participation in routine pre-season training by a strength and conditioning coach. Subjects were randomised into a treatment group (n=11), receiving a thigh massage using effleurage, petrissage and vibration by two licensed massage therapists, or a control group (n=11) who rested, without any stretching or activity. Each 17-minute massage session around the knee and anterior and medial thigh followed the following routine: four minutes of effleurage, six minutes of petrissage (kneading), two minutes of vibration, two minutes of petrissage (pressing and rolling), and then culminated with three minutes of effleurage. A tape recording was played to announce the changing of strokes. The researchers concluded that massage improved vertical jump displacement, but not shuttle run times. Both the experimental and control group shuttle run times slowed. No significant differences were found between the pre-massage and post-massage measures for quadriceps femoris length.

Jönhagen et al. (2004) examined the effect of sports massage on maximal quadriceps strength and functional one-legged hops in 16 recreational athletes (mean age 28 years). Subjects performed 300 maximal eccentric contractions of the quadriceps muscle bilaterally. Massage (effleurage and petrissage) was given to one leg, whereas the other leg served as a control. Subjects were treated once daily for three days. Maximal strength was tested on a

Kin-Com dynamometer, and functional tests were based on three one-legged hops. The researchers stated that the functional test is dependent on muscle strength as well as coordination, therefore it could also be a test of the recovery of the neuromuscular system involved. No significant differences were found in maximal strength testing results between the treated leg and the control leg before exercise, directly after exercise, and two days after the exercise. The result patterns were similar for the functional one-legged hop. It was concluded that the sports massage was not efficient in influencing local recovery by reducing functional loss as measured with the one-legged hop, or decreased muscle strength following hard eccentric exercise of the quadriceps muscle.

The effects of massage on mood state and exercise performance together were studied by Micklewright, Griffin, Gladwell and Beneke (2005a). Ten male and six female participants (mean age 22 years), who had participated in a minimum of 30 minutes of moderate intensity physical activity two to four times per week, were randomly assigned to either massage therapy or rest condition sequences, with the order of the conditions counterbalanced. Participants completed the POMS immediately before and after the rest and massage interventions, and immediately after the Wingate anaerobic cycling test (WAnT). In the rest condition, participants remained in the supine position on a massage couch for 30 minutes in a quiet room. In the massage condition, participants received a 30-minute back massage, using a combination of effleurage and petrissage. Back massage was selected in order to avoid manipulating the muscle groups of the legs, which would be recruited during the Wingate anaerobic cycling test. After each 30-minute intervention, cycling performance was measured using the 30-second Wingate anaerobic cycling test as maximal effort short duration task. Results indicated a significantly better WAnT performance in the massage condition than in the rest condition. Massage did not have any positive effect on mood state. The researchers stated that the pre-intervention mood states of the subjects were positive, and that the effects might have been different upon negative mood states. It could also be that the anticipation of performing a maximal cycling task might have had a dampening effect on the POMS response to massage.

With reference to their study on the effect of effleurage on the intramuscular temperature in the vastus lateralis, Drust et al. (2003) stated that massage had limited effects on deep muscle temperature. Massage is associated with superficial warming and is therefore fundamentally different from the mechanisms of heating associated with other types of pre-warming or warm-up. Massage might elevate muscle temperature from the outside as a

result of mechanical manipulations, while more active techniques elevate temperature from the inside, partially due to skeletal muscle metabolism. This could indicate that massage would not elevate performance in subsequent exercise.

Holey and Cook (2003) wrote that the timing of post-event massage is crucial. The authors referred to Soviet literature when they stated that massage should be conducted two hours after an athletic event for the best therapeutic benefit and enhanced athletic performance. They also mentioned that there are thoughts that an intense, vigorous massage might stress the body like a training session and that activity should therefore be reduced slightly over the following 24 to 48 hours.

Psychological benefits from massage

Goats (1994b: 155) wrote that "manual therapy is a well documented aid to relaxation", and stated that physical relaxation might accelerate physical repair. The psychological benefits of sports massage are reported as enhanced emotional well-being, calmness, improved mood, relaxation and reduced anxiety. Links between psychology and muscle tone are widely recognised, and one of the most common reasons for the use of massage is to calm and soothe. Vickers (1996) wrote that "tense" can be used to describe both a muscle and a mental state, and particular patterns of muscular tension are associated with particular emotions.

Research on massage is often done in institutional and hospital settings. Field et al. (1992) found that massage was of benefit for depressed and adjustment disorder children and adolescents. A total of 52 subjects received either a 30-minute back massage or watched relaxing videotapes for five days. The effect of massage was assessed through POMS, night time sleep, pulse rate, behaviour ratings, and levels of cortisol and catecholamines. Massage had positive effects immediately after treatment, and differences between the massage and control groups still existed at the end of the trial. It was concluded that massage lead to a decrease in the stress response in depressed subjects over the five-day period.

A hundred post-cardiac-surgery patients were randomised into four groups. Two groups received a gentle 20-minute foot-massage with or without essential oils, while the other two groups were submitted to a chat or no intervention. Physiological effects were assessed by measuring heart rate, respiratory rate and blood pressure. Psychological effects were measured by means of a modified Spielberger questionnaire which assessed pain, anxiety,

tension, calm, rest and relaxation. Assessments were repeated on five occasions both before and after the intervention. The physiological effects of massage were minor, but the psychological changes were statistically significant. Vickers (1996) concluded that evidence does exist to show that massage can lead to a lowering of anxiety scores in healthy subjects. The mechanical stimulation from massage might stimulate parasympathetic activity as shown by reduced saliva cortisol levels (an indirect measure of parasympathetic activity) (Weerapong et al., 2005). Leivadi et al. (1999) studied the effects of massage or relaxation therapy in 30 female university dancers over a period of five weeks. Dancers were randomly assigned to a massage or relaxation therapy group, and underwent a 30-minute session twice a week. Both groups reported a less depressed mood (assessed through the POMS) and lowered anxiety levels, but saliva cortisol decreased only for the massage therapy group. Field, Hernandez-Reif, Diego, Schanberg and Kuhn (2005) did an extensive review of the effects of massage therapy, including studies on depression, pain syndrome, immune studies (HIV and breast cancer), reduction of stress on the job, and pregnancy stress. The researchers concluded by stating: "Although each condition may be affected by massage therapy in some unique ways, some effects generalize across these highly variable conditions. Of these, the stress reduction effects (cortisol reduction) of massage therapy and the activation effects (increased serotonin and dopamine) would appear to generalize across conditions" (Field et al., 2005: 1398).

Cady and Jones (1997) wrote that on-site massage of a seated person is becoming an increasingly popular and accepted intervention for reducing stress in the workplace. The researchers examined whether a 15-minute on-site massage at the workplace could show significant reductions in physiological indicators of stress. Fifty-two white-collar state government employees (mean age 40 years) were given a massage by a licensed massage therapist. A significant reduction in blood pressure after the massage was found.

The relationship between emotional state and athletic performance has been explored by several researchers. It would seem that suboptimal athletic performance is an expected consequence of a negative mood state, while individuals with a positive mood state with low levels of depression are more likely to perform well. It is also stated that oscillating psychological states including mood have been found to be quite normal among elite athletic performers, particularly during periods of intense training. Micklewright et al. (2005a) stated that massage might be used to reverse a negative psychological state detected in an athlete.

Micklewright et al. (2005b) compared changes in mood state following various types of massage. Thirty-two subjects were randomly assigned among four 10-minute conditions, which consisted of supine rest, effleurage, petrissage and tapotement. POMS was used to measure mood states before and after each condition. Results indicated that effleurage lead to significant reduction in anger and fatigue. Following petrissage there was a significant reduction in fatigue, while tapotement lead to a significant reduction in tension and depression. The researchers concluded that a reduction in negative mood states scores occurred after all of the massage interventions and that combined massage intervention remains a useful means of manipulating mood states.

A meta-analysis of massage therapy research was done by Moyer, Rounds and Hannum (2004). Studies were included if a massage therapy group was compared with one or more non-massage therapy groups, if subjects were randomly assigned to groups, and if sufficient data were reported for a between-groups effect size to be generated on at least one dependent variable of interest. The researchers analysed single-dose effects, multiple-dose effects, moderator variables such as length of massage sessions, gender, age, therapist training, and laboratory effect. Thirty seven studies on massage therapy met the inclusion criteria. Single applications of massage therapy were effective in reducing state anxiety and blood pressure. The researchers concluded that "reductions of trait anxiety and depression were massage therapy's largest effects, with a course of treatment providing benefits similar in magnitude to those of psychotherapy" (Moyer et al., 2004: 14). It was also stated that even relatively short sessions of massage therapy could be effective, and that laypersons with some training could provide beneficial massage therapy, although a study by Moraska (2007) showed that the level of therapist training had an impact on the effectiveness of massage as a post-race recovery tool for runners, where therapists with 950 hours of training were more effective than with 450 or 700 hours of training.

Tiidus (2000) and Hemmings (2001) wrote that the scientific evidence supporting the psychological benefits of massage is growing, with several studies reporting a significant psychological effect in terms of relaxation, or mood enhancement benefits to the athletes, with these benefits being potentially of significant importance to athletes.

Weerapong et al. (2005: 247) wrote: "It is believed that one of the greatest advantages of sport massage is to overcome fatigue and reduce recovery time, especially during periods of competition, and consequently, enhance performance at the next event. Even though many

elite athletes believe that massage is an important part of their success, the effects of massage itself are still questioned." The authors stated that there are a few, well controlled studies that have examined the potential for massage to influence performance, recovery or injury risks. If psychological effects of fatigue are to be considered then massage might provide some benefit.

Robertson et al. (2004) also stated that most of the claims that massage can aide recovery and optimise performance are anecdotal or come from research flawed by methodological variations and poor experimental control. According to the authors, literature does support the psychological benefits from massage, but physiological and performance benefits have not been consistently observed. Hemmings (2001: 165) wrote: "recent research seems to demonstrate massage having positive effects on perceptions of recovery."

Massage therapy is one of the fastest growing sectors of the expanding complementary and alternative medical therapies, and the use of massage by the athletic population for a variety of purposes is growing. Tiidus (1997) concluded after a review of literature that manual massage did not have a demonstrated effect on muscle damage caused by eccentric muscle action, or on the retention and recovery of muscle strength and performance following eccentric muscle damage, or reduction of delayed onset muscle soreness, or the recovery of muscle strength and performance following anaerobic exercise. Calder (1996: 7-9) stated that a major benefit of massage lies in the relaxation that athletes experience when massaged, which can make them feel less fatigued and more relaxed, with a corresponding improvement in mood state. She also added that one of the greatest benefits might be the biofeedback that athletes gain as they become more aware of their body and which muscles and body parts are stressed. Being "tuned in" to the way the body has been stressed can help the athlete identify and manage the stressed areas better.

A number of researchers concluded that more scientific research on the effects of massage needs to be undertaken to clarify the precise effects of massage for athletes (Callaghan, 1993; Hemmings, 2001; Menard, 2002; Moyer et al., 2004; Tiidus, 1997; Tiidus, 2000; Weerapong et al., 2005).

Compression therapy

Devices that compress tissue are sometimes being added to gain the therapeutic and performance benefits accredited to massage. Warm flowing water is the basis for many massage treatments, which can include "undercurrent massage" with an underwater jet applied to the skin, "needle showers" of fine, forceful jets of water, or the jacuzzi (Goats, 1994a: 151).

The use of compression clothing such as elastic shorts, tights, vests and stockings has become increasingly widespread among athletes in an attempt to aid recovery following exercise, and enhance subsequent performance. The main feature of compression clothing is the high Lycra content, which imparts a stretching quality to material. The amount of Lycra in the fabric determines how strong the compression will be (Harrison & Thompson, 2007).

Results from a study by Viitasalo et al. (1995) showed that underwater water-jet massage enhanced the maintenance of neuro-muscular performance capacity. Fourteen junior track and field athletes spent, in randomised order, two identical training weeks, engaging in five strength and power training sessions lasting three days. During the treatment week, underwater jet massage was used three times for 20 minutes each. Results showed that continuous jumping power decreased and ground contact time increased significantly less during the treatment week than during the control week. It was suggested that the warm underwater water-jet massage in combination with intense strength and power training increased the release of proteins from muscle tissue into the blood and enhanced the maintenance of neuro-muscular performance.

One of the reasons stated for use of the compression garment, is the positive effect it might have on the control of oedema. Initial studies on the use of compression garments focused on postoperative patients and the potential protection that compression could provide against a venous thrombosis (Harrison & Thompson, 2007). Healthy individuals show a diurnal volume change or oedema of the lower legs during a working day. Jonker, de Boer, Adèr and Bezemer (2001) monitored the diurnal volume change of the lower legs during full working days in 116 healthy volunteers (60 males and 56 females), and found that healthy females had a 2.3% daily volume increase of the legs, and healthy males an increase of 1.6%. This common phenomenon is often accompanied by feelings of heaviness, tiredness

and even pain. The researchers wanted to assess the effect of mild compression through lycra support stockings on the development of swelling and on subjective feelings in healthy adults, without venous insufficiency. Participants were randomly divided into two groups for a cross-over study between two kinds of support stockings (pressure at the ankle of 14 mmHg and 18 mmHg respectively) and a control stocking exerting 6 mmHg at the ankle (the lowest pressure technically possible for the manufacturer). Each stocking was worn for five days. Volume measurements were done at the beginning and end of a full working day on two days. It was shown that both support stockings induced significantly lower diurnal volume increase than the control stocking, with the diurnal volume increase significantly lower while wearing the 18 mmHg-stocking. Beneficial effects on subjective complaints of tired feelings and swollen ankles and feet were also found. O'Brien and Chennubhotla (2005) also showed that compression garments could be helpful in the treatment of lymphedema.

It is suggested that compression garments might enhance recovery and physical performance in athletes. A study by Kraemer et al. (2001) to determine if a compression sleeve, worn after maximal eccentric exercise would enhance recovery of physical function and decrease symptoms of soreness, showed that the compression garments maintained muscle function and reduced perceived muscle soreness. Twenty women, unaccustomed to strength training, participated in the study, and were randomly placed into a control group (n=10) or an experimental compression sleeve group (n=10). The experimental group wore a compressive sleeve garment for five days following eccentric exercise. Eccentric exercise consisted of two sets of 50 passive arm curls with the dominant arm on an isokinetic dynamometer. One repetition maximum elbow flexion, upper arm circumference, relaxed elbow angle, blood serum cortisol, creatine kinase, lactate dehydrogenase, and perception of soreness questionnaires were collected prior to the exercise bout and daily thereafter for five days. Compression sleeve use prevented loss of elbow motion, decreased perceived soreness, reduced swelling, and promoted recovery of force production, which was attributed to the effect of the compression garments preventing oedema within the muscle.

A study by Gustafson (1998) with 60 females (age 18 to 25 years) did not support the claim that compression clothing could delay the onset of fatigue. No significant difference in rating of perceived exertion between subjects wearing compression shorts and subjects wearing loose-fitting shorts was found. Eleven male recreational athletes (mean age 21.2 years) participated in a study by Trenell, Rooney, Sue and Thompson (2006) to assess the effect of compression garments applied after eccentric exercise. Subjects completed 30 minutes of downhill walking as eccentric muscle exercise and immediately following exercise wore

graduated compression garments on one leg for 48 hours. Compression garments covered the calf and thigh on the leg. The non-compressed leg acted as internal control. Phosphorous magnetic resonance spectroscopy (P-MRS) was used as a non-invasive appraisal of phosphorous containing metabolites. P-MRS evaluations and perceived muscle soreness assessments were made at baseline and repeated one hour and 48 hours following the downhill walking. Results showed no significant difference in perceived muscle soreness between the two legs at any points in time, suggesting that compression garments showed no treatment effect on DOMS. Results from P-MRS evaluations led the researchers to conclude that wearing the compression garments in the recovery from eccentric exercise might alter the inflammatory response to damage and accelerate the repair processes inside the muscle.

Gill et al. (2006) focused on compression clothing and its potential to aid post-exercise recovery. Twenty-three elite male rugby players were monitored immediately after, and then 36 and 48 hours after competitive rugby matches to examine the effectiveness of four interventions on the rate and magnitude of muscle damage recovery, as measured by creatine kinase (CK). Players were randomly assigned to either contrast water therapy, low-intensity active cool down, passive recovery, or compression tights. No significant difference in CK recovery was observed between the contrast water therapy, low-intensity active cool down, and compression tights at any of the time points.

Harrison and Thompson (2007) stated that there might be recovery benefits in wearing compression clothing, including optimisation of blood flow, reducing blood pooling, and reducing swelling. Ali, Caine and Snow (2007) suggested that an improvement in venous return during and after exercise might facilitate the clearance of metabolites produced during exercise.

Ali et al. (2007) examined the effect of wearing graduated compression stockings on physiological and perceptual variables during and after intermittent, and continuous running exercise. Fourteen recreational runners (mean age 22 years) performed two multi-stage intermittent shuttle running tests with one hour recovery between tests. A further 14 participants (mean age 23 years) performed a fast-paced continuous 10-kilometre road run. Participants in the experimental group wore commercially available knee-length graduated compression stockings (pressure at ankle 18 - 22 mmHg) beneath ankle-length sports socks, while the control group just wore ankle-length sports socks, in a randomized

counterbalanced design. For the intermittent shuttle running, no performance or physiological differences were observed between conditions. During the 10-kilometre trials, there was a reduction in delayed-onset muscle soreness 24 hours after exercise when wearing graduated compression stockings. The researchers concluded that wearing graduated compression stockings during a 10-kilometre road run appeared to reduce delayed-onset muscle soreness after exercise in recreationally active men.

The effect of wearing full-body compression garments on throwing and repeat-sprint performances in 10 club-level cricket players (mean age 22 years) was assessed by Duffield and Portus (2007). The researchers also compared three varieties of full-body compression garments, namely, Skins, Adidas and Under Armour (UA). All compression garments were worn throughout the testing session and during the 24 hours after exercise. In terms of exercise performance, there were no significant differences in 10- or 20-metre sprint times. There was also no improvement in maximal throw distance or total distance thrown. No differences in heart rate, body mass difference, or blood measures of lactate were found. Significant differences were found for lower 24-hour post-exercise CK values and lower post-exercise ratings of muscle soreness in the compression-garment conditions. The researchers concluded by stating that little performance benefit was noted when using the compression garments. Compression garments could be used as recovery tool after intense exercise and may help to reduce post-exercise swelling, reduce post-exercise perceived muscle soreness, and promote greater psychological comfort.

Other physical recovery methods

There are some other physical recovery methods that are used which might be beneficial to the regeneration process, although it is not discussed in detail. Electrophysical modalities for electro-therapy can include electro-massage, gyratory vibrators, infra-red lamps, ultrasound (Ward, 2004), electromyostimulation or electrical muscle stimulation (EMS), transcutaneous electrical nerve stimulation (TENS) (O'Connor & Hurley, 2003; Ward, 2004), and laser therapy (Siff & Verkhoshansky, 1993). The following physical recovery methods are also mentioned in literature, namely, balneo-therapy (Bompa, 1999), barotherapy (Siff & Verkhoshansky, 1993), and hyperbaric oxygen therapy (Barnett, 2006).

Psychosocial strategies

Physical, mental, emotional, and social components in the athletic environment are dynamically related, especially in a team-sport setting. Most physical training programmes today are designed to be of high quality and can, when regeneration is optimal, push the athlete right to the edge. But, athletes today are facing more mental and emotional demands daily than ever before. Tight training schedules put pressure on personal relationships, and personal space and time for recovery techniques are often disappearing (Botterill & Wilson, 2002). The researchers indicated that athletes often increase volume and/or intensity of training, because hard training often gives athletes a feeling of accomplishment, with training often becoming “therapeutic” and a conditioned response to setback, guilt, or failure (Botterill & Wilson, 2002: 146), instead of applying suitable psychological coping skills.

Onestak (1991) also mentioned that, at the highest level of competition, differences in skill level itself are typically minimal. Coaches and athletes are increasingly perceiving that strength, speed, co-ordination, and other athletic abilities are in themselves not enough to produce a champion. The mental aspects of sport are also crucial determinants of success or failure. Andrew, Grobbelaar and Potgieter (2007: 2) referred to a number of studies on the relationship between different sport psychological skills and rugby performance which indicated the positive contribution of sport psychological skills for success in rugby, with, for instance, better general coping skills, better concentration skills, higher scores in mental preparation and confidence, and less worries. Although these studies did not specifically focus on the use of psychological skills for regeneration, it might positively influence the regeneration process if athletes know how to cope with the stresses, and “have less worries”.

A number of strategies relating to the psychological regeneration of athletes have been discussed previously under the natural and physical strategies. These include, for example, the role of sleep, nutrition, hydrotherapy, and massage, which will not be discussed again in this section.

Factors relating to emotional aspects of regeneration

Athletes are often excessively stressed at key times during the year: competitions and tournaments, having lost a game, or having performed below expectations. Jake White, coach of the Springbok rugby team who won the Rugby World Cup in 2007, recalled an incident where one of his senior, experienced players broke down and cried after a disappointing loss. White wrote: "He sat there and sobbed his eyes out. ...He was very emotional. ...And even the best of them hurt.Just being on the field in a test requires extraordinary commitment and tremendous sacrifice to get there" (White & Ray, 2007: 195).

In an assessment of the effects of game outcome, harbouring pleasant and unpleasant emotions and stress during elite-level competition, Kerr, Wilson, Bowling and Sheahan (2005) found that emotions and stress reflected the team's success in a tournament. Sixteen members of the Japanese women's field hockey team (mean age 22.1 years), playing in a world cup preliminary qualifying tournament, were monitored before and after each of their seven games. The team had a successful tournament: won five of the six matches leading to the final, and then losing in the final. After the loss in the first match, scores for anxiety, humiliation, and sullenness were high, with low scores on excitement and relaxation. Pleasant emotions increased, and external tension stress decreased as the tournament proceeded and the team were more successful.

The emotional domain is seen as a very powerful domain. Botteril and Wilson (2002: 145) wrote:

"When individuals are emotionally healthy, they have tremendous capacities to process and harness emotions. They usually enjoy extensive natural energy, and the tasks in the physical and mental domains are handled with enjoyment, gratitude, and efficiency; recovery is usually proactive and efficient. In addition to being powerful, the emotional system is also tremendously resilient, as long as it is managed properly. When the emotional domain is exhausted, the performer's capacities in all three domains can be affected."

Effective "emotional management" is important and can affect the athlete's ability to perform, regenerate, and stay healthy. The inability to manage emotions can lead to underperformance and health problems. Botterill and Wilson (2002: 149) indicated that

emotional mismanagement costs society immensely and stated: "Fear out of control leads to anxiety. Anger out of control leads to violence. Guilt and sadness out of control lead to depression." The authors concluded that it is amazing how few people are taught emotional management, and advise athletes to have regular "emotional processing" sessions with people they trust to enhance emotional health, performance, and regeneration. The ability to process emotions effectively and being and feeling genuine and at peace can make a big difference in athletes in terms of regeneration. It is suggested that athletes should get much more assistance in learning and mastering emotional intelligence.

Stevens and Lane (2000) stated that, since mood is an important predictor of performance, the ability to control mood would be a useful psychological tool for any athlete. Davis et al. (2002) also emphasised the importance of emotional management when they addressed the effect of high-intensity training and underrecovery on mood, stating that it evokes acute negative emotional changes as well as more stable negative mood states. The authors described three forms of negative mood, namely, depressive thinking, anxiety, and fear, which often lead to low self-regulation. Athletes with low self-regulation often sabotage training effectiveness with low self-discipline in areas of nutrition, sleep, and social activities. Excessive alcohol on days off, binge eating, and a tendency to keep exercising while ignoring fatigue, soreness, and injury can also be attributed to low self-regulation.

Psychological skills associated with developing emotional control involve a variety of relaxation strategies. According to Calder (2000a) and Davis et al. (2002: 172), relaxation techniques are essential for the "toolbox" of the athlete; calming mind and body, lessening muscle tension, decreasing subjective anxiety and perceived stress, helping to cope with the consequences of poor self-regulation and anxiety, assisting recovery after traveling, and facilitating deep and restful sleep (Calder, 2000a; Davis et al., 2002; Orlick, 2000). Davis et al. (2002) referred to various researchers when they mentioned that relaxation techniques can be divided into two categories. The first category involves "muscle-to-mind" techniques, in which athletes train their sensitivity to muscle tension and learn to release that tension. Breathing exercises and progressive muscle relaxation are examples. The second category involves "mind-to-muscle" techniques which involve cognitive or mental approaches, such as meditation and visualisation.

Bompa (1999) stated that the various techniques that can be used are highly individual—what works for one athlete, may not work for another. The relaxation strategies used will

depend upon the nature of the stressors the athletes experience, and personal preference (Jeffreys, 2005). It is also important to understand that the techniques, like any sport skill, require regular practice to be most effective (Calder, 2000a).

Relaxation techniques

Progressive muscle relaxation (PMR)

Schomer (1992: 2) wrote that progressive relaxation is a method “whereby the neuro-muscular system, as well as the mind, could be brought to rest through an extreme degree of relaxation.” Under such conditions of rest, mental and emotional activity become minimal, and this pleasant and restful state may lead to natural sleep.

Progressive muscle relaxation (PMR) involves tightening specific muscle groups for a short time (5 to 10 seconds), then relaxing (Calder, 2000a), with athletes being initially instructed to notice the difference between tension and relaxation (Schomer, 1992). The regimen usually works by starting at either the feet or head and neck, and working through muscle groups to the other end of the body (Peterson, 2005). The athlete will be able to identify muscle tension and relaxation specific to each region of the body (Bompa, 1999; Calder, 2000a).

In a review of research projects which focused, amongst other, on the effect of progressive relaxation on athletic performance, Onestak (1999) stated that progressive relaxation procedures appeared to be effective in reducing anxiety levels and alleviating both the psychological and physiological indices of anxiety. Schomer (1992) mentioned that a great advantage of PMR is that athletes are in full control of their own relaxation. PMR can be especially beneficial at the end of a training session (Calder, 2000a) or just before bedtime (Bompa, 1999; Schomer, 1992).

Imagery

All athletes have an imagination (Calder, 2000a), and everyone has the ability to generate images (Short, Tenute & Feltz, 2005) which can be developed to contribute to the regeneration process and ultimately affect performance positively. Morris, Spittle and Perry (2004: 344) indicated that imagery is “intuitively appealing”, because many people daydream and prepare themselves mentally for future action in everyday life. Evidence over the years has shown that imagery in sport is a popular, and a highly effective performance

enhancement technique for athletes (Duda, 1998; Short et al., 2005), with Orlick (2000) stating that the world's best athletes have extremely well-developed imagery skills.

Shaw, Gorely and Corban (2005) described imagery as a conscious internal process that mimics a real life experience in the physical absence of the real life perceptual and sensory experience. Imagery involves using the imagination to create a vivid scene, with "pictures that evoke sensory images and thoughts that stream through consciousness" (Davis et al., 2002: 172). A number of other terms have been used interchangeably with imagery or mental imagery. These include mental rehearsal, imaginal practice, imagery rehearsal, symbolic rehearsal, and visual motor behaviour. Morris et al. (2004) indicated that visualisation is one of the most popular terms used for imagery, but this term or expression fosters the misconception that imagery is totally or largely visual in nature.

The use of imagery involves all senses (sight, smell, sound and touch) and emotions (Calder, 2000a; Clews, 1996; Davis et al., 2002), to which Short et al. (2005: 951) referred as a "polysensory experience." A person can imagine smelling freshly cut grass, or athletes can see themselves performing a task, or imagine feeling the consequences of a movement (Shaw et al., 2005), or create or re-create an experience and feelings of comfort and relaxation (Short et al., 2005), and anger, joy, and other positive emotions (Weinberg & Gould, 2003). The two most popular modalities cited in sport research, and employed by athletes, are visual (seeing) and kinaesthetic (feeling) imagery (Short et al., 2005; Weinberg & Gould, 2003).

A distinction is made between external imagery and internal imagery. Athletes can imagine watching themselves performing a task as an external observer from a third person perspective (external imagery), or they can imagine themselves performing the task (internal imagery) (Cabral & Crisfield, 2005; Shaw, et al., 2005; Turner, 2007; Weinberg & Gould, 2003). In generating images of performing the actual task, it can include the associated sensory input of the movements, or the outcome of the movement. Results from a study by Gordon, Weinberg and Jackson (1994) on the effect of internal and external imagery on cricket performance, showed that 61% of the players reported internal imagery easier to use. Even subjects from the external-imagery group found themselves switching between internal and external imagery. Onestak (1991) also indicated that imagery from an internal perspective facilitated athletic performance to a greater extent. Duda (1998) cautioned that athletes might find it easier to vividly imagine themselves performing a skill, but it does not

mean that they have the ability to vividly imagine themselves being in control of a difficult situation.

One of the most appealing aspects of imagery, according to Morris et al. (2004), is that it is an extremely versatile technique that can be used in a wide range of situations in sport, and for a variety of reasons. One of the most common uses of imagery is as mental practice for skill learning and practice. Other uses of imagery in sport are for the development of perceptual and cognitive skills, to help the athlete with competition and performance (pre-competition, mental warm-up, previews and reviews of competition), and to learn and apply psychological skills (stress management, control anxiety, increase concentration, boost confidence) (Morris et al., 2004; Turner, 2007; Weinberg & Gould, 2003). Weinberg and Gould (2003) stated that athletes reported using more imagery before competition than during and after competitions. The authors mentioned that imagery after practices and competitions appear to be underutilised.

Imagery is also used for rehabilitation purposes (Weinberg & Gould, 2003), especially for soft tissue injuries (Morris et al., 2004), because a variety of benefits, including faster healing, have been identified. When imagery is used for rehabilitation purposes, the focus tends to be on motivation to recover and to rehearse rehabilitation exercises (Weinberg & Gould, 2003). Brown (2005: 226) mentioned the benefits of imagery to facilitate injury rehabilitation where athletes spent 10 – 15 minutes a day visualizing a peaceful scene. A routine practice of "healing imagery" was also one of the factors that differentiated the "fast-healing athletes" from the "slow-healing athletes".

Research on the benefits of imagery in terms of regeneration could not be found, but seeing the value of imagery for rehabilitation purposes, it could be possible that the regeneration process could also benefit from imagery. Shaw et al. (2005) referred to research indicating that imagery aided people's ability to cope with pain, while Blach and Blach (2000) stated that imagery has been used successfully to stimulate the immune system.

Short et al. (2005) wanted to determine whether an athlete's efficacy in his/her ability to use imagery is related to the frequency with which imagery will be used. The researchers wrote that it has been shown that efficacy beliefs will influence the choices athletes will make and the courses of the action they pursue, indicating that when an athlete is highly efficacious for a particular task, he or she will initiate and persist in performing the task more than

someone lower in efficacy for the same task. Athletes therefore need to have confidence in themselves and their ability to perform a specific task. Individual differences in imagery ability can also influence the frequency with which imagery is used and how effective imagery will be. The 74 competitive female athletes (mean age 19.5 years) came from six collegiate sports, namely, basketball, hockey, soccer, tennis, softball and volleyball. The 30-item *Sport Imagery Questionnaire* (SIQ) was completed as an indication on how frequently the athletes imaged the item suggested. The SIQ was modified by asking the participants to rate their confidence in their ability to image the item suggested. The *Movement Imagery Questionnaire* was used to assess visual and kinaesthetic imagery ability. Results supported the hypothesis stated by the researchers that the more efficient athletes are in their ability to use imagery, the more they would use imagery. Short et al. (2005) stated that the finding was encouraging, because it suggested that having a sport psychologist build an athlete's efficacy in using imagery may facilitate the athlete's use of imagery. An efficacy-building strategy would therefore be better than trying to increase or improve an athlete's imagery ability.

When imagery as a psychological skill is learnt, it is suggested that the athlete goes through a few stages. It is advocated that athletes, in the early stages, incorporate imagery at the end of a quality relaxation session, away from training or competition venues (Calder, 2000a; Davis et al., 2002; Morris et al., 2004; Schomer, 1992). It is also recommended that the athlete starts with easy images of well-known objects (a family pet, or a favourite location like the beach or a mountain), which should be relatively easy for most people (Morris et al., 2004; Short et al., 2005). Once athletes are proficient in this, they should move to more sport-specific examples, also applied at the end of a relaxation session and away from the the venue. Athletes should also use as many senses as possible. Morris et al. (2004) suggested that the athletes should, in the next stage, practise imagery at the training venue. The athletes should produce mental images without the need for total relaxation, therefore being able to block out distractions.

Morris et al. (2004) indicated that imagery is a skill that should be practised often. Imagery can be used for short periods ("very small doses") many times a day, or once a day for up to 30 minutes before going to bed. Clews (1996) and Shaw et al. (2005) cautioned that athletes should not be instructed to imagine unsuccessful outcomes, but should create successful outcomes. Imagery can be used as an effective tool to eliminate negative thoughts and replace them with positive ones (Blach & Blach, 2000). Peterson (2005)

suggested that imagery can increase the relaxation effect. Athletes can create or remember a relaxing scene and deepen the effect by imagining the sounds, smells, and kinesthetic features of the scene.

Restricted environment stimulation therapy (REST)

Restricted environment stimulation therapy (REST), sometimes called sensory deprivation or sensory minimising techniques (Calder, 2000a), attempts to create feelings of deep relaxation (Morris et al., 2004). Reducing the amount of stimulation to the brain enables the athlete to focus more effectively on relaxing and becoming emotionally calm (Calder, 2000a). Some of these REST-skills can simply be closing the eyes to reduce stimulation, while other techniques require specialised equipment, such as flotation.

Flotation is a mild form of sensory deprivation where an individual is placed in a horizontal floating posture and immersed in a dark flotation tank in a highly concentrated Epsom salts solution, dense enough to support the body (Bood, Sundequist, Kjellgren, Nordström & Norlander, 2007; Calder, 2000a; Morris et al., 2004). In order to further reduce incoming sensory perceptions, the individual usually wears earplugs, and the saline water solution is also heated to skin temperature, therefore reducing auditory and tactile stimulation (Kjellgren, Sundequist, Sundholm, Norlander & Archer, 2004). Apart from being an environment with minimal stimulation (no sight and no sound), a flotation tank reduces the sensation of gravity, reproducing weightlessness.

Research has suggested that flotation-REST can activate a range of positive physical, behavioural, and psychological changes. Relaxation exercises are seen as a means to reduce physiological and psychological reactions to stress, with the relaxation techniques leading to the relaxation response. A flotation tank is used, for instance, to induce the relaxation response (Bood et al., 2007), which should enhance regeneration (Calder, 2000a). Bood et al. (2007) listed a number of positive effects from flotation-REST: increased well-being, mild euphoria, reduced stress, reduced tension and anxiety, reduced muscle tension, and improved sleep. Morris et al. (2004) stated that, in the case of muscle soreness, more rapid healing can occur with the removal of a large part of gravity. Flotation also appears to be a good environment for imagery (Morris et al., 2004), while some athletes might choose to relax to music or listen to affirmation tapes (Calder, 2000a).

Bood et al. (2007) compared the effectiveness of 12 flotation-REST sessions with 33 flotation-REST sessions on stress-related pain in 37 participants (mean age 49.54 years). Participants suffered from localised muscle tension pain in the neck and shoulder areas, associated with myofascial tender points or trigger points. The researchers indicated that typical flotation-REST treatment consisted of 12 flotation-REST treatments, scheduled as two treatments per week for three weeks, one week without treatment, and again two treatments per week for three weeks. Results showed that the 12 sessions were enough to get considerable improvements in the most severe and normal pain intensity, and pain frequency. A similar pattern was observed in the stress-related psychological variables. After 12 flotation sessions, participants' experienced stress had decreased with 25%, anxiety with 26%, depression with 32%, while sleep quality improved with 18%. No further improvements after 33 flotation sessions were experienced.

Calder (2000a) indicated that most athletes need two or three trials before they feel comfortable in the enclosed environment of the tank. Morris et al. (2004) suggested the initial periods of orientation should start with 15 minutes, and then gradually increase to 25, 35, and 45 minutes. The duration of full sessions is between 45 and 60 minutes.

Autogenic training (AT)

Stetter and Kupper (2002) explained that autogenic training (AT) is based on passive concentration of bodily perceptions (e.g., heaviness and warmth of arms, legs, and abdomen; rhythm of breath; and heartbeat) that are facilitated by self-suggestions. Through self-suggestions, the athlete imagines relaxing intensively, which facilitates a state of actual relaxation and calmness (Peterson, 2005; Schomer, 1992). If this relaxation process is repeated frequently and systematically, the excited autonomic nervous centres of the brain are brought increasingly under conscious control. The relaxed state is then brought about voluntarily (Schellenberger, 1990).

Stetter and Kupper (2002) suggested that AT should be introduced in individual sessions, but AT is also appropriate for group settings. Autogenic training should be practiced in a quiet surrounding, in a seated or reclined position with the eyes closed. A set of standard phrases are repeated, with the focus on heaviness and warmth of the limbs, a calm and regular heartbeat, calm and relaxed breathing, a warm solar plexus, and a cool forehead (Schellenberger, 1990; Shomer, 1992).

Acquisition of AT can take varying amounts of time, with Schomer (1992) indicating that it usually takes time (up to several months) to become proficient in the use of autogenic training. It is especially useful in a competitive environment, but has shown to have the best results with athletes who are intelligent and possess good powers of concentration.

Stetter and Kupper (2002) did a meta-analysis of published clinical outcome studies between 1932 and 1999 on autogenic training and its effects. The main outcome variables were grouped as either physiological, behavioral or psychological. In this meta-analysis, 73 controlled trials concerning the effects of therapy with AT could be quantitatively reviewed. The researchers summed up the results by stating that "one can assume that a therapy with AT results in medium-to-large clinical main effects that are stable at follow-up and exceed placebo effects (control conditions)." In the field of psychological disorders, AT turned out to be effective in anxiety, mild-to-moderate depression, and functional sleep disorders. AT proved to be an effective relaxation method being about as effective as other relaxation methods.

Meditation

Although passive rest is an important component in the regeneration process, the time spent during passive rest can be used to apply a relaxation technique, such as meditation (Calder, 2000a). Although the roots of meditation can be traced back to the Eastern religions of India and Tibet, it has developed into a form that can be easily learnt, namely transcendental meditation (Shomer, 1992). Meditation trains the athlete to relax by controlling the parasympathetic (calming) nervous system through reducing stimulation (or noise) to the brain. By controlling the parasympathetic nervous system, the athlete can lower heart rate, lower blood pressure, slow down breathing rates, relax muscles, and calm the sympathetic (excitatory) nervous system (Calder, 2000a).

According to Blach and Blach (2000: 726), meditation techniques can fall into one of two categories: concentrative and mindfulness. During concentrative meditation, attention is focused on a single sound, an object, or one's breath, to bring about a calm, tranquil mind. During mindfulness meditation, the mind becomes aware of but does not react to the wide variety of sensations, feelings, and images within the situation. By sitting quietly and allowing the images of the surrounding to pass through the mind without reacting to or becoming involved in them, the athlete can attain a calm state of mind.

Meditation has been shown to reduce anxiety, as well as being related to more positive feelings after a stressful event, and improvement in sleeping patterns (Shomer, 1992). Meditation is seen as an effective self-care technique for the athlete (Blach & Blach, 2000). Beary, Benson and Klemchuk (1974) showed that, during the practice of meditation, oxygen consumption decreased by 13%, carbon dioxide production decreased by 12%, and respiratory rate decreased 4.6 breaths per minute below control values in 17 male and female subjects (mean age 24 years), when compared to control periods in which subjects sat quietly and read material selected for its emotional neutral content. The researchers concluded that meditation can elicitate the relaxation response, and could be of therapeutic value.

Solberg et al. (2000) wanted to investigate whether stress reactivity and recovery were changed in runners after six-month programmes of either autogenic training or meditation, each compared with a placebo control condition. Thirty one experienced runners (mean age 39 years) were randomly assigned to one of the three abovementioned groups. Groups in the experimental condition had weekly meetings for seven consecutive weeks, combined with regular practice at home. For the meditation group, each session lasted two and a half hours, while the autogenic training group had sessions that lasted one and a half hours. The home programme was 30 minutes each for meditation, and sessions of 5-10 minutes repeated three times for autogenic training. Before and after the six-month intervention, blood lactate concentration, heart rate, and VO_2 were tested immediately after, and 10 minutes after exercise. Resting heart rate was also assessed weekly at home. State anxiety was measured before and after the intervention. It was concluded that meditation training might reduce stress reactivity as measured by lactate response to an exercise bout. There were no significant differences among the groups with regard to heart rate, VO_2 , or levels of anxiety.

Prayer

It is suggested that prayer is one of the most common religious practices in sport. Czech and Bullet (2007: 49) wrote: "In today's society, prayer and/or spiritual rituals permeate high school, collegiate, and professional sports," with Czech, Wrisberg, Fisher, Thompson and Hayes (2004) indicating that athletes may utilise prayer more than was previously believed by researchers. Prayer is defined by Hoeger and Hoeger (2007: 13) as "sincere and humble communication with a higher power."

The therapeutic potential of spirituality and religion has recently been recognised. Watson and Czech (2006) referred to a number of research investigations in health psychology, medical science, and the psychology of religion which have demonstrated the significant positive psychological and physiological effects of prayer. A number of possible reasons why athletes utilise religious prayer are suggested. Jones (2003) mentioned that many people reported using prayer as a stress management technique, while Watson and Czech (2006) added that athletes use prayer to help to live a morally sound life; to sanctify athletes' commitment to sport; to put sport in perspective; to establish a strong bond of attachment between teammates; and to maintain social control. The use of prayer in coping with the uncertainties in sport is prevalent among athletes, and more so for athletes playing elite sport.

Czech and Bullet (2007) investigated Christian collegiate athletes' perceptions of prayer in sport. Nineteen athletes from a NCAA Division II university participated in the project. The participants were nine men and ten women (mean age 19.6 years) from various religious affiliations who participated in basketball, track and field, football, and baseball. Participants completed the 10-item *Johnson-Chan Prayer Effectiveness Survey*, as well as the 20-item *Religious Behavior Survey*. Upon completion of the questionnaires, the participants were interviewed using a person-to-person, open-ended format. Results showed that all nineteen athletes indicated that prayer intensity, prayer meaning, and the number of times praying increased with the importance of the performance (e.g., championship game). The researchers mentioned that another major theme from the data was that athletes did not pray to win, but prayed for safety, to play to the best of their ability, and to give glory to a higher being after success.

Twelve male athletes (mean age 20.8 years) from a Division I College Football Team participated in the study by Turman (2003) in which athletes were interviewed and had to describe their coach's behaviour, as well as the impact it had in developing cohesion and unity in the team. Results showed, amongst other, the impact of team prayer during pre-game and post-game interaction as a technique in promoting team cohesion. Athletes indicated that they were not praying to win, but to be drawn to each other. Athletes described a separation between different groups on the team. Offensive athletes had limited interaction with the defense, starters found themselves separated from non-starters, and racial differences made that athletes felt separated away from the sport. Athletes described

team prayer as one of the most effective strategies for allowing separation, animosity, and individual prejudices to be wiped away.

Czech and Bullet (2007) suggested that coaches should not discourage religious prayer if athletes find it useful, and should also be mindful of individual athletes spending time praying outside of performance and instructional time. Care should be taken before a prayer routine is started for a team, due to the differences in religious thought. Watson and Czech (2006) also mentioned the importance for coaching professionals to understand the diversity of religions and spiritual practices amongst athletes.

Hypnotherapy

Hypnotherapy is described by Blach and Blach (2000) as a method by which a qualified physician or therapist can induce a positive mental state in an individual. After the initial stage of deep relaxation or lethargy, a heightened receptivity to suggestions follows (Schomer, 1992). During hypnosis, subjects respond to suggestions in such a way as if they were really happening. In the case of pain experienced by the athlete, simple verbal suggestions that can help the mind block the awareness of pain and replace it with a more positive feeling, such as a feeling of warmth. The athlete may also be helped to more clearly remember the incident that caused the pain, which often helps with alleviating anxiety and reducing pain (Blach & Blach, 2000). To make use of the benefits of hypnotherapy, athletes must be willing participants in the process, because they cannot be forced into hypnosis.

Breathing exercises

Blach and Blach (2000) indicated that proper breathing techniques can speed up the healing process, help to relieve anxiety, insomnia, and stress. Learning breathing techniques and focusing on relaxing tense muscles leads to a more efficient physical state (Calder, 2000a). Athletes need to be aware of the specific technique of breathing in and out through the nose and expanding the rib case laterally, rather than protracting the abdomen.

Debriefing

After a significant competitive event, there is a need for a meaningful evaluation to establish and share accurate performance information. Hogg (2002) explained that debriefing involves the downloading of information by those answerable to the event, where the performance is relived to determine a number of aspects relating to the competition. He stated that a win,

loss, or an unexpected result can elicit strong mental and emotional responses in athletes, which should be addressed in some way to give athletes an opportunity to download all troubling feelings and thoughts. Jeffreys (2005) stated that a postgame debrief that focuses on the emotional requirements of the athlete, not the coach, should always follow competition.

As mentioned previously in the section on kinotherapy, Fuller and Paccagnella (2004) noted that the cool-down period after the competition can be the first step in giving the athlete time to reflect on the training session or competition and begin the debriefing process. The process then continues when athletes and coaches engage in an evaluative activity with the purpose of analysis to determine what might be improved for future performance satisfaction, enjoyment, success, and fulfilment. Debriefing should enhance mental recovery and leave the athlete feeling excited, reenergised, and renewed (Hogg, 2002). Beckmann (2002) mentioned that an important precondition for the regeneration is the detachment from past activity so that athletes can fully enter into the regeneration-oriented process, undisturbed from intrusive thoughts related to past activities. Effective debriefing can play a role in this regard.

Hogg (2002) suggested a debriefing model consisting of six steps, namely, selection of the best time, place, and occasion for debriefing; indulging in meaningful self-analysis; being open to an exchange of performance feedback; determine the need for change; set new goals; self-monitor for improved performance. The author emphasised that asking the right questions plays a major role in the success of the debriefing process. Apart from the "hard and important performance questions," that should be asked, Hogg (2002: 185) gave the following five "core questions" that should be asked first:

- What happened exactly? ...for you? ...for the team?
- What is the impact of your performance on you? ...on the team?
- How did your performance make you feel?
- What did you learn – technically, physically, tactically, and mentally?
- What are you encouraged to repeat or do differently for the next game?

Coaches are cautioned to avoid overloading athletes with performance information, imprecise feedback, or meaningless statistics, and to avoid being judgmental in their feedback (Hogg, 2002; Shaw et al., 2005). Hogg (2002: 196) concluded by writing:

"Debriefing is a motivational tool that provides opportunities for athletes to safeguard and ensure continuous learning and improvement; to work cooperatively with coaches, support staff, and team-mates; to absorb the fun and enjoyment of the journey to excellence; and to develop self-discipline, responsibility, and performance accountability. Recovery thrives in this positive frame."

Jeffreys (2005: 84) suggested that the debriefing process should be followed by appropriate opportunities for social and emotional recovery in a "safe" environment away from the media.

Music and sound

De Sousa (2005: 52) wrote:

"Music is an ancient art that has soothed the souls of human beings for ages. Songs offer people solace in adversity and joy in prosperity. They are sung on birthdays and even at the death of a loved one. Music is accepted as a universal means to express one's emotions. It was an essential component of ancient healing. A drum was beaten when treatment was offered to a patient, and a successful recovery was announced with trumpets. Music was used to treat illness in ancient Greek and Roman cultures, and great philosophers have assigned important roles to music in the expression of their emotions and teachings."

Music has therefore been used throughout history for therapeutic purposes (Le Roux, 2006), and more recently has been widely recommended as a technique to enhance the psychophysical state of participants in sport and exercise (Karageorghis & Terry, 1997).

It has been suggested that music can influence mood. Stevens and Lane (2000) investigated the strategies that athletes use to regulate mood. Participants in the study were 107 male and female athletes (mean age 19.8 years) from different sports (badminton, basketball, hockey, karate, netball, rugby, soccer, swimming, and track and field). All participants had competed at least at county level in the United Kingdom. The athletes completed the Self-Regulating Strategies of Mood Questionnaire. Participants were first asked if they thought it possible to change a mood state. Then they had to read the 29 strategies, nominate strategies they use to change each mood dimension, and rate the effectiveness of the method(s). This procedure was conducted for strategies to regulate anger, confusion,

depression, fatigue, tension, and vigor. "Listening to music," "exercise," and "change location" were reported to be the three common strategies as regulators of all six mood dimensions. Blach and Blach (2000) and Jeffreys (2005) stated that music has been shown to have various therapeutic capabilities and may develop the positive mood states of calmness, happiness, reduced tension, and reduced depression.

Studies on the physiological responses to music mostly focused on cardiovascular and respiratory responses. Le Roux (2006) wrote that heart rate can be increased by exiting music, music in minor tones, prolonged exposure to a pulse with a repetition rate higher than the normal heart beat, depressing music, and noise. Music also affects blood pressure. Significant decreases in blood pressure were found from classical music like the *Serenade* from *Madam Butterfly*, the sound of ocean waves, and soothing music like the *Moonlight Sonata* by Beethoven (Le Roux, 2006). A study by Le Roux (2005) showed that listening to choral music positively affected the psychological status of patients with infectious lung conditions, as well as their endocrine, immune functions and lung functioning. The researcher found a significant reduction in anger, hostility and depression in the group exposed to the music. The music also changed the biomedical state of the patients.

It is suggested that subjects listening to certain types of music not only experience strong moods, but show physiological responses associated with the emotions. Etzel, Johnson, Dickerson, Tranel and Adolphs (2006) assessed the cardiovascular and respiratory responses of 18 subjects (mean age 50 years) during musical mood induction. Music stimuli were chosen by the researchers based on its ability to reliably induce reports of strong happiness, sadness, and fear in the listeners. The stimuli consisted of 12 classical-type music clips (four for each target mood) from movie soundtracks, ranging in length between 74 and 189 seconds, presented in a randomised order. Some examples of music clips for the target moods were: *Mammy* from *Gone with the wind* and *Buffalo hunt* from *Dances with wolves* for happiness; *Tourvels Flight* from *Dangerous liaisons* and *The battle of Agincourt* from *Henry V* for fear; *Alone on the farm* from *Out of Africa* for sadness. Cardiovascular and respiratory responses were recorded using an electrocardiogram and chest strain-gauge belt. Subjects also recorded mood on a questionnaire after each clip. Subjects consistently reported experiencing the targeted mood, suggesting successful mood induction. Results also indicated that the time domain measures of subjects' cardiovascular responses did not vary significantly between the induced moods, although heart rate deceleration was found during the sadness inductions, and an acceleration during the fear inductions. Differences in

total breath length and total expiration length were found in the expected direction, with slower respiration during sadness than the fear and happiness inductions. The researchers concluded that they found modest evidence that physiological changes occurred consistently with the mood inductions, with distinct differences in measures of respiratory and cardiovascular activity occurring between the mood inductions. Etzel et al. (2006: 66) did mention that the age of the participants could have influenced the results, because, due to their age, had "muted" cardiovascular responses.

Gomez and Danuser (2004) investigated not only the effect of music on physiological and affective responses, but also the effect of other environmental noises. Thirty-one participants (mean age 24 years) were presented with 16 environmental noises (e.g., siren, crowded city centre, flying airplane, sea roar) and 16 musical fragments (mostly classical selections) of 30 seconds each, and were asked to make judgments of affective valence (pleasantness) and arousal. Respiration, skin conductance level and heart rate were also recorded. For noises, the largest number of ratings for positive valence and low anxiety were given for "little stream with bird twitter," and for positive valence and high arousal it was "cheering spectators at sport event." For music stimuli, the largest number of ratings for positive valence and low anxiety were given for "Dvorak, Symphony no. 9-Largo" and "Gandalf, From Source to Sea-Refuge Island." The researchers found that, although noises and music are both sound vibrations, differences in the relationship between affective judgments and physiological responses were found.

Different types of music have been found to also induce different neuroendocrine changes. Gerra et al. (1998) evaluated the changes of neurotransmitters/hormonal levels induced by techno-music and their correlation to emotional states, as well as their dependence on personality features. The researchers also mentioned that neuroendocrine changes induced by techno-music could suggest the existence of a biological co-factor linking this kind of music with the use of stimulants and after-hours or all-night dancing. Hormonal-, neurotransmitter-, and psychometric changes that were measured before and after listening to techno-music (compared to classical music), were chosen for the involvement in the responses to various stressful and emotional stimuli. Sixteen normal, healthy male and female subjects (mean age 18.6 years) were submitted to two music trials (30 minutes each), in random order, three days apart. They listened to classical music (L. van Beethoven, *Symphony no.6*) which has shown to have quiet sounds, expressing the feelings of joy, happiness and a relaxing life. Techno-music is produced by electronic instruments and a

computer, with the unreal sounds obtained through computer mixage. The techno-music (*Cyber Trip, Techno Shock*) in the study was fast, and included screeching-like sounds. Results from the study indicated that the techno-music induced significant physiological and neuroendocrine changes in the subjects. The neuroendocrine pattern induced by the fast music was described as being not dissimilar to the biological reaction to psychological stress, with the high frequency of the beats, the strident tone clusters, and the duration of the music inducing a stressful condition in the subjects. The researchers also stated that the fast music communicated a sense of urgency and anxiety and acted as a powerful stimulus for activation of systems for biological coping with the arousal condition. With reference to the biological effects induced by techno-music, the researches indicated that it could explain a tight link between techno-music and all-night dancing during a "rave" and after-hour parties. It is suggested that techno-music and the recreational use of amphetamine-type stimulants often used at parties, create a synergetic effect on monoaminergic pathways, decreasing the perception of fatigue and increasing endurance.

It has been shown that men and women differ in their music preferences, but not much is known about gender differences in psychophysiological reactions to music. To address this aspect, Nater, Abbruzzese, Krebs and Ehlert (2006) examined the responses of 53 subjects (mean age 26.1 years) to music stimuli in terms of heart rate, electrodermal activity, skin temperature, endocrine measures in saliva, and psychological variables. The slow and comforting music stimulus consisted of *Miserere* of the Renaissance composer Allegri. As a fast and arousing music stimulus, music pieces from a heavy metal band *Marduk* were chosen. Psychological measures included the German versions of the Stress Reactivity Scale, and Perceived Stress Scale. General music preference was assessed. Subjects also had to rate their feelings on a 5-point Likert scale after listening to the music (e.g., sad, cheerful, aggressive, excited). Dimensions of mood were measured by the *Multidimensional Mood Questionnaire*. Stimuli were presented for 10 minutes in a randomised order on two consecutive afternoons. Although results indicated that general liking of hard rock/metal was significantly lower in women than in men, and liking of classical music was significant higher in women than in men, men and women did not differ in their reaction to renaissance music. In both men and women, renaissance music led to significant calmness, induced more relaxation, more cheerfulness, more harmony, and more drowsiness than heavy metal music. Subjects felt significantly more aggressive and activated after the heavy metal stimulus. Only women displayed heightened physiological reactions to heavy metal music. The researchers

indicated that it could be due to the fact that the men in the sample liked heavy metal music more than the women did.

Le Roux (2006: 112) stated that continuous hard rock and heavy metal music brings forth stress, loss of energy, negativity, depression, isolation, hopelessness, and aggressive behaviour, with heavy metal music among adolescents often seen as a red flag for suicidal vulnerability. Rap music and insistent sounds of perpetual drumming on a continuous basis are also seen as inappropriate for therapeutic purposes.

Music is often used in connection with other relaxation techniques, and Schellenberger (1990) stated that music harmonises and makes athletes more receptive to verbal suggestion. McKinney, Antoni, Kumar, Tims and McCabe (1997) determined the effect of guided imagery and music (GIM) therapy on mood and cortisol in 28 healthy adults (age between 23 and 45 years). Participants were randomly assigned either to a GIM-group or to a wait-list control group for the seven-week programme. The GIM-group had six individual GIM-sessions, each lasting 90 to 120 minutes. Classical music that had been found to be effective in evoking, supporting, and sustaining deep imagery was used. Measurements included: *POMS*, *Creative Imagination Scale* (measuring imaging ability), cortisol (venous blood sample), and aspects like hours of sleep, aerobic exercise, and alcohol consumption. Results showed that the GIM-participants demonstrated significant decreases between pre- and post-session depression, fatigue, and total mood disturbance, and had significant decreases in cortisol levels, all of which remained significantly lower at least seven weeks following the final session.

When music is used in combination with relaxation techniques, Schellenberger (1990) suggested that relaxing music (very calm melodies in concerto form) should be played for approximately three to four minutes before practicing a technique. This procedure promotes rapid psycho-physical recovery following strenuous training and to compensate for overexertion. This procedure can also be used in groups.

A number of therapeutic uses for music are indicated by Le Roux (2006). It is suggested that music reduces the perception of pain, can enhance feelings of being energetic, helps create a positive frame of mind, helps with release of anger, and encourage relaxation. With reference to the effect of music therapy on insomnia, Le Roux (2006) wrote that music can be more soporific than the taking of any sleeping tablets.

For music to have a positive effect, it needs to be a pleasant and meaningful experience for the listener. The athlete's preferences must be taken into account. According to Calder (2000a), athletes should be encouraged to create a bank of music they like which generate a range of moods and atmospheres, to produce a stimulating or calming effect. Milne, Shaw and Steinweg (1999) suggested that athletes should use their "personal" music as a method to minimise travel stress.

Music is not the only type of sound that has been found to have therapeutic value. For many years, environmental sounds—the sound of a running stream, a waterfall, or bird songs—have been used by therapists and psychologists as a means of supporting treatment. According to Blach and Blach (2000), these sounds can do much to relieve stress, lift depression, and evoke positive moods.

Mood lifting activities

Mood lifting activities are invaluable in times of emotional stress. These emotion-focused strategies aim to tap into the positive emotional experiences of the individual (Jones, 2003), and can include watching an amusing video or comedy show, or going to a fun park, zoo or a light entertainment centre. A sense of humour and laughter, and feelings of team support can also be beneficial to the athlete. Calder (2000a) suggested that such activities should be planned as part of the tour for teams in extended competitions away from home.

Factors relating to the social aspects of regeneration

Psychological stress in team sports is the result not only of the various demands of a particular activity, but also of demands which come from outside training and competition. According to Schellenberger (1990), it has been shown that a competitive ability is often influenced to a greater degree by factors resulting from demands outside training and competition than by factors experienced directly in training and competition. Stress factors in an athlete's daily life may include relationships with family, love life, studies, housing, and health. Forsyth and Catley (2007) mentioned that an important source of tension and potential stress for full-time athletes lies in the difficulty the sportspeople and their families have in recognising and establishing the boundaries between work-time and non-work time.

It is also assumed that social relationships within the team have a profound influence on the psychological states of players, and therefore on their playing performance (Schellenberger, 1990). Apart from assessing the sport psychological skill levels of 120 elite U/19 rugby union players (mean age 18.17 years), Andrew et al. (2007) also determined the psychosocial factors that influenced these athletes' participation and performance in rugby. Players indicated a number of factors which were perceived as being the most facilitative towards participation and performance, as well as the most debilitating factors. The effect of family/personal life, of team spirit, and the effect of coaches were indicated by the top-ranked players as being the most facilitative towards their participation and performance. Factors which had potentially negative effects on participation and performance in both groups were: the quota system applied in rugby, academic pressure, and thoughts about serious career-ending injuries. The researchers noted that the top-ranked players in the group perceived the effect of the scoreboard and away games as more debilitating than the lower ranked players. It was suggested that these factors should deliberately be accounted for in the coaching programmes of the players. These factors indicated by the players linked to a number of aspects identified by Hanton et al. (2005), mentioned previously, who studied the content and quantity of competitive and organisational stressors in elite sport performers.

Botterill and Wilson (2002) stated that team dynamics can be powerful, contagious, and complex, and that the emotional climate for work and regeneration is dramatically superior when there is a high level of trust, respect and support in a team. Schellenberger (1990) investigated social relationships and team dynamics in order to find various ways of controlling its development. Questions in the various categories related to competition, leisure, political activities discussions, training intensity, and leadership role/independent training in small groups. The researcher stated that the athletic ability and actual performance of individual players were the most important characteristic of social collectivity. The following aspects were also indicated as prerequisites for a good sports team: frequent positive relationships within the group, minimal outside relationships, low team turnover, a high number of frequently chosen athletes, and a high level of athletic activity.

Results from the study by Sullivan and Gee (2007) on the relationship between team communication and athletic satisfaction emphasised the importance of intrateam communication, because it has been shown that intrateam communication and athlete satisfaction influenced overall team performance. The researchers suggested that team-

building activities should focus on improving team communication as a method of increasing athlete satisfaction and team performance.

It is suggested that team managers and coaches should give consideration to the mood profiles of their teams, because research by Totterdell (2000) showed that players seemed to perform better when their teammates were happier. Totterdell (2000: 858) indicated that a mood linkage was confirmed, which showed that the competitive subjective performances of individuals in professional sport teams are linked to the ongoing collective mood of the team and suggested that team performance may benefit if "players put on a smile and show everyone they are enjoying it." Highly committed players showed greater mood linkage. Attention should also be given to the way players express their emotions, because it can influence the mood of the team. Particular focus should be put on those players who have a special communication role within the team, such as the captain.

Perceived social support within the athletic environment also plays an important role in the emotional well-being of the athlete within the team. Paskevich (2002) mentioned five components of effective social support: being cared for and loved with the opportunity for shared intimacy; being esteemed and valued, therefore having a sense of personal worth; having a sense of belonging by companionship, communication, and mutual obligations with others; having informational support such as access to information, advice, as well as guidance; and having access to physical and/or mental material assistance. Apart from family and friends, the team setting should also be an area of valuable social support. Voigt and Carroll (2006: 328) highlighted the role of the "strong support factors" (e.g., families, former players, community groups, and fans) in the achievements of USC football coach, Pete Carroll, one of the most successful NFL coaches. Perceived coach support also represents an important mediating factor in the sport stress process. Paskevich (2002) concluded that, because supported individuals are physically and emotionally healthier than non-supported individuals, care must be taken by people involved with the team to ensure that athletes perceive that they are supported, but that they are also satisfied with the support. Social recovery efforts can focus on interpersonal contact with friends or intimate relationship partners away from the training venue (Davis, Orzeck & Keelan, 2007).

Robbins and Rosenfeld (2001) showed that social support from coaches is valued by athletes, especially during a period of injury. The 35 athletes who participated in the research project had minor to severe injuries and were forced to sit out of practice or

competition for at least three days due to their injury. All the athletes who served as respondents mentioned that more support from the coaching staff would have been appreciated. The researchers suggested that coaches should involve athletes, even in minor ways, like putting them in stationary positions in drills or assign various duties to them. By involving athletes they may feel more appreciated and noticed, which could help them feel less isolated and frustrated. If athletes can't be involved, the coach could still provide support with a concerned comment or remark of appreciation. It is suggested that coaches should sometimes stop at the rehabilitation centre and check upon the athlete, rather than finding out about the athlete's progress only from the fitness trainer. Robbins and Rosenfeld (2001: 295) stated that injured athletes do not want to be "brushed aside", receive a pat on the back, a concerned remark or question. A visit to the athletic training room from a coach are important to ensure a more positive recovery experience.

Psychological skills training (PST), education, and professional guidance

Psychological skills training (PST) refers to "systematic and consistent practice of mental or psychological skills for the purpose of enhancing performance, increasing enjoyment, or achieving greater sport and physical activity self-satisfaction" (Weinberg & Gould, 2003: 242). The use or application of psychological skills in sport has been shown to be related to success in a variety of sports. Although many athletes indicate that they regard sport psychological skills as important, Andrew et al. (2007) reported on studies where not many of the players involved in the studies actually consulted a sport psychologist, or perceived their own ability to be psychologically well prepared as very good. Results from the study by Andrew et al. (2007) emphasised the need for sport psychological skills training programmes for athletes.

Research by Grobbelaar (2007) confirmed the need for implementing mental or psychological skills training programmes, also for coaches. A total of 265 South African provincial players and 28 coaches participated in the survey to assess the opinions, abilities, and limitations of the coaches regarding mental skills training. Data were gathered by means of questionnaires, specifically compiled for the project, at interprovincial tournaments. Coaches and players had to evaluate the coaches' ability to implement the 14 mental skills chosen as focus for the study. The mental skills were: positive self-talk, goal setting, imagery, team cohesion, enhancing commitment, coping skills, self-confidence, concentration skills,

stopping and replacing negative thoughts, muscle relaxation, music for relaxation, pre-competition routines, psychological strategies for the match, and post-match performance analysis. Rankings indicated that the coaches felt most confident in terms of team cohesion, improving self-confidence, setting goals, applying positive self-talk, and enhancing commitment. Relaxation exercises, pre-competition routines, the use of imagery and psychological strategies for matches received poor ratings by both the coaches and their players. Only 46.43% of the coaches implemented a mental skills training programme, or made use of experts in the field of mental training. A lack of knowledge was highlighted by 88.82% of the coaches as a hindrance in conducting mental skills training programmes. Although the study did not focus on regeneration, proficiency in the use of some of the mental skills chosen as focus for the study might have a positive influence on regeneration, and athletes could benefit from knowledge gained by their coaches.

This confirmed some of the reasons Weinberg and Gould (2003) indicated why PST is neglected by many coaches and athletes. One of the reasons is the lack of knowledge on how to teach or practise psychological skills. Athletes and coaches might also have the misconception that psychological skills are innate and cannot be taught. A third reason cited by athletes and coaches for not practising psychological skills, is a lack of time. Coaches typically add time to physical practice when performances were not good, although the reasons often stated for bad performances relate to mental skills.

Harmison (2006) highlighted the need for athletes to possess psychological and adversity-coping strategies and skills to actively increase the probability of achieving peak performances. And he also emphasised the role of education and professional assistance in the development of psychological skills in athletes. Harmison described the systematic approach he followed in helping coaches and athletes, which consists of: educating the team about the required skills, promoting the acquisition of the skills via training programmes, and integrating the skills into the team's practices and competitions until the skills become habitual and part of their routines.

Complementary and alternative strategies

Although scientific evidence is lacking in terms of the effectiveness of complementary and alternative medicine (CAM) therapies and practices, indications are that there has been a substantial increase internationally in the popularity of alternative medicine for a variety of illnesses and symptoms (Cohen, Penman, Pirota & Da Costa, 2005), as well as for preventative health practices and general self-care (Johnson & Blanchard, 2006). Although recommendations for the use of CAM are often made in the absence of clear empirical evidence of either its safety or efficacy (Carpenter & Neal, 2005), MacLennan, Myers and Taylor (2006) identified an increase in CAM use in Australia between 1993 and 2004, while Johnson and Blanchard (2006) found that 58% of the undergraduates in their survey had used at least one type of CAM in the previous 12 months surveyed. White (1998) stated that many athletes use CAM when conventional medicine, according to them, fails to relieve their musculoskeletal symptoms. Due to the increasing popularity of CAM-therapies and strategies, maybe also for athletes, these aspects are briefly mentioned in this section.

Johnson and Blanchard (2006) described complementary and alternative medicine as a group of diverse medical and health care practices and products that are not considered to be part of conventional or mainstream medicine. Many CAM-therapies are regarded as "effective self-care" (Bascom, 2002: 468). CAM includes therapies such as acupuncture, aromatherapy, chiropractic, energy healing, herbal medicines, homeopathy, hypnosis, magnets, massage, nutritional supplements, reflexology, shiatsu, vitamin and mineral therapy, and yoga (Carpenter & Neal, 2005; Cohen et al., 2005; Johnson & Blanchard, 2006; MacLennan et al., 2006). Attitudes toward some of the CAM-therapies have led to the suggestion that they should be considered mainstream in general practice (Cohen et al., 2005).

MacLennan et al. (2006) did a survey on the use of complementary and alternative medicine in Australia. Respondents reported self-prescribed vitamins as the most used CAM-medicine, followed by herbal medicines. Aromatherapy was the only other category mentioned by more than five percent of the sample. The researchers reported that chiropractors were the most commonly used CAM-therapists. Women used CAM therapists more often than men. The primary reason for using CAMs was for general health.

In their study, involving 506 university students, Johnson and Blanchard (2006) found that 58% of the participants had used at least one type of CAM. The most frequently used types of CAM were massage, yoga, relaxation, and aromatherapy. Seventy-nine percent of the students had used at least one herbal substance in the previous 12 months. The researchers also found that women used CAM more often than men. The symptom categories that were most closely associated with CAM use included pain, fatigue, sleep problems, and mood changes. A study by Factor-Litvak, Cushman, Kronenberg, Wade and Kalmuss (2001) on CAM use among women in New York showed that herbs, homeopathic remedies, and/or vitamins were mostly used by the women, followed by manual therapies such as chiropractic, massage and acupressure.

Other types of CAM therapies that individuals might use include, chromotherapy (colour therapy), light therapy, aerotherapy (negative ions in the air), gemstones and crystals. Some of the CAM therapies will be explained briefly. Maffetone (1999) mentioned that some complementary therapies, previously seen as unacceptable, are becoming more accepted by mainstream practitioners working with athletes.

Reflexology, acupressure, acupuncture, and shiatsu

Blach and Blach (2000) indicated that reflexology originated thousands of years ago from China, and was taken up in the United States in the 1950s. It is believed in reflexology that areas on the foot correspond to organs or structures of the body. It is based on the principle that the body can be divided into ten vertical zones, each corresponding to an area on the foot, so that the feet are in effect a map of the body. A specific region or reflex zone of the foot corresponds to disease or damage in an organ (White, Williamson, Hart & Ernst, 2000). Some reflexologists also apply pressure to different spots on the hands and ears that presumably correlate with the body's organs (Blach & Blach, 2000). On palpation, the individual experiences pain or pricking, no matter how gently pressure is applied. The reflexology treatment then consists of massage of the specific reflex zones. Reflexology therapists claim that reflexology offers various health benefits: it can be an effective way of relieving pain, reduces stress, improves circulation, revitalise energy levels, and helps to restore well-being (McGilvery et al., 2002; Vickers, 1996).

Reflexology treatment is generally accepted to be relaxing and calming. Although practitioners claim that they are able to elicit specific improvements in health, Vickers (1996: 20) stated that the research base of reflexology is "extremely narrow compared to that of

most other therapies.” Although more physiotherapists, nurses and complementary practitioners are being trained in reflexology, with the technique gaining more recognition from professional societies (Vickers, 1996), White et al. (2000) found that reflexology techniques were not a valid method of diagnoses.

Acupressure, also known as “contact healing” (Blach & Blach, 2000) is the manipulation of acupuncture points with the fingers, based on traditional Chinese medicine. As in acupuncture, health is seen to be dependent on the correct flow of *chi* energy through the body, along channels called meridians. Disruption in the energy flow due to improper diet or too much stress can lead to medical problems (Bompa, 1999; Vickers, 1996). Particular points on the body are treated depending on perceived imbalances in the individual’s energy flow. In acupressure, fingers replace needles as the primary means of affecting the flow of *chi*, which makes the experience more personal. Whereas an acupuncturist will needle four or five locations during a session, an acupressure practitioner will generally cover the whole body, focusing on balancing energy fields via specific points located on fourteen meridians which pass through the body. Effects last from a few minutes to several hours. Acupressure is often seen as being between massage and acupuncture (Bompa, 1999; Calder, 1996; Vickers, 1996).

Acupressure is seen as a safe, simple, and relatively inexpensive treatment. Because of the treatment’s non-invasive nature, acupressure may also be performed by the individual for the immediate relief of pain. A number of techniques for self-acupressure do exist to help control pain through finger pressure (Blach & Blach, 2000).

Acupuncture is practiced according to the same principles of acupressure, but in the acupuncture treatment, thin needles are inserted at specific points in the body. Lee and Liao (1990: 402) wrote that the word *acupuncture* was derived from two Latin words, *acus* (needle) and *punctura* (puncture). Although acupuncture is used for a variety of health problems, it is most commonly used to relieve pain (Sood, Sood, Bauer & Ebbert, 2005). Acupuncture seemingly has no side effects (Blach & Blach, 2000).

Shiatsu is a Japanese system of acupressure. The name literally means “finger pressure”—*shi* (finger) and *atsu* (pressure) (Blach & Blach, 2000; Lee & Liao, 1990: 402). The body is divided into lines, known as meridians, which are seen as “channels of living magnetic energy” connecting the main vital organs. An imbalance in a person’s energy levels manifests

itself as a back problem, headache or in many other ways. Pressure is applied to specific points on the lines for between three to ten seconds (Blach & Blach, 2000), with rocking, kneading and stretching techniques applied with the palms, fingers, and especially the thumbs. A wide range of common, immediate and longer-term effects are attributed to shiatsu, including relaxation, sleeping and posture. A shiatsu session normally lasts up to an hour. The therapist will generally work on the whole body (McGilvery, 2002; Wikipedia 2007).

Bompa (1999) wrote that acupuncture, shiatsu and various such therapies are known by Chinese practitioners to treat various forms of diseases, although Westerners are still unsure about its effectiveness. Vickers (1996) pointed out that, although acupressure, acupuncture, and shiatsu are becoming more popular in Western culture, more rigorous research is needed to demonstrate their value as treatment modalities.

Chiropractic interventions

Chiropractors believe that if the spinal vertebrae are properly aligned, impulses from the brain are able to travel freely along the spinal cord to the various organs, maintaining healthy functioning throughout the body. Spinal vertebra misalignments interfere with the normal activity of the nervous system to cause functional problems on a physical, chemical, or mental/emotional level, resulting in pain as well as other physical disorders (Blach & Blach, 2000; Maffetone, 1999). It is believed that realignment of the spinal vertebrae alleviates these problems.

Herbal therapy, and homeopathy

Kleiner (1995) stated that herbs are the oldest, most popular self-prescribed medications, with about 30% of modern drugs being derived from herbs. A herb is described as a plant valued for its medicinal qualities, aroma, or taste. There are too many herbs on the market to mention the full range, but some of the popular herbs, with their assumed functions are mentioned: buchu (antiseptic properties), ginseng (muscle building, reducing mental stress), chamomile (anxiety), valerian (sleep, digestive problems), willow bark, and turmeric (anti-inflammatory) (Bascom, 2002; Kleiner, 1995).

Maffetone (1999: 20) wrote that the word "homeopathy" is derived from the Greek words *homoios* (*similar*) and *pathos* (*suffering*) to refer to a pharmacological principle, namely, the "law of similars". The practitioner seeks to find a substance that, if given in overdose, would

produce symptoms similar to those a sick person is experiencing. Maffetone (1999) indicated that the most controversial aspect of homeopathy is the dosages. Although many of the homeopathic solutions are diluted beyond 24 times, homeopaths state that "something" remains that still have an effect.

Aromatherapy

Aromatherapy is the use of pure essential oils from plant extracts (e.g., lavender, lemon, chamomile, peppermint, rosemary, tea tree, etc.) for their healing, cleansing, and mood-enhancing properties, working on the powerful senses of smell and touch (Field et al., 2005; Lehrner, Marwinski, Lehr, Jöhren & Deecke, 2005; McGilvery et al., 2002). The inhalation of certain essential oils has been associated with the release of brain chemicals that stimulate various emotions. Knasko (1997) reported on the scenting of work environments, hotels, and business stores in an attempt to affect mood, increase sales, and improve productivity. Various devices are available for inhalation therapy, such as diffusers, simmer pots, aromatherapy lamps, and light bulb rings. Essential oils are also part of massage oils and bath oils (Blach & Blach, 2000; Lehrner et al., 2005; Svoboda, Karavia & McFarlane, 2002).

Magnet therapy

Magnet therapy is used with the belief that it can provide relief from pain and accelerate healing. Magnets are believed to work by increasing circulation and blood flow to affected areas, which in turn reduces swelling and inflammation. Magnets in the range of 400 to 25000 gauss strength are used (the average refrigerator magnet is about 200 gauss). Magnets for bodily use are available as small chips on pillows, as mattress pads, knee pads, bracelets, wraps for the neck, and other body parts (Blach & Blach, 2000).

Aerotherapy, and earthing systems

Bompa (1999) discussed aerotherapy as recovery method. Particles in atmospheric air are positively and negatively charged (aeroions). Positive ions occur due to fossil fuel combustion, in an environment with electronic equipment, air conditioners, and where air moves over dry, arid surfaces like a desert or metal. Such an environment may increase lethargy, depression and headaches in a training situation. The air around mountains and around moving water (sea shores, waterfalls, and after rainstorms) has the highest proportion of negative ions (Howard, 2006). It is suggested that negative ions facilitate regeneration, and increase working capacity. Ionised air can be produced artificially by

placing machines and air purifiers in locker rooms (Bompa, 1999), although Howard (2008) warned against some machines emitting dangerous levels of ozone.

Oschman (2008: 41) reported on earthing systems and the physiological and emotional benefits to "making a barefoot connection with the earth." There are suggestions that the oscillating electric field of the earth could be a *zeitgeber* for the body's cortisol clock. This leads to the suggestion that the effects of jet lag can be reduced at one's destination by removing shoes and socks and standing directly on the earth for about 15 minutes. A second concept relates to the suggestion that free electrons from the earth can neutralise inflammatory free radicals. Oschman (2008) reported on the effectiveness of connecting the body to the earth in enhancing performance, speeding injury repair and facilitating recovery when he referred to the *Tour de France* victories of the US Cycle Team lead by Lance Armstrong. Cyclists were connected to the earth during sleep and during the acute phases of injury. Athletes are advised to maintain contact with the earth as much as possible throughout the day.

Psychoneuro-immunology

The relatively new interdisciplinary scientific field of psychoneuro-immunology recognises the inextricable linkage between body, mind, and spirit (Bauer-Wu, 2002). The athlete's thoughts, emotions and immune systems are intertwined, and when the organism reacts to an incident, the whole body responds (Le Roux, 2006). The field of psychoneuro-immunology (PNI) provides an explanation of why "mind-body therapies" can improve psychological and physical functioning, quality of life, and perhaps disease-related outcomes (Bauer-Wu, 2002: 243). When the athlete is tired, stressed, or depressed, the immune system is being taxed. Exposure to noise, stress, anger, pessimism, and repressed emotions depletes the immune system, while strengthening the immune system develops from calmness, relating meaningfully with others, listening to music, laughing, relaxing, prayer, and freely expressing emotions (Le Roux, 2006).

Bauer-Wu (2002) described four general categories of mind-body interventions: sensory, cognitive, expressive, and physical. Sensory interventions incorporate smell (e.g., aromatherapy), sight (e.g., colours, natural light, aesthetic surroundings), taste (enjoying food, but also socialising during dining experience), hearing (e.g., music, soothing sounds), and touch. Cognitive interventions include meditation, imagery, humor and laughter, and

changing thoughts to be more positive. Expressive writing about thoughts, feelings and events, tapping into creativity, and support are examples of expressive interventions. Various researchers also referred to the value of “restorative environments” for psychological restoration (Bodin & Hartig, 2003; Kaplan, 1995; Scopelliti & Giuliani, 2004; Watts, 2002), emphasising the potential of natural environments for restorative experiences.

Chapter Four

Statement of the problem

It is clear from the literature presented in chapters one, two and three that regeneration is an important aspect of athletic performance. What is apparent, is the lack of information on recovery strategies used by elite team athletes during the competitive phase of the training year. Sport at elite level has become an entity on which huge amounts of money are spent. Attempts are made to improve performance through the development of shoes, clothes, and equipment. Advanced technology is implemented to do biomechanical and match analyses. Innovative training systems and techniques are also implemented with state of the art equipment being used. The question can be asked: what investments are made into efforts to enhance the regeneration process in elite performers? If athletic regeneration is addressed, recovery methods are often used in isolation, and often used according to the perceptions of the benefits of a particular method.

Aim

The aim of the study is to develop a model that could serve as a guideline for regeneration of team athletes within the South African context. Two phases are involved in the process of developing a model. Phase one involves a research of literature in order to assess which strategies can be implemented for athletic regeneration, and what information team athletes are given for regeneration. The second phase involves an investigation into the current situation with regard to the recovery strategies that are currently used for regeneration by elite South African team players during the competitive phase of the year.

Objectives

The main objectives of phase two of this study are as follows:

1. To assess the importance of various recovery strategies to elite team players.
2. To identify the recovery strategies that are most widely used by elite team players.
3. To compare the recovery strategies of various sporting codes, and levels of participation.
4. To determine the reasons why players choose to use the strategies.

Research questions

The following questions guide the research:

1. How do players rate the importance of various recovery methods?
2. Which recovery methods do elite team players mostly use during the competitive season?
3. Are there differences between the four sport codes (hockey, netball, rugby, soccer) in terms of the recovery methods applied?
4. Are there differences in the use of recovery methods between different levels of performance?
5. What are the main reasons for using specific recovery methods?

Model development

On the basis of information gained from phases one and two a model for regeneration of team players will be proposed.

Chapter Five

Methodology

In this chapter the methods and procedures for gathering and analysing data will be presented. A description of the research design, sample, research instrument, data collection and analysis is included.

The study has approval from the Ethics Committee of Stellenbosch University (registration number 38/2007).

Research design

Calder (1998) stated that, along with experiments and case studies, surveys are one of the major methodologies used in research. The two main purposes of surveys are either to describe, or to explain something. Descriptive studies focus particularly on the "who," "what," "when," and "how" types of questions. Explanatory studies focus on the "why" questions (Babbie, 2004: 89; Calder, 1998: 639). This study was both descriptive and explanatory.

The survey design used in this study was a one-off cross-sectional design, providing data at one fixed point in time, gathered from self-administered questionnaires from naturally occurring subgroups (Babbie, 2004; Calder, 1998; Fink, 2003b; Mouton, 2001).

Surveys have a particular strength with respect to external validity if the sample is representative of the population, with the ability then to apply findings to the population (Calder, 1998; Fink, 2003a). A design is internally valid if it is free of non-random error or bias.

The researcher is faced with two major challenges when using surveys in research, namely sampling errors and nonresponse. The measures taken to address these potential problems, as suggested in literature, are discussed in the following sections.

Sampling

Sample design

A probability sampling method, with cluster sampling, was applied in the current study. A cluster is described as a naturally occurring unit, such as a sporting code which consists of many teams (Fink, 2003a). In cluster sampling, there is a selection of groups or a cluster rather than individuals from the population. Groves et al. (2004) indicated that cluster sampling is used when populations are geographically wide-spread, and the population does not appear on a single list, therefore making it impossible to compile an exhaustive list of all the members. Cluster sampling is widely used in large surveys, and is highly recommended for its effectiveness (Babbie, 1998; Fink, 2003a). Once the clusters have been selected, all the individuals in that cluster can then be included in the sample, or a second selection can take place, within the selected clusters (Calder, 1998). Sampling errors due to cluster sampling can be addressed by an increase in sample size, and increased homogeneity of the participants (Babbie, 2004; Weisberg, Krosnick & Bowen, 1996). This aspect was addressed in the current study by an increase in sample size. Participants were also relatively homogenous due to the fact that they were team members from the same sport codes.

After the decision was made to use cluster sampling, sample frames were obtained from the sport codes for the various leagues and tournaments. The sample frame is described as the set or source of target population that includes the eligible groups from which a random sample is selected (Babbie, 1998; Babbie, 2004; Czaja & Blair, 2005; Groves et al., 2004). For this study, lists of teams participating in the A-sections of major leagues and tournaments were obtained from the respective governing bodies and organising committees to construct sample frames. As suggested by Calder (1998), various sources were checked to assess the completeness and accuracy of the sample frame.

A common problem with sample frames is that some individuals might be listed more than once (Czaja & Blair, 2005). The researcher was confronted with this problem in the current study, due to the fact that some players participated for their tertiary institution, competed at provincial level, and represented the national side. The researcher attempted to eliminate duplication by attaching a note to the questionnaire instructing subjects not to complete the questionnaire again, if they had completed it previously.

With reference to sample size, it is recommended that the total sample needs to be large enough to enable the researcher to investigate subgroups and draw reliable conclusions about them, as well as drawing conclusions about the overall sample. It is a reality that not all members of the sample will respond to the survey, or sets of data might be incomplete (Babbie, 2004; Calder, 1998).

Subjects

The subjects who participated in the study were players from hockey, netball, rugby, and soccer, teams who participated at the highest level of their major competitions and tournaments during the 2007 season in South Africa. These are all field-based team sports, classified as complex sports, "where there is a high variability of motor actions under conditions of advancing fatigue and varying intensity of work" (Siff & Verkhoshansky, 1993: 362). Netball and rugby have long histories as single-gender sports not only in participation, but also in coaching and administration. Hockey and soccer are dual-gender sports (separate participation by both males and females). Hockey, netball, rugby and soccer all enjoy some of the highest participation rates for team sports in South Africa.

Field hockey

Field hockey is represented by both female and male competitions at the Olympic Games and conducts World Championships for both sexes. Hockey is classified as a fast game of intensive play, with light activity between bursts. There are 11 players in a team, who play two halves of 35 minutes each. As well as being skilled, hockey players have to be fast and agile. Players vary widely in body size, and differences in physical characteristics determine position on the field, or style of play (Burke, 1998).

Spencer et al. (2004) emphasised the limited information on the characteristics of play in field hockey. Researchers did time-motion analyses on elite, Australian male hockey players (mean age 26 years), and reported a number of movement patterns. The majority of the total player game time was spent in the low-intensity motions of walking, jogging and standing. The proportions of time spent in striding and sprinting were 4.1% and 1.5% respectively. Seventeen occasions of repeated-sprint activities (minimum of three sprints, with mean recovery time between sprints of less than 21 seconds) occurred during the game. On average, 95% of the recovery during the repeated-sprints was of an active nature. The researchers concluded that the motion activities of elite field-hockey competition were similar to those of elite rugby.

Netball

Netball is described as a fast, skillful team game based on running, jumping, throwing and catching. Two teams contest play, with seven players taking the court at any one time. Each player has a playing position determined by the areas on the court where they may move. The major aim of the game is to score as many goals as possible within the four 15-minute quarters. An interval of three minutes is allowed between the first and second, and third and fourth quarter, with a five-minute half-time interval (IFNA, 2007).

Players are required to perform a range of work intensities, durations, and recovery periods. A typical netball game is characterised by repetitive bursts of high-intensity play, interrupted by periods of low-intensity activity (Ellis & Smith, 2000). The specific physical and physiological requirements of players will vary somewhat according to playing positions (Ellis & Smith, 2000). Considerable demands are placed upon anaerobic energy systems, with aerobic fitness assisting recovery between bursts of play (Burke, 1998).

Rugby

Rugby is played by many nations throughout the world, with the International Rugby Board (IRB) encompassing many nations across five continents. Rugby union became professional in 1995. Two teams contest play, with 15 players of each team on the field at one time. Each player has a designated position and number outlined by the IRB. The game is played over two 40-minute halves separated by a break no longer than 10 minutes (IRB, 2007). According to Duthie, Pyne and Hooper (2003), the ball is in play for an average of 30 minutes out of the 80 minutes.

Duthie et al. (2003) presented the following details of the characteristics of rugby union and the players. Players are required to perform a range of work intensities, durations, and recovery periods. Rugby requires qualities such as endurance, speed, agility, power, and sport-specific skill. Rugby players typically sprint between 10 and 20 metres. Muscle strength and power is needed for the execution of tackles, explosive acceleration, scrummaging, forceful play during rucking and mauling, and jumping by some. During rugby competitions, 85% of the game time is spent in low-intensity activities, and 15% spent in high-intensity activities. The high-intensity activity is made up of 6% running, and 9% tackling, pushing, and competing for the ball. During international matches, 135 activity periods have been reported, with 56% of activities lasting less than 10 seconds, 85% lasting less than 15

seconds, and 5% lasting longer than 30 seconds. Players cover between four and five kilometres during a match, depending on their playing position.

Rugby union players have a diverse range of physical attributes. It is described as an atypical sport when compared with a number of other team sports, because a distinct physique will naturally orientate a player towards a particular position (Duthie et al., 2003). Rugby union is also a contact sport. The direct impact of tackles on the body is seen by many as the major cause of muscle damage observed after a competitive rugby match, in addition to the repeated eccentric muscle contractions involved in intermittent running and sprinting of rugby matches (Takarada, 2003).

Soccer

Stølen, Chamari, Castagna and Wisløff (2005) stated that soccer is the most popular sport in the world, performed by men and women of different ages and levels. Two teams contest play, with 11 players of each team on the field at one time. During a 90-minute game, elite-level male players run about 10 to 12 kilometres (four kilometres for the goal keeper), at an average intensity close to the anaerobic threshold (80-90% of maximal heart rate). A sprint bout occurs approximately every 90 seconds, each lasting an average of two to four seconds, 96% being shorter than 30 meters. Sprinting the fastest and jumping the highest is often crucial for the match outcome. Strength and power are thus also important aspects for the soccer player. Stølen et al. (2005) reported that professional players perform about 50 turns during a game, and have to maintain control of the ball against defensive players in these situations. Although soccer is also known as association football, the term soccer will be used in this text.

Inclusion criteria

Fink (2003b) stated that the criteria for inclusion in a survey come from three sources, namely the target population, as well as geographical and temporal proximity. Inclusion criteria in terms of these sources were:

- Target population: players from hockey, netball, soccer and rugby who participated in the highest division or section of their major competitions and tournaments (A-Sections at club- and provincial-level as well as at international tournaments and competitions).
- Geographical area: South Africa.
- Temporal: 2007-season.

Exclusion criteria

- Unable to read English.
- Younger than 18 years.
- Presence of only some of the inclusion criteria.

Players from the following teams participated in the study:

- Hockey: Male and female players. SA National teams, SA Club Championships, Senior Interprovincial Tournament, Tertiary institutions qualifying for SA Student Sport Union (SASSU) Championships
- Netball: Female players. SA National team for World Championships, National Netball League, SA Senior Interprovincial Tournament, SA U/21 Championships, Tertiary institutions qualifying for SA Student Sport Union (SASSU), Boland and Western Province Super League
- Rugby: Male players. Springbok team for World Cup, SA Super-14 teams , Currie Cup Competition A-division, Universities Super Bowl-competition, Western Province A-section
- Soccer: Male and female players. Tertiary institutions qualifying for SA Student Sport Union (SASSU) Championships, one professional club

Players were informed that their responses would be anonymous, rather than confidential. Unlike a confidential survey, in which a researcher can link participants to their responses, the procedures of an anonymous survey prevent anyone, even the researcher, from linking the participants individually to their answers (Czaja & Blair, 2005).

Subjects volunteered to participate in the study. Most of the subjects gave written informed consent for participation in the study. A few professional players were willing to participate in the study, but specifically did not want to give their signature on the consent form.

Data collection

A number of survey approaches or methods for data collection are available to the researcher. These include mail surveys, telephone or face-to-face interviews, Internet surveys, group-administered questionnaires, or combinations of methods. Each survey method has strengths and weaknesses, with no "best" survey method to be found. It is advised that decisions about a method of data collection should be made from study to

study. Many factors must be considered, with the practical constraints within which the researcher will have to work often playing a major role in determining the survey design. Key aspects to consider are: administration and resources (finance, length of data collection period, geographic distribution of sample), questionnaire issues (length, complexity), and data-quality issues (sampling frame bias, response rate, quality of responses) (Calder, 1998; Czaja & Blair, 2005; Groves et al., 2004). Czaja and Blair (2005) stated that the money and time available are important factors to consider in survey research. Money and time determine for instance how many clusters can be surveyed, and how large a geographic area can be included. It also influences the mode used for collecting data, for example group-administered questionnaires, mailed questionnaires, or interviews.

After consideration of various factors, it was decided to use multiple modes of data collection, namely, personal-visit group-administered questionnaires, mailed surveys, and combinations and variations of the two. Groves et al. (2004) discussed reasons for using a combination of methods for collecting data. According to the authors, one of the reasons for mixing modes is to maximise response rates. The use of multiple modes of data collection may also reduce costs. The logic of mixed modes is to exploit the advantages of modes while neutralising the disadvantages, and optimise resources to improve co-operation.

“Channels of communication” is a phrase that refers to the various sensory modalities (sight, sound, touch, and combinations) used to obtain information (Groves et al., 2004: 143). Survey modes vary in how they communicate questions to respondents. Mail surveys are visual, with the personal visit mode of data collection adding a verbal element. In a face-to-face situation, the researcher overcomes obstacles in delivering the questionnaires, can address concerns of the respondents, and offer encouragement or clarification, which might enhance the quality of responses. Face-to-face contacts have been found to lead to higher response rates. Face-to-face contacts as a mode of data collection is almost always used with clustered samples, due to the expense of face-to-face contacts (Babbie, 1998; Groves et al., 2004).

Questionnaires used in mail surveys have several advantages. Self-administered questionnaires are seen as a very efficient survey design. Groves et al. (2004) wrote that self-administered, paper-based questionnaires obtained higher response rates than their electronic equivalents (email and Web). It is a cost-effective means of surveying, with good response rates. Using visual aids like a list to respond to, results in greater response

accuracy. Mail surveys are seen as non-threatening to participants, with self-administered methods having a consistent advantage over other modes of data collection, when sensitive behaviours have to be reported. Groves et al. (2004: 157) referred to "socially desirable responding" for the tendency of survey respondents to present themselves in a favourable light, and therefore over report on behaviours such as church attendance, voting, and exercise and healthy eating. Self-administered questionnaires usually produce fewer social desirability effects. Mail surveys can be relatively cheap, but can be time-consuming. Czaja and Blair (2005) concluded from research that the data collection phase of a mail survey usually lasts eight to ten weeks, regardless of the sample size and its geographic distribution. The length of time to conduct a mail survey is therefore fairly constant, but this can also be a disadvantage if a specific time period plays a factor. When mail surveys are used, the geographic distribution of the sample can be wide. Reasonably high response rates can be achieved if the respondents are interested in the topic, and also through incentives and repeated follow-up attempts.

There are also some disadvantages associated with mail surveys. The ability to obtain co-operation from a person is reduced by the lack of personal contact. With respect to data completeness, more questions go unanswered due to the lack of personal contact. Response bias can occur when one subgroup is more or less likely to co-operate than another. According to Weisberg et al. (1996) response rates for mail questionnaires tend to be low: between 10% and 50%. Mail surveys also do not achieve good response rates from people with low education, those who have difficulty reading, and those who do not have interest in the topic (Czaja & Blair, 2005; Groves et al., 2004).

Data were collected during one season, from May 2007 to December 2007. Data collection was planned for one competitive phase of one year to avoid bias due to historical circumstances.

Research instrument

Questionnaires were used for collection of data through a one-off survey, indicating that data were collected via one approach to the players.

Questionnaire

Czaja and Blair (2005: 65) made the following statement about three fundamental characteristics of a good questionnaire: "it is a valid measure of the factors of interest; it convinces respondents to co-operate; and it elicits acceptably accurate information." A systematic process of questionnaire design was followed according to guidelines found in literature, with the following steps being applied: assessing variables against the general plans for data analysis, listing of survey topics, listing of research questions, proposing a question order, drafting the survey introduction or cover letter, pre-testing the instrument, revision and re-testing of revisions, and application (Babbie, 2004; Czaja & Blair, 2005; Groves et al., 2004; Weisberg et al., 1996).

After a study of literature, a set of topics related to recovery strategies was compiled. The topics were then listed and each one broken down into smaller descriptions of required information, from which questions were drafted. Czaja and Blair (2005: 71) wrote that "each question has a cost and must be justified," and specified criteria that a question should satisfy before it should be used in a study. Table 5.1 shows the specified criteria and suggested key decision guide for question utility.

Table 5.1: Key decision guide: question utility (Czaja & Blair, 2005: 71)

- | |
|---|
| <p>A. Does the survey question measure some aspect of the research questions?</p> <p>B. Does the question provide information needed in conjunction with some other variable?
<i>[If no, to both A and B, drop the question. If yes to one or both, proceed.]</i></p> <p>C. Will most respondents understand the question and in the same way?
<i>[If no, revise or drop. If yes, proceed.]</i></p> <p>D. Will most respondents have the information to answer it?
<i>[If no, drop. If yes, proceed.]</i></p> <p>E. Will most respondents be willing to answer it?
<i>[If no, drop. If yes, proceed.]</i></p> <p>F. Is other information needed to analyse this question?
<i>[If no proceed. If yes, proceed if other information is available or can be obtained from the questionnaire.]</i></p> <p>G. Should this question be asked of all respondents or of a subset?
<i>[If all, proceed. If a subset, proceed only if the subset is identifiable beforehand or through questions in the questionnaire.]</i></p> |
|---|

The questionnaire (in Appendix C) was organised into different sections according to topic order (Weisberg et al., 1996). It is stated that the covering letter and the appearance of the questionnaire are critically important in encouraging co-operation and minimising response bias. In the cover letter, the players were given information about the research project and the questionnaire in an effort to encourage them to provide complete and accurate responses. As suggested by Czaja and Blair (2005), the letter did not exceed one page and was on a letterhead from Stellenbosch University. The covering letter was followed by demographic information (age and gender) to classify the players, because the researcher was interested in obtaining data from the study population as a whole, but also wanted to study the subgroups individually, and make comparisons between them. This led to questions on the specific sport the subject participated in, current highest level of participation, and training hours per week. These questions were stated at the beginning of the questionnaire to serve as "screening questions," therefore determining eligibility of the subjects for the study (Czaja & Blair, 2005: 70), but also "warm-up questions" (Weisberg et al., 1996: 96) to put the respondents at ease.

The importance of the very first questions is often mentioned in literature. Some authors stated that they even do not ask demographic questions first, due to the fact that some respondents might view it as irrelevant to the topic (Babbie, 2004). According to Czaja and Blair (2005), the first question(s) should have specific characteristics. It should be relevant to the topic, and easy to answer. It should also be interesting, with respondents finding a question more interesting when they can give an opinion. The first question should also be applicable to and answerable by most respondents, and of closed format.

In an attempt to comply with the guidelines, the next section in the questionnaire (Section B), following the demographic information, consisted of a number of recovery strategies that players could use, with a rating by the player on how important they perceived the various recovery strategies. An attempt was made to focus on the topic, to be applicable to all players, of closed format, and gave the players the opportunity to give their own opinion.

Questions on a particular topic were grouped into sections to put conceptually-related information physically together or form "batteries of questions" (Weisberg et al., 1996), therefore avoiding having questions on a topic scattered throughout the questionnaire (Groves et al., 2004). This could add to internal logic, and give the player a sense of flow or natural progression of the questionnaire (Babbie, 2004; Dillman, 2000). Instructions about

how to indicate an answer were placed just before the answer options themselves. It is advised by Czaja and Blair (2005) that, if the researcher is asking a series of questions in a section, and one is more general and the others more specific, it would be better to ask the general questions first. The questionnaire used in this study was designed according to these guidelines, with a few general questions on the use of a recovery technique, followed by more specific and detailed responses to be made by the player. Groves (2004: 158) discussed "response order effects" which refers to changes in the distribution of the answers as a result of changes in the order in which the possible answers are presented. Respondents tend to sometimes select the first or second answer category presented to them (a "primacy effect"), while in other cases they favour the options presented at the end of a list (a "recency effect"). These problems are less likely to occur in self-administered questionnaires due to the fact that the questions are revealed to the respondents, and they can read through entire groups of questions before they answer them.

Czaja and Blair (2005: 73) emphasised that the questions must be written with the respondent in mind. It should therefore be clear and uncomplicated, allows the respondent to read the content smoothly, and in words simpler than the "scientific intentions that drive them." The decision was made to mostly ask closed-ended questions, where the respondents were given explicit answer or response choices. The close-ended question consisted of two parts: the statement of the question and the response categories (Czaja & Blair, 2005). It is stated that closed-ended questions lend themselves more readily to statistical analysis and interpretation, and that it is particularly important in large surveys because of the number of responses and respondents (Babbie, 2004; Fink, 2003a). Weisberg et al. (1996) wrote that a closed-ended question format provides the same frame of reference for all respondents to use in determining their answers, and that the answers have a better chance of being more reliable and consistent over time.

The answer choices given to the players with the closed-ended questions have taken various forms or levels of measurement from a variety of response categories, as described in literature (Babbie, 2004; Calder, 1998; Czaja & Blair, 2005; Fink, 2003a; Groves et al., 2004; Weisberg et al., 1996). In the categorical or nominal response choices, no numerical value was attached to the response, for example questions about the player's gender, sport, and highest level of participation. In the numerical response choices, players were asked about their age, number of training hours per week, as well as ratings on the importance of various recovery strategies.

Some examples of the formats used in the questionnaire for closed-ended questions are shown in more detail. Matrix questions were used in Section B where several questions had the same set of answer categories (Babbie, 2004). The matrix format has several advantages: it uses space efficiently; subjects will find it faster to complete; and respondents can quickly review their answers to earlier items to decide on the strength of their responses. Subjects had to indicate on a five-point scale how important they rated the various recovery strategies. The use of the five-point scale was applied according to the guidelines by Weisberg et al. (1996). The authors stated that psychological research has shown that no more than seven distinctions should be given, that a middle alternative should be provided, and that only the end points should be labelled with words.

In Section B, as shown below, subjects had the choice to also mark the NF-choice (not familiar with method). Beatty and Herrmann (2002: 72) reported that the responses of subjects to questions are also driven by "cognitive state," referring to the availability of the information requested. With the NF-choice, it was communicated to the subjects that it was possible for them not to know the method. The NF-choice served as a "filter" (Krosnick, 2002: 88) preventing the subjects from just giving arbitrary answers, but to be honest and more accurate in their responses.

<p>Athletes can use a number of recovery methods to assist them with their physical and psychological regeneration during the competitive season. The following are examples of recovery techniques or methods. Please indicate how important you rate the contribution of each of these to recovery and regeneration by making an X in the corresponding block.</p> <p>NF = Not familiar with method 1 = Not important at all 5 = Extremely important</p>						
Active cool-down	NF	1	2	3	4	5
Daytime naps	NF	1	2	3	4	5
Sleep	NF	1	2	3	4	5

To add an element of consistency throughout the questionnaire, response choices for the remaining sections stayed the same. Each section had three formats of answer choices to help keep the respondent's attention, without leading to confusion (Weisberg et al., 1996).

The first part of a section started with a "contingency question format" (Babbie, 2004: 251), where subjects were asked whether they used the recovery strategy mentioned in that

section. Only those who said yes, would be asked to continue with the questions in that section. Contingency questions facilitate the subject’s task in completing the questionnaire, because they are not faced with trying to answer questions irrelevant to them. Within the contingency format, the subject had to give an indication of the frequency of events or behaviours (Czaja & Blair, 2005).

1. Do you perform an active cool down after training sessions?	Yes			No
	Sometimes	Regularly	Always	
2. Do you perform an active cool down between training sessions?	Yes			No
	Sometimes	Regularly	Always	
3. Do you perform an active cool down after matches ?	Yes			No
	Sometimes	Regularly	Always	

If you answered **No to all the statements**, please **proceed to Section D**.
 If you answered **Yes to any of the questions**, please **proceed to the following statements**.

The second part of a section used checklisting, where subjects had to mark their applicable choices. The list should be exhaustive and include all the possible responses. A category labelled “Other (Please specify)” was added in order to accomplish this (Babbie, 1998; Babbie, 2004).

Make an X in the box(es) to indicate your response.	
<i>The active cool down I perform consists of...</i>	
Slow jogging	<input type="checkbox"/>
Stretching	<input type="checkbox"/>
Low-intensity activities in a cold swimming pool	<input type="checkbox"/>
Low-intensity activities in a heated swimming pool	<input type="checkbox"/>
Low-intensity cycling	<input type="checkbox"/>
Other (Please specify)	

In the third and last part of a section, subjects had to give a rating on a five-point scale, with only the end points of the scale being labelled. In the initial developmental stages of the questionnaire, rank-ordering a list of items was considered. Babbie (1998) mentioned that

rank-ordering is more time-consuming and more difficult for respondents, because they have to read the list(s) several times. It is also suggested that subjects should not be asked to rank-order more than five items. Babbie (1998) and Babbie (2004) wrote that the same results can usually be achieved by having subjects rate items. It was therefore decided to use a rating system in the questionnaire. Only some of the response choices are indicated below.

Reasons why an active cool down could be performed are listed below. Please read the list and then rate the reasons why you personally perform the active cool down by allocating a score from 1 to 5 to each item . 1 = least important reason 5 = most important reason <i>I perform an active cool down, because it...</i>	
Speeds up removal of waste products from muscles	
Helps me to wind down	
Gives me time to socialise with team mates	
Helps me to relax	
Decreases muscle soreness	
Is something the coach told me to do	
Other (please specify)	

With regard to questionnaire length, Czaja and Blair (2005: 100) referred to “the perception of burden” that can have an effect on subjects’ willingness to participate, or their responses to the questions. It is suggested that a questionnaire should not exceed eight pages, although a medium length questionnaire can consist up to 12 pages. Babbie (2004: 250) cautioned about efforts to squeeze questions in and clutter pages in an attempt to try to use as few pages as possible, and wrote that these efforts are ill-advised and even “dangerous.” Respondents who find they have spent considerable time on the first page of what seemed a short questionnaire will be more demoralized than respondents who quickly complete the first several pages of what initially seemed a rather long form. Moreover, the latter will have made fewer errors. The desirability of spreading out questions in the questionnaire is emphasised. Babbie (1998: 135) advised researchers to “maximize the white space” in the questionnaire and spread out the questions in the questionnaire. The questionnaire used in this research consisted of 13 pages. An attempt was made to unclutter the questionnaire and start each section on a new page.

Redline and Dillman (2002: 181) wrote that, in addition to language, a self-administered questionnaire also contains “graphic paralanguage,” which refers to brightness and colour, shape, and location as elements of visual perception. Guidelines by Czaja and Blair (2005), Redline and Dillman (2002) and Weisberg et al. (1996) were followed in the questionnaire design to decrease the perception of burden or effort, and guide the subjects through the questionnaire:

- categories were grouped and spaced;
- categories were arranged vertically, and not spread horizontally across the page;
- variations were brought into the design to attract attention;
- simple instructions for answering the questions were given;
- check boxes for responses were put next to the categories;
- increases in contrast ratio was addressed by different font sizes, grey scaling, and boldness for section headings, transitions, and response categories;
- close-ended questions were used.

Pre-test methods

The purpose of the early phases of the pre-test is to get feedback on individual questionnaire items, while the latter phases focus on testing the entire questionnaire and survey procedures (Czaja & Blair, 2005). It is advised that the survey instrument should be reviewed by a number of people, including some experts, and a sample of potential respondents (Fink, 2003a). It was found that the use of a panel (consisting of three to eight members) was very effective, compared to other methods, in identifying problems in a questionnaire. The first draft of the questionnaire items was tested informally on a family member, two colleagues at a tertiary institution, two former elite players not participating in the study, and two subject-matter experts. After revision of the instrument, a pilot test was done. Czaja and Blair (2005) suggested the participation of 20 to 40 respondents from the target population for a pilot study prior to the main fieldwork and data collection stage, while Weisberg et al. (1996) suggested 25 to 75 respondents for a major survey. For this study, a group of 67 team players volunteered to participate in the pilot study. Two changes to the questionnaire were made. The heading of Section E was changed from *Thermotherapy* to *External Heat*, because a number of players did not know the term and asked questions about the heading. A question in Section L occurred twice, and was removed from the questionnaire.

Data collection procedures

Suggestions from several authors for data collection through mail surveys were used as guidelines (Calder, 1998; Czaja & Blair, 2005; Dillman, 2000; Groves, et al., 2004; Weisberg et al., 1996).

After permission to carry out the study was obtained from the relevant authorities (e.g., national associations, directors of sport at universities, chairpersons of SASSU, organisers of tournaments), the contact details (telephone number or e-mail address) of a manager or coach of the team were obtained. If only the telephone number was available, an initial telephone call was made to establish contact. Guidelines by Czaja and Blair (2005) and Groves et al. (2004) were followed in the telephone introductions of the research project. It is recommended not to state a personal name at the onset of the conversation, because an unfamiliar name could send out a negative signal. Hearing the name of a legitimate organisation alerts the respondent that it might be a business call, rather than a wrong number or a sales call for instance. After stating the institute, the identity of the researcher and the research project, the contact person was then asked if he/she would consider participation in the study. Groves et al. (2004) stated that it is not advised to recite a standard script with the request for participation. In a freer, unscripted extended conversation the researcher can tailor remarks to the perceived concerns of the sample person and customise the description of the research and request for participation. After the telephone conversation, an e-mail address was obtained, with the researcher promising to send more detailed information on the project.

Once an email address of the relevant chief executive officer, manager, coach, or team doctor was obtained, an advance letter was sent via email. Researchers have listed typical things that respondents want to know before agreeing to participate in a study. The following aspects emphasised by Czaja and Blair (2005) were communicated to address these aspects:

- the purpose of the study;
- who is collecting the data;
- who is to complete the questionnaire;
- why a response is important;
- when and how to return the questionnaires, or how the questionnaires will be obtained again;
- and what will be done with the study results.

Assurance of confidentiality and anonymity was also given. The advance letter aimed at giving the potential participants sufficient information about the study to satisfy the needs of informed consent. It also made the credibility and relevance of the research clear to convince the management and players that the study is important enough to give personal time and effort to participate. It also aimed to encourage the respondents to take the study seriously and provide complete and accurate responses. The letter also provided a telephone number for respondents to call should they have any queries.

The relevant people were contacted again by telephone to secure their agreement to participate. Depending on the mode of data collection, a mutually convenient appointment was made for the actual face-to-face data collection session, or personal delivery of the questionnaires. Access often had to be negotiated through someone else, such as a CEO, team manager, or the team doctor. It was often difficult to get access to potential respondents because of working through an intermediary, termed by Calder (1998: 648) as the "gate-keeper effect."

The following modes for collecting the data were implemented:

- Personal contact sessions where players completed the questionnaires in a group setting in the presence of the researcher.
- Personal contact sessions where the researcher delivered the questionnaires, the players took it with them, and the researcher collected them again. In one region of the country the researcher used the assistance of a colleague at a tertiary institution for this mode of data collection.
- Personal contact sessions where the researcher delivered the questionnaires (to players or management), and the players mailed them back in stamped return envelopes.
- Questionnaires were mailed via the overnight counter-to-door service (post office) or sent with a courier service to a contact person (manager or coach) for distribution, and the researcher or an assistant collected them from the teams at a later stage.
- Questionnaires were mailed via the overnight counter-to-door service (post office) or sent with a courier service to a contact person (manager or coach) for distribution, and players mailed them back in stamped return envelopes.

Response rates

It is often stated that well-designed surveys strive for high response rates, with response rates being an important measure of survey quality (Czaja & Blair, 2005). The response rate is the number of eligible sample members or actual respondents who completed a questionnaire, divided by the total number of eligible sample members (Czaja & Blair, 2005; Fink, 2003a). The term "nonresponse" is used by researchers to describe the failure to obtain any measurements on sampled units. "Unit nonresponse" occurs when a sampled unit does not respond to the request to be surveyed, while "item nonresponse" is the failure to answer a specific item in a questionnaire (Dillman, Eltinge, Groves & Little, 2002: 3; Groves et al., 2004: 169; Mason, Lesser & Traugott, 2002: 150).

Singer (2002) wrote that not much is known about the reasons why respondents choose to participate in survey research, or not. A number of theoretical perspectives are given that are most commonly applied to survey participation. "Social isolation" refers to persons at the high and low ends of the socio-economic spectrum that refuse to survey requests from major institutions. The "leverage-salience" theory states that different persons place different emphasis on various features of the survey request (e.g., the topic of the survey, how long it might take to complete, what the data will be used for) (Dillman et al., 2002: 8; Groves et al., 2004: 176). Singer (2002) described three types of participants: those who respond for altruistic reasons (the survey is useful for some purpose important to the respondent, or the respondent is fulfilling a social obligation); those who respond for survey-related reasons (interested in the topic); and personal reasons (they promised to do it). Depending on how much the person positively or negatively values a specific feature, it could move him or her toward or away from co-operation.

Mail surveys have been criticised for their large nonresponse problems (Moore & Tarnai, 2002). Fink (2003a) wrote that it is not uncommon to have a 20% response for a first mailing of questionnaires. With effort, response rates on surveys can be elevated to 70%. Babbie (2004) stated that a response rate of 50% is adequate for analysis and reporting. A 60% response is seen as good, and a 70% rate is very good. Babbie (1998) reported on data from 26 published surveys where the response rates averaged 69%. It has been stated often that face-to-face contact increases response rates, because of the higher success at delivering the survey request, and because of the effectiveness in addressing concerns.

Calder (1998: 648) used the term "chasing up" for attempts to address non-response to questionnaires. Repeated contacts tend to reduce nonresponse (Czaja & Blair, 2005; Fink, 2003a; Fink, 2003c; Groves et al., 2004), with the number of contacts for mail surveys being stated as up to four contacts (Czaja & Blair, 2005). Follow-up procedures can include reminder notices, and also switching to another mode of contact offering more interaction (Dillman et al., 2002). Babbie (2004) suggested a period of between two to three weeks as a reasonable time between ordinary mailings and follow-up contacts. In the current study, the researcher made contact after ten days of mailing the questionnaires, due to the fact that questionnaires were sent via an overnight service and not ordinary mail. Modes of contact implemented by the researcher were emails, telephone calls and short-message-service (sms)-reminders.

Higher response rates to mail surveys can be achieved when the topic is salient to the respondent, with nonresponse being strongly related to interest in the topic. It is recommended that a larger number of eligible respondents than needed should be identified to get the sample size needed. Respondents can be protected by keeping survey responses confidential or anonymous. When a research project is confidential, the researcher can identify a given person's responses, but promises not to do so publicly. A research project that guarantees anonymity is when the researcher—not just the people who read about the research—cannot identify a given response with a given respondent (Babbie, 2004). Participants in this research project were guaranteed anonymity, and no means of identification were put on the questionnaires.

Offering an extrinsic benefit for participation increases co-operation rates, with incentives prior to participation being more powerful than those offered after completion of the questionnaire (Dillman et al., 2002; Singer, 2002). Cash incentives and higher incentives are more powerful, but diminishing returns as the amount rises have been reported. It was found that incentives put respondents in a more positive mood, which can lead to less item-missing data and longer open-ended responses (Singer, 2002). Krosnick (2002) reported that a small token of appreciation minimises the person's ability to attribute completing the questionnaire to the reward, because it is small and therefore appears to be a genuine expression of gratitude. Weisberg et al. (1996) wrote that material incentives with the questionnaire can be included as a way of thanking respondents in advance for their time. For this research project, yellow pencils with "Train hard, recover well" printed in green on

the pencil were included as a small token of appreciation, but also to assist the respondents in completion of the questionnaire.

Weisberg et al. (1996) reported that a stamped return envelope had a six percent enhancing effect on response rates, and also found significant effects for using a first-class mailing system. In this study, stamped return envelopes were used where subjects had to mail the questionnaires back. Mailing of questionnaires to teams were also done using first-class mailing systems, such as door-delivery of questionnaires by the post office service or a courier service.

Cultural factors that can also influence response rates were mentioned by Johnson, O'Rourke, Burris and Owens (2002: 67). Because of cultural differences and different expectations regarding appropriate forms of cross-gender communication, male respondents may be less inclined to comply with requests from females. The authors also discussed "helping behaviour" which described the potential cultural differences in willingness to assist a stranger, and stated that "in all cultures people are more likely to help an in-group member than an out-group member."

According to Moore and Tarnai (2002), past research has shown that the use of multiple follow-up contacts, special postage or priority mail, and incentives are the most effective nonresponse-reducing factors overall. These aspects were addressed by the researcher in the current study in an attempt to increase response rates.

Item nonresponse occurs when respondents do not complete all items on a questionnaire. Item nonresponse is more likely to occur in self-administered questionnaires in the absence of face-to-face contact (Dillman et al., 2002). Dillman et al. (2002) also reported that item nonresponse often occurs more toward the end of a questionnaire. Some of the causes of item nonresponse that are reported include poor layout of a questionnaire, inadequate comprehension of the question, perception of psychological threat of some questions, open-ended questions, and a lack of willingness or motivation to answer the question. There is also evidence that the burden of the perceived length of time to complete a questionnaire reduces response rates (Dillman et al., 2002; Groves et al., 2004). The tools used to reduce item nonresponse can be reduction of the burden of any question (closed questions tend to have less missing data), the increase in privacy (e.g., self-administration; anonymity), and

addressing concerns about participation that sample persons may have (Fink, 2003c; Groves et al., 2004).

Data analysis

Calder (1998: 651) suggested that “eyeballing” must be high on the list of early tasks when completed questionnaires are received back from the respondents. The researcher has to look for emerging patterns, skipped questions, incomplete information, and illogical entries. Four questionnaires were rejected in this study where respondents simply marked all the possible responses on nearly all the pages, with a rating of five in all the categories.

Each questionnaire that was returned was given an identification number to which the recorded data could be linked, as suggested by Babbie (2004). Data were then encoded into a spreadsheet on a computer by two pairs of assistants, where one read the responses and the other one typed in the responses, verbally repeating the response that was typed in. Random checks of the data entered were made by the researcher to control accuracy of the entries.

The StatSoft *STATISTICA* data analysis package (Version 8) was used for data analysis. For descriptive purposes means with standard deviations (SD) were reported for ordinal (likert scale) measurements and frequency histograms for categorical data. For comparison of likert scale ordinal data between different groupings of respondents, one-way ANOVA was used with Bonferroni post-hoc testing. Statistical significance was set as $p < 0.05$. The reader should note that lines used on the graphs in the text do not indicate a time factor or time line, but it is presented as a visual aid.

Chapter Six

Results

Introduction

This chapter focuses on the presentation of the research findings of the investigation into the recovery strategies used by elite team players to enhance their regeneration during the competitive phase of the year. Five questions were asked in an attempt to provide answers to the main research topic. These questions focused on the perceived importance of various recovery methods to the players, the recovery methods used as part of a recovery strategy, and the relationship between sport and level of participation in the use of recovery strategies. To this end, players from field hockey, netball, rugby and soccer completed a questionnaire, specifically designed for this study. This study did not attempt to assess the knowledge of the players on recovery methods.

The first section of the chapter focuses on matters related to the sample, as well as information on some aspects of their training. The second section concentrates on results pertaining to the recovery strategies that the players use. To provide an overall picture of the players' ratings, the responses often are pooled together, before the responses of the various groups are discussed.

Response rates

In total, 890 completed questionnaires were collected from the players. The response rate of the completed questionnaires for the total group was 74%. Response rates for the four sport codes were as follows, hockey: 74%; netball: 81%; rugby: 80%; soccer: 61%.

Biographic and training information

In Section A of the questionnaire (in Appendix C), players provided information about their age, gender, highest level of participation at the time of data collection, number of hours per week typically spent training during the competitive season, and if they had a rest day off from training during the week. Table 6.1 shows the results of the 890 participants in terms of the number of players from each sport, and their age (Mean±SD). The total group of players consisted of 57% males (n=507) and 43% females (n=383). Of the total group,

75% (n=668) of the players were from national teams and provincial teams, and 25% (n=222) from club teams.

Rugby players were significantly older ($p < 0.05$) than players from hockey, netball and soccer, while soccer players were significantly younger ($p < 0.05$) than players from the other sport codes.

Table 6.1: Number and age of players within each sport code

Group	n	% of total group	Mean age	±SD
Total pool of players	890		22.26	±3.37
Hockey	213	24%	21.78	±3.29
Netball	215	24%	22.00	±4.00
Rugby	317	36%	23.19	±3.03
Soccer	145	16%	21.33	±2.23

A statistically significant difference ($p < 0.05$) was found between the ages of the players from national teams (23.0 ± 3.58 years), and players from clubs (22.1 ± 2.73 years) and provincial (22.07 ± 3.55 years) teams who participated in the study, with players from national teams being significantly older.

Figure 6.1 shows the number of hours per week typically spent training during the competitive season by players from the total group, while Figure 6.2 represents the number of hours for each sport code and level of participation.

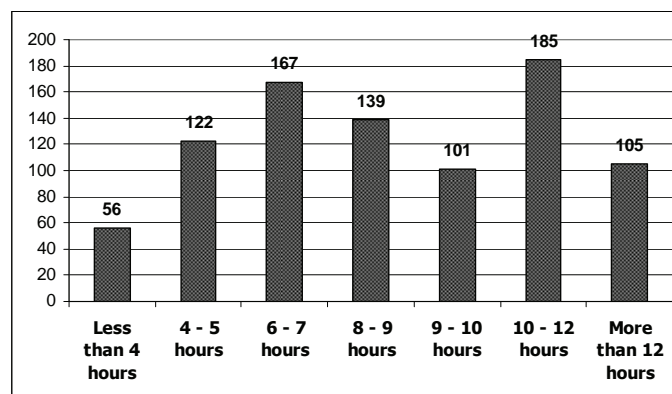
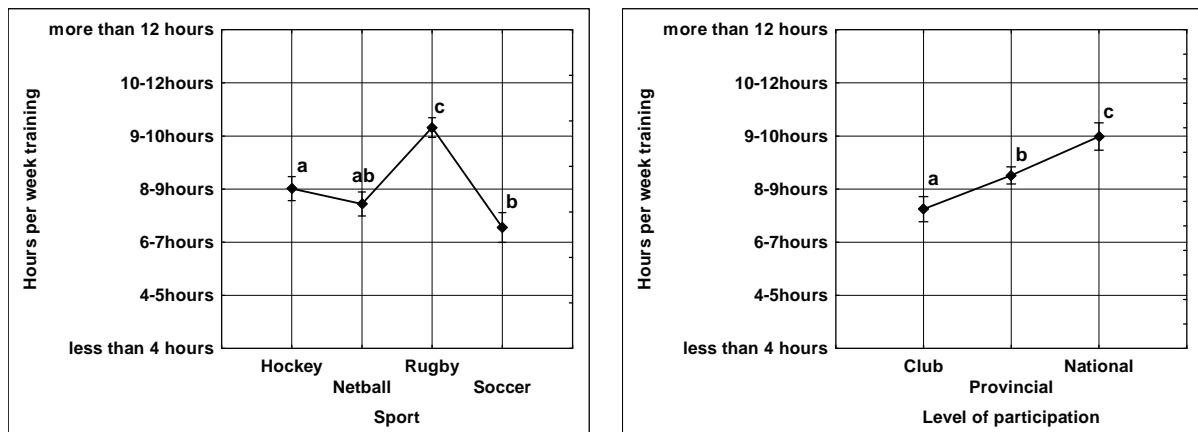


Figure 6.1: Number of hours per week typically spent training by players from the total group



[The letters indicate a significant difference on a 5%-level]

Figure 6.2: Number of hours per week spend training by players from various sport codes and levels of participation

Rugby players spend significantly ($p < 0.05$) more hours training per week than hockey, netball and soccer players. Hockey players spend significantly ($p < 0.05$) more hours training per week than soccer players. With regard to level of participation, results show a statistical significant difference ($p < 0.05$) between players from the various levels of competition. National-level players spend more hours per week training than provincial- and club-level players. Provincial-level players spend more hours per week training than club-level players.

With regard to a rest day from training in a week, 91% ($n=882$) of the respondents indicated that they have a day off.

Perceived importance of various recovery methods

Section B of the questionnaire consisted of a list of 33 possible recovery methods or techniques that could be used by athletes as part of a recovery strategy to enhance the regeneration process. This list was compiled from a literature search and contained methods or techniques that could be used for the physiological and psychosocial regeneration of elite athletes. Players had to indicate on a scale (1-5) how important they rated the contribution of each method to their recovery and ultimate regeneration. The researcher decided to use average scores of 3.50 out of 5 (70%) as the cut-off point for ratings for perceived importance.

The recovery methods that received the highest ratings in terms of importance for the total group (n=890) are (in rank order): *sleep, regular healthy meals, fluid intake, prayer, socialise with friends, discussion with teammates after training/match, discussion with coach after training/match, active cool-down, snacks after match, music*, and an *ice bath*. Table 6.2 shows the recovery methods that received the highest ratings from female and male players.

Table 6.2: Recovery methods perceived as most important by female and male players

Female players	Male players
Sleep	Sleep
Regular healthy meals	Regular healthy meals
Fluid intake	Fluid intake
Prayer	Socialise with friends
Discussion with teammates after match/training	Prayer
Discussion with coach after match/training	Supplements
Socialise with friends	Ice bath
Active cool-down	Snacks after match
Music	Discussion with teammates after match/training
Snacks after match	Active cool-down
	Discussion with coach after match/training

Music receives a higher rating from females than males, while male players rate *supplements* and *ice bath* higher than female players.

The recovery methods that are perceived as the most important by hockey, netball, rugby and soccer players are shown in Table 6.3. *Sleep, fluid replacement, regular healthy meals*, and *socialise with friends* are perceived as important by players from all four sport codes, although to varying degrees. Hockey players do not rate *prayer* as important, while prayer is perceived as important by players from netball, rugby and soccer. Rugby players do not rate an *active cool-down* amongst the most important recovery methods, while hockey, netball and soccer players perceive it as important. Only netball players perceive *imagery/visualisation* as important, while only soccer players perceive *breathing exercises* and *progressive muscle relaxation* amongst the most important methods. *Supplements* and *massage by therapist* are amongst the methods that receive the highest ratings from rugby players and not from any other group. All the other methods rated amongst the most important methods were selected by two or more groups.

The methods that are perceived as most important by players from the different levels of participation are shown in Table 6.4.

Table 6.3: Recovery methods perceived as most important by players from the four sport codes

Sport code	Recovery method	Mean*
Hockey	Sleep	4.58
	Fluid replacement	4.58
	Regular healthy meals	4.40
	Socialise with friends	3.95
	Active cool-down	3.91
	Snacks after match	3.90
	Ice bath	3.88
	Discussion with teammates	3.84
	Discussion with coach	3.74
	Music	3.65
	Eating shortly after training/match	3.55
Netball	Prayer	4.61
	Sleep	4.50
	Regular healthy meals	4.46
	Fluid replacement	4.43
	Discussion with teammates	4.21
	Discussion with coach	4.14
	Active cool-down	4.03
	Socialise with friends	3.94
	Snacks after match	3.65
	Music	3.51
	Imagery/visualisation	3.50
Rugby	Sleep	4.70
	Fluid replacement	4.48
	Regular healthy meals	4.42
	Supplements	4.13
	Prayer	4.05
	Socialise with friends	4.02
	Ice bath	3.97
	Snacks after match	3.67
	Eating shortly after training/match	3.59
	Massage by therapist	3.50
	Soccer	Sleep
Regular healthy meals		4.50
Discussion with teammates		4.37
Socialise with friends		4.28
Discussion with coach		4.24
Prayer		4.17
Active cool-down		4.16
Breathing exercises		3.87
Progressive muscle relaxation		3.77
Music		3.67
Fluid replacement		3.64

*Mean score out of 5

Table 6.4: Recovery methods perceived as most important by players from the different levels of participation

Level of participation	Recovery method	Mean*
Club	Sleep	4.58
	Regular healthy meals	4.31
	Fluid replacement	4.27
	Socialise with friends	4.03
	Prayer	4.02
	Discussion with teammates	3.87
	Discussion with coach	3.78
	Active cool-down	3.75
	Music	3.5
Provincial	Sleep	4.60
	Regular healthy meals	4.47
	Fluid replacement	4.38
	Prayer	4.12
	Socialise with friends	4.05
	Discussion with teammates	3.90
	Discussion with coach	3.81
	Active cool-down	3.72
	Snacks after match	3.65
	Ice bath	3.58
	Eat shortly after training/match	3.53
	Supplements	3.52
	Music	3.50
National	Sleep	4.71
	Regular healthy meals	4.54
	Fluid replacement	4.47
	Prayer	4.00
	Socialise with friends	3.95
	Snacks after match	3.88
	Ice bath	3.83
	Active cool-down	3.83
	Discussion with teammates	3.74
	Music	3.73
	Discussion with coach	3.70
	Supplements	3.62
	Massage by therapist	3.59
	Eat shortly after training/match	3.58

*Mean score out of 5

With regard to the level of participation, results show that players from all levels perceive *sleep, regular healthy meals, fluid replacement, socialise with friends, prayer, discussions with the coach and teammates after training and matches, an active cool-down, and music* as important methods to use in the regeneration process. These abovementioned methods are also the methods that are perceived by club-level players as the most important

methods. Provincial- and national-level players add *snacks after a match*, an *ice bath*, *supplements*, and *eating shortly after training/match* to that. The method that is only rated by national-level players amongst the most important methods and not by players from the other levels, is *massage by a therapist*.

Recovery methods applied

Players had to indicate for most of the recovery methods whether they use the specific recovery method and when they are using it (after training, between training sessions, after matches, on non-training days where applicable). Players also had to record to what extent they are using the specific method in the abovementioned situations by marking *never*, *sometimes*, *regularly* or *always*. Players chose from a list to show what they are doing when they use the method, their reasons for using the method, and also had to rate (scale of 1-5) the importance of the reason or reasons for using the method.

Natural strategies

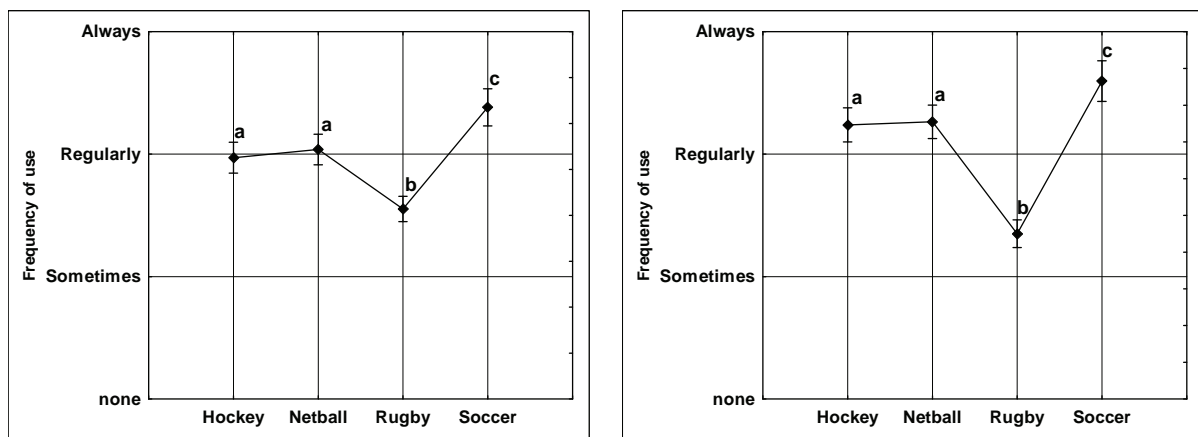
Active cool-down

Of the 865 players from the total group who responded to the questions on the use of an active cool-down after training, between sessions, and after matches, players indicated that they use an active cool-down to varying degrees. Eight percent of the players *never* use an active cool-down after training, 28% use it *sometimes*, 29% use it *regularly* and 35% *always* use an active cool-down after training sessions. With regard to the use of an active cool-down between training sessions, 11% of the players from the total group *always* use an active cool-down, 18% use it *regularly*, 31% *sometimes*, and 40% reported that they *never* use an active cool-down between training sessions. With regard to the use of an active cool-down after matches, 47% of the players indicated that they *always* use an active cool-down after matches, 22% use it *regularly*, 16% used it *sometimes*, and 15% *never* use an active cool-down after matches.

Stretching and *slow jogging* are most often used during an active cool-down. The most important reasons presented by the total group for using an active cool-down are that it *decreases muscle soreness*, *speeds up removal of waste products*, and thirdly that it *assists in countering the negative effects of intense training on the immune system*.

Players could add to the list under the option *Other (please specify)* in the questionnaire. Four players mentioned that they use *walking* or *walking down* as part of their active cool-down, while one player mentioned *rowing* and another one *self-massage*. Reasons added for using an active cool-down are: *prevents, reduces or removes stiffness, drops heart rate, decreases chance of getting injured and reduces further injury, returns blood to heart, reduces amount of lactic acid, and muscle recovery.*

Responses to the use of an active cool-down for recovery purposes from the four sport codes are as follows, hockey: 207 (97%), netball: 210 (97%), rugby: 309 (97%), soccer: 141 (97%). Figure 6.3 shows the results of the use of an active cool-down by players from the four sport codes.



[The letters indicate a significant difference on a 5%-level]

After training

After matches

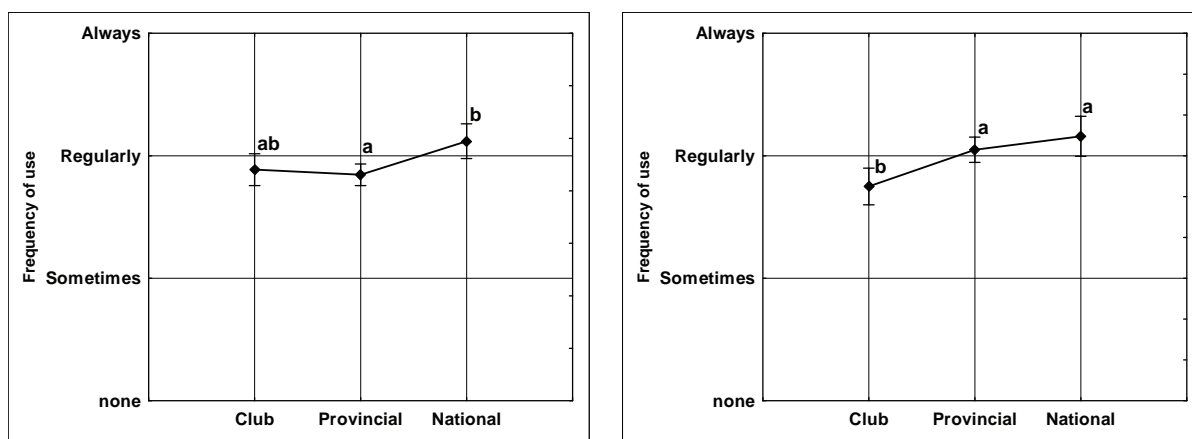
Figure 6.3: Use of an active cool-down after training and after matches by players from the four sport codes

A statistically significant difference ($p < 0.05$) was found between the use of an active cool-down after training sessions and after matches by soccer players when compared to hockey, netball and rugby players. Soccer players use an active cool-down after training sessions and matches significantly more than players from the other sport codes. Rugby players use an active cool-down after training sessions and after matches statistically significantly less ($p < 0.05$) than hockey, netball and soccer players. Rugby players use an active cool-down after matches less than they use an active cool-down after training sessions. Results also show that rugby players do not use an active cool-down as regularly as players from the

other sport codes. Players from hockey, netball and soccer use an active cool-down after matches more than after training sessions.

The most important reason stated by players from the four sport codes for using an active cool-down is that it *decreases muscle soreness*. No statistically significant differences existed between the four groups in terms of this given reason for the use of an active cool-down. For hockey, netball and rugby players the second most important reason for using an active cool-down is that it *speeds up removal of waste products from the muscles*. A statistical significant difference ($p < 0.05$) was shown between hockey, netball and rugby players in terms of the importance of an active cool-down for the *removal of waste products*, with hockey and rugby players rating this reason more important than the netball players. Soccer players' second most important reason for using an active cool-down is that it *helps to relax*, with a statistically significant difference ($p < 0.05$) between the ratings of the soccer players and those of the hockey, netball and rugby players. Players from hockey, netball and rugby indicated that their third most important reason for using an active cool-down is that it *assists in countering the negative effects of intense training on the immune system*. Soccer players reported that their third most important reason is that an active cool-down *helps to wind down*, with a statistically significant difference ($p < 0.05$) between the ratings of the soccer players and those of the hockey and rugby players.

Figure 6.4 shows that the provincial- ($n=453$) and national-level ($n=176$) players use an active cool-down more after matches than they use it after training sessions. National-level players use an active cool-down after training sessions statistically significantly ($p < 0.05$) more than provincial-level players. National- and provincial-level players use an active cool-down after matches regularly, and statistically significantly ($p < 0.05$) more than club-level players.



[The letters indicate a significant difference on a 5%-level]

After training

After matches

Figure 6.4: Use of an active cool-down after training and after matches by players from different levels of participation

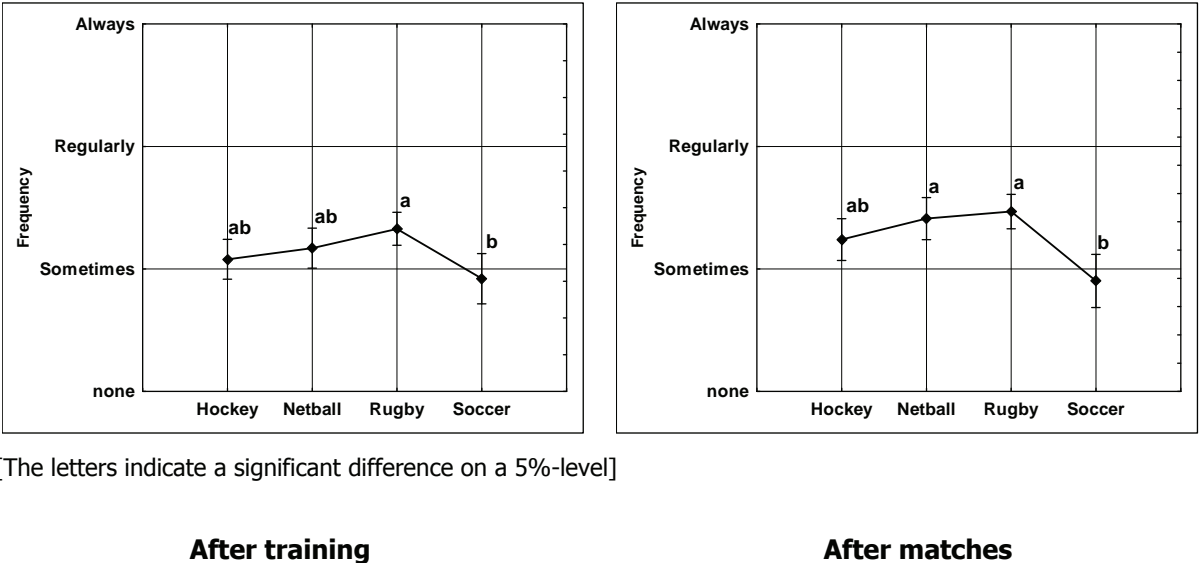
The most important reason stated by players from all levels for using an active cool-down is that it *decreases muscle soreness*, with the second most important reason being that it *speeds up removal of waste products*. Results showed a statistically significant difference ($p < 0.05$) between players at club level and national level in terms of the importance of an active cool-down for the removal of waste products, with national-level players regarding an active cool-down for the removal of waste products more important than club-level players. The third most important reason for using an active cool-down for provincial- and national-level players is that it *assists in countering the negative effects of intense training on the immune system*. Club players reported their third most important reason is that it *helps to relax*. A statistically significant difference ($p < 0.05$) existed between the club- and provincial-level players on the one hand and national-level players on the other hand in terms of the importance of an active cool-down for relaxation. Club- and provincial-level players rate the role of an active cool-down for relaxation more important than national-level players.

Nutrition

Of the total group, 93% (824) players responded to questions in the section on nutrition. In terms of a strategy for fluid intake, 44% of the players from the total group indicate that they *never* have a strategy for fluid intake after training sessions, 15% of the players *sometimes* have a strategy, 22% *regularly* have a strategy, and 19% state that they *always* have a fluid replacement strategy. With regard to having a strategy for fluid intake after

matches, 41% of the players report that they *never* have a strategy, 13% *sometimes* have a strategy, 21% *regularly* have a strategy, and 25% of the players *always* have a fluid replacement strategy after matches. With reference to a strategy for refuelling after training sessions, results show that 48% of the players *never* have a strategy, 14% *sometimes* have a strategy, 20% *regularly* have a strategy, and 19% of the players *always* have a strategy after training. When it comes to a strategy for food intake after matches, results show the following: 49% of the players *never* have a strategy, 15% *sometimes*, 19% *regularly*, and 18% *always*. The glyceamic index (GI) of food is *never* used by 76% of the players to assist them with their food choices for recovery.

Responses from the four sport codes to the section on nutrition are as follows, hockey: 201 (94%), netball: 202 (94%), rugby: 297 (93%), soccer: 127 (87%). Figure 6.5 shows the extent to which players from the various sport codes have a strategy for fluid replacement. Results show that players from all four sport codes do not have a strategy for fluid replacement that they apply on a regular basis. A statistically significant difference ($p < 0.05$) was found between soccer and rugby player in terms of having a strategy for fluid intake after training sessions, with soccer players having less of a strategy than rugby players. With regard to a strategy for fluid intake after matches, a statistically significant difference ($p < 0.05$) was found between soccer players and players from netball and rugby teams, with netball and rugby players having more of a strategy for fluid intake after matches than soccer players.



[The letters indicate a significant difference on a 5%-level]

Figure 6.5: Application of a strategy for fluid intake after training and after matches by players from the four sport codes

No significant differences were found between players from the various sport codes in terms of having a strategy for food intake after training and after matches, as seen in Figure 6.6. Results show that players from all sport codes do not have a strategy for food intake that they apply regularly.

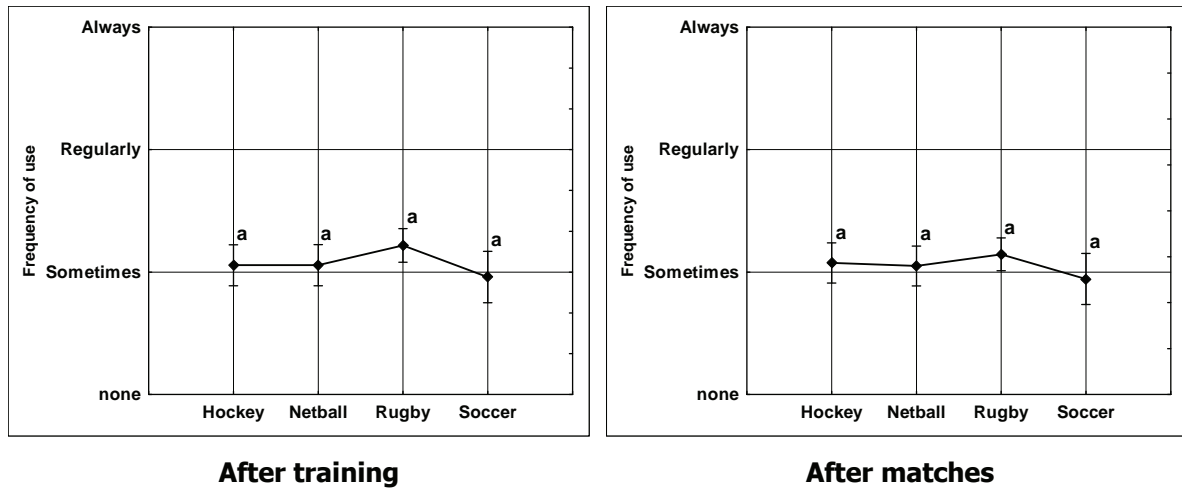
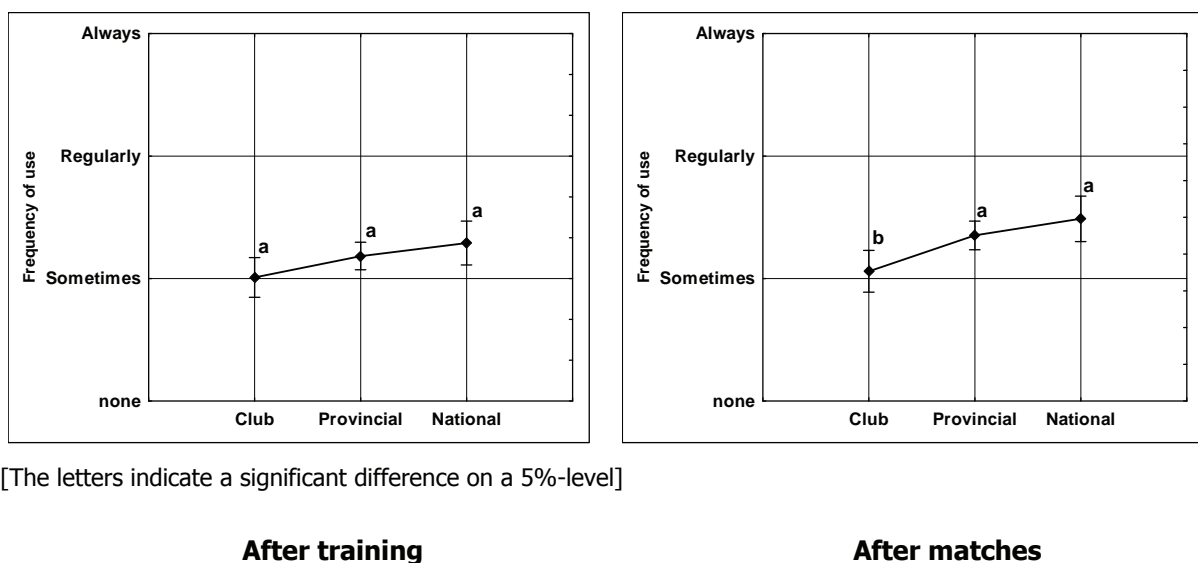


Figure 6.6: Application of a strategy for food intake after training and after matches by players from the four sport codes

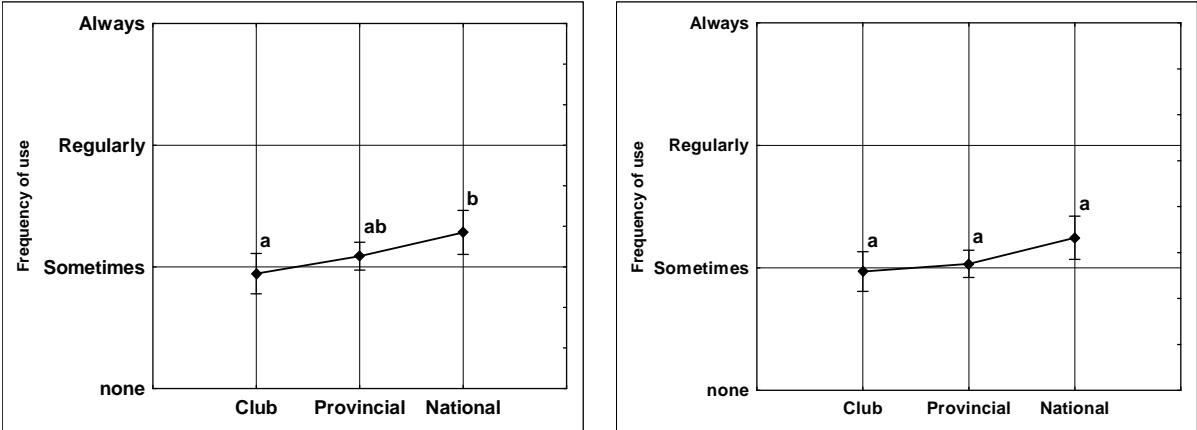
With regard to a strategy for fluid intake, results, as shown in Figure 6.7, show that players from all levels of participation have more of a strategy for fluid intake after matches than after training sessions, although not regularly. Statistically significant differences ($p < 0.05$) existed between players from the various levels of participation with provincial- and national-level players having more of a strategy for fluid intake after matches than club-level players.



[The letters indicate a significant difference on a 5%-level]

Figure 6.7: Application of a strategy for fluid intake after training and after matches by players from different levels of participation

As with a strategy for fluid replacement after matches, results show that players from different levels of participation do not regularly have a strategy for food intake (Figure 6.8). A statistically significant difference ($p < 0.05$) existed between national- and club-level players in terms of a strategy for food intake after training, with national-level players having more of a strategy than club-level players.



[The letters indicate a significant difference on a 5%-level]

After training

After matches

Figure 6.8: Application of a strategy for food intake after training and after matches by players from different levels of participation

Results show that provincial- and national-level players have more of a strategy for food intake after training than they have a strategy for food intake after matches, although not statistically significant.

In the section on nutrition, players could respond to a number of statements to report which of the statements were applicable to them. The ten statements that received the highest number of responses from the whole group are as follows (in order of frequency and % respondents from the total group): *I drink within 30 minutes after training (52%), I drink within 30 minutes after a match (52%), I use vitamins and minerals (37%), I combine carbohydrates and protein after a hard training session or match (37%), I drink sports drinks after matches (35%), I eat and drink within 2 hours after a match (33%), I eat and drink within 2 hours after training (32%), I eat within 30 minutes after a training session (32%), I only drink water after training (32%), I use supplements (31%).*

The most important reason indicated by hockey, netball and rugby players for addressing nutritional aspects in recovery is that *it helps to replace fluid losses*. Soccer players reported as their most important reason that it *helps to train hard again*. Hockey, netball and soccer players mentioned *it gives energy* as their second most important reason, while rugby players indicated *it repairs muscles* as their second most important reason. A statistically significant difference ($p < 0.05$) existed between hockey, netball and soccer players versus rugby players in terms of the importance of the role of recovery nutrition in muscle repair, with rugby players rating it significantly more important. The third most important reason indicated by hockey, netball and rugby players is indicated that *it helps to train hard again*, with a statistically significant difference ($p < 0.05$) between rugby and soccer players. Soccer players rated the abovementioned reason as more important than rugby players.

Sleep

A total of 824 players (92.6% of the total group) responded to the questions in the section on sleep. A regular sleep routine is indicated by 67% of the players. Most of the players (75%) reported that they sleep between 6-8 hours per night, 9% sleep less than 6 hours, and 16% sleep more than 8 hours per night during the week. Changes in sleep patterns occur over weekends, 11% indicated that they sleep less than 6 hours, 60% sleep between 6-8 hours, and 29% sleep more than 8 hours per night.

With regard to falling asleep at night, 59% of the players stated that they *never* have problems falling asleep, 2% reported that they *always* have problems, 8% *regularly* have problems, and 31% *sometimes* have problems. Players (60%) indicated that they experience problems waking in the morning to varying degrees: 37% *sometimes* experience problems, 14% *regularly* experience problems, and 9% *always* experience problems. A statistically significant difference ($p < 0.05$) existed between hockey and rugby players in terms of the degree to which problems are experienced in falling asleep at night and waking in the morning. Hockey players experience significantly more problems than rugby players. With regard to taking a nap during the day, 32% of the players *never* take a nap, 47% *sometimes* take a nap, 17% *regularly* take a nap, and 4% *always* take a nap.

Players reported that *noise* and *light* in the sleep environment are the two factors that affect the quality of their sleep the most. National-level players indicated to a greater extent that light in the sleep environment affect the quality of their sleep, although the differences are not statistically significant. Most of the players reported that they do not use sleeping pills

(96%) or alcohol (98%) to enhance sleep (*to sleep better*). More national-level players (26%) than provincial- (22%) and club-level (21%) players indicated that they do something to relax before they go to sleep, but the differences are not statistically significant.

With reference to managing jet lag, most of the players reported that they do not know how to manage jet lag. Only 15% of the hockey players, 12% of the netball players, 20% of the rugby players, and 12% of the soccer players indicated that they know how to manage jet lag. National-level players indicated to a greater extent that they know how to manage jet lag, although the differences are not statistically significant. Melatonin is used by 4% of the respondents to manage jet lag. 23% of the respondents do something to relax before they go to sleep.

Growth and repair of the body is mentioned as the main role of sleep in the regeneration process by hockey, netball and rugby players. The main role of sleep is reported by soccer players as *helping to maintain body rhythms*. Netball and rugby players indicated that the second most important role of sleep is that it is *important for emotional well-being*. Hockey players mentioned *maintaining body rhythms* as the second most important role, while soccer players indicated *growth and repair of the body* as the second most important role of sleep in the regeneration process. Rugby players differed significantly ($p < 0.05$) from hockey and soccer players in terms of the importance of sleep for maintaining body rhythms. Rugby players rated the role of sleep in increasing the *secretion of growth hormone* significantly ($p < 0.05$) more important than hockey players, while hockey players rated the role of sleep in *countering depression* significantly ($p < 0.05$) more important than rugby players.

Players from all levels stated that the most important role of sleep is that it is *essential for growth and repair of the body*. National-level players indicated the role of sleep for *emotional well-being* as the second most important role of sleep, while club- and provincial-level players indicated *maintaining body rhythms* as the second most important role.

Physical strategies

Cryotherapy (external cold)

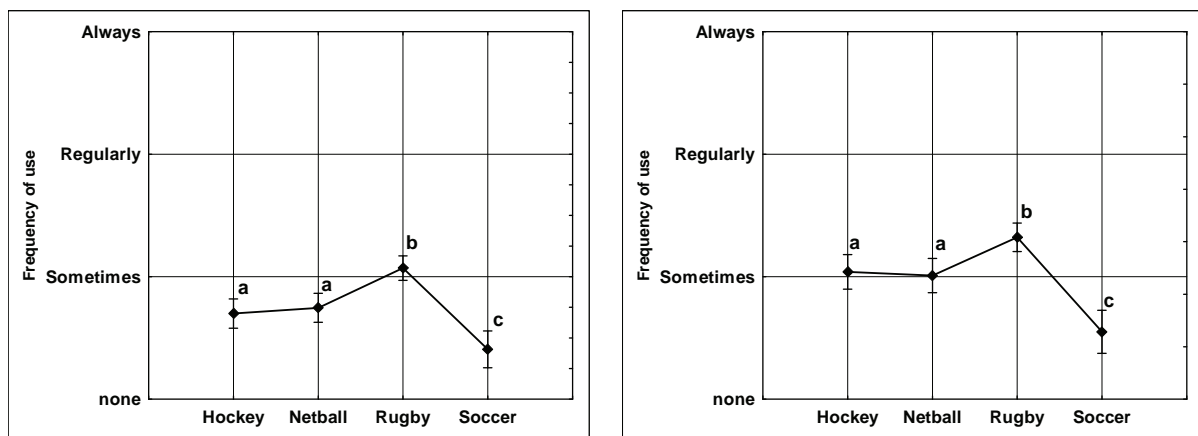
Of the 848 players (95%) who responded to questions on the use of external cold for recovery purposes, players indicated that they use external cold to varying degrees after training, between training sessions, after matches, and on non-training days. External cold

after training sessions is *never* used by 48% of the players, *sometimes* by 30%, *regularly* by 17%, and *always* by 5%. The extent to which the application of external cold is used after matches varied within the total group, namely, *never*: 40%, *sometimes*: 29%; *regularly*: 18%; *always*: 13%. External cold on non-training days is *never* used by 74% of the players.

Methods of cooling that are used the most are (in order of frequency): *ice packs*, *ice bath*, *cold shower*, and *activities in cold swimming pool*. Some players added the following to the list under the option *Other (please specify)*: *compression with Rocket skins*, *Arnica ice*, *Ice-man (ice-rub on muscles)*, and *jacuzzi after game*.

Responses from the four sport codes are as follows, hockey: 206 (96%), netball: 209 (97%), rugby: 299 (94%), soccer: 131 (90%). Figure 6.9 shows the use of external cold by players from the four sport codes, which indicates that players do not use cryotherapy on a regular basis.

Rugby players use external cold statistically significantly more ($p < 0.05$) after training sessions and after matches than players from field hockey, netball and soccer. Soccer players use external cold significantly less ($p < 0.05$) than players from hockey, netball and rugby.



[The letters indicate a significant difference on a 5%-level]

After training

After matches

Figure 6.9: Use of external cold after training and after matches by players from the four sport codes

Results also showed that rugby players also use external cold significantly more ($p < 0.05$) than hockey and soccer players between training sessions, and significantly more ($p < 0.05$) than netball players on non-training days.

External cold is used more often after matches than after training sessions by players from all levels of participation, as shown in Figure 6.10.

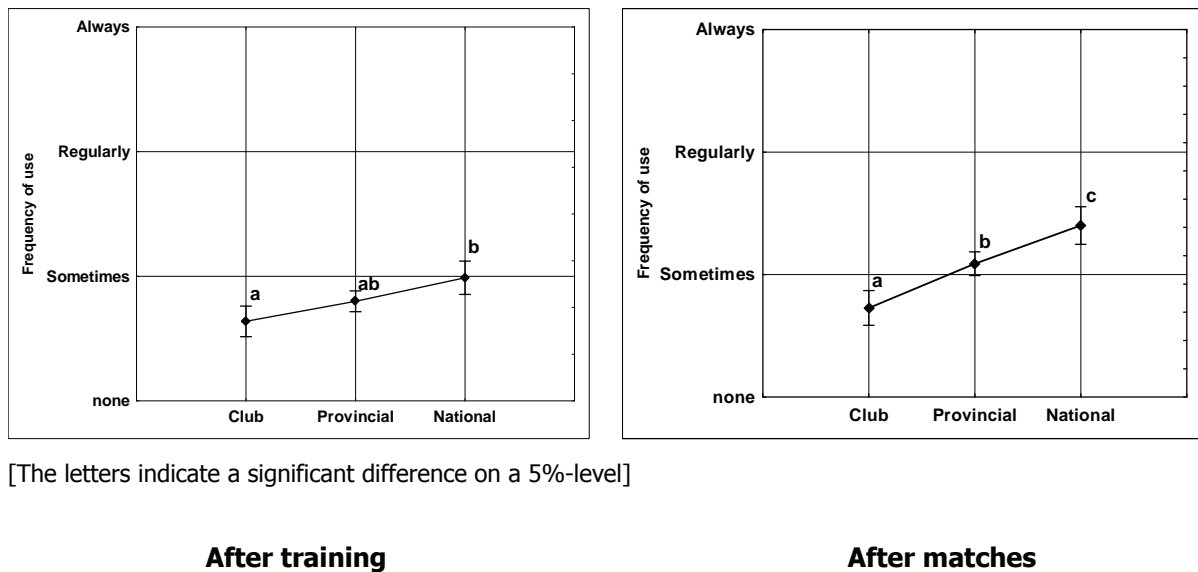


Figure 6.10: Use of external cold after training and after matches by players from different levels of participation

Results show a statistically significant difference ($p < 0.05$) between club- and national-level players with regard to the use of external cold after training sessions. National-level players use external cold statistically significantly ($p < 0.05$) more than club-level players after training sessions. National-level players also use external cold statistically significantly ($p < 0.05$) more after matches than club-level players. Provincial-level players use external cold statistically significantly ($p < 0.05$) more after matches than club-level players. Results show that external cold is not regularly used for recovery purposes after training, after matches or on non-training days by the players.

Hockey, netball and soccer players mentioned *decreases muscle soreness* as the most important reason for using external cold. Rugby players use external cold mostly to *reduce inflammation*, and secondly to *decrease muscle soreness*. Rugby players rate the role of external cold in *reducing inflammation* significantly ($p < 0.05$) more important than netball

players. The second most important reason for players from hockey and netball is that external cold *reduces swelling*, while soccer players indicated that it *decreases pain*. The third most important reason for using external cold for recovery as indicated by rugby and soccer players is that it *reduces swelling*, by hockey players that it *reduces inflammation*, and by netball players that it *decreases pain*.

Players from all levels (n=474) mentioned the same three main reasons for using external cold, namely that it *decreases muscle soreness*, *reduces swelling*, and *reduces inflammation*. No statistically significant differences were found between players of the different levels of participation in terms of the reasons and perceived importance for using external cold, except for the role of external cold to *increase muscle performance* and *faster removal of waste products*. National-level players rated it as statistically significantly ($p < 0.05$) more important than club-level players.

Thermotherapy (external heat)

The 865 players who responded to the questions in the section on the use of external heat for recovery purposes indicated their use of external heat as follows: 75% (n=649) *never* use external heat for recovery after training sessions, 70% *never* use it after matches, and 80% *never* use it on non-training days (Figure 6.11).

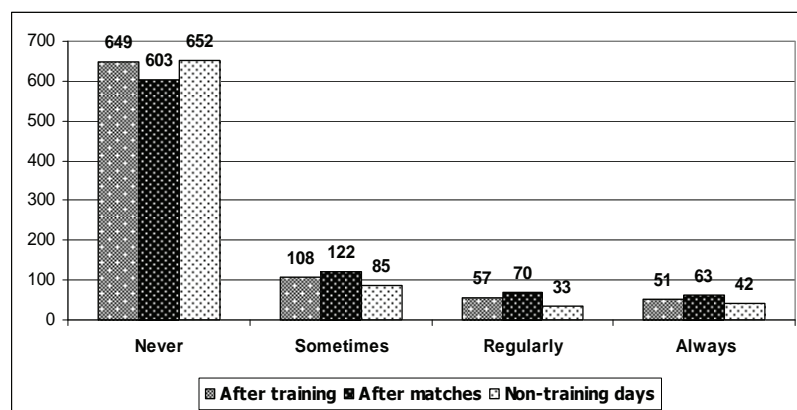


Figure 6.11: Use of thermotherapy after training, after matches and on non-training days by players from the total group

A *hot bath* or *hot shower* is indicated as main methods of heating. The main reasons stated by those who did use external heat are: to *relax*, to *decrease muscle soreness*, to *feel good*, and it *makes stretching more effective*.

Contrast temperature therapy

Figure 6.12 shows the use of contrast temperature therapy by players from the total group. Of the 857 players who responded to the section on the use of contrast temperature therapy, 68% players report that they *never* use contrast temperature therapy after training and 65% indicate that they *never* use it after matches. Of the 32% players who use contrast temperature therapy after training, 21% use it *sometimes*, 7% *regularly*, 4% *always*. Of the 35% of the players who use it after matches, 20% use it *sometimes*, 10% *regularly*, 5% *always*. *Hot and cold showers* and *a cold pool with a hot shower* are the main methods used to apply contrast temperature therapy. Most players indicate that they *started and ended the session with cold application*, and spend more time exposed to the colder temperature than the warmer temperature.

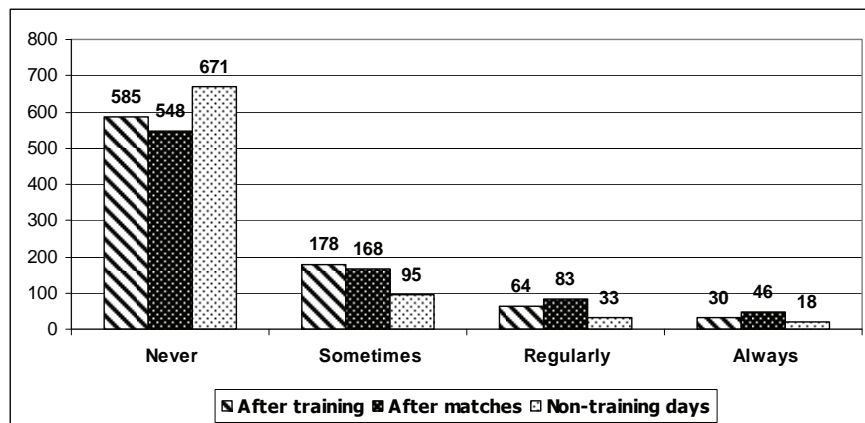


Figure 6.12: Use of contrast temperature therapy after training, after matches and on non-training days by players from the total group

Some players added the following methods to the list under *Other (please specify)*: *ice and a hot water bucket, cold bath and hot jacuzzi, hot packs and cold packs, ice bag and hot bean bag*. Reasons for using contrast temperature therapy that were added are, *reduce stiffness, blood circulation, and injury*.

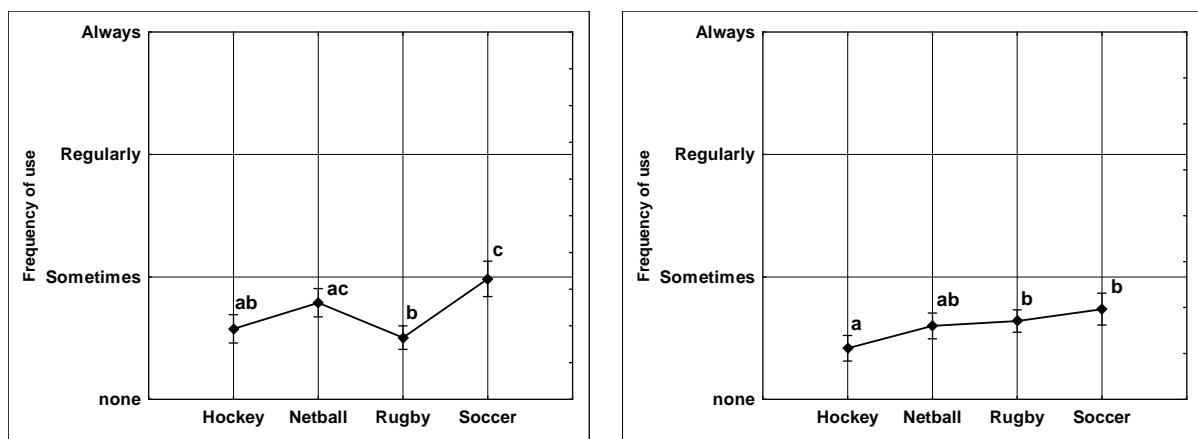
Players who use contrast temperature therapy more often, use it more after matches than after training sessions. The main reason rugby players (n=92) reported for using contrast temperature therapy is that it *reduces swelling and inflammation*. Hockey (n=55) and netball (n=87) players indicate *decreases muscle soreness* as the main reason for using contrast temperature therapy, while soccer players (n=40) state that it *decreases pain* as their main reason for using contrast temperature therapy. Results show a statistically significant

difference ($p < 0.05$) between rugby and soccer players with regard to the importance of contrast temperature for *decreasing pain*. Soccer players rated the role of contrast temperature therapy for *decreasing pain* as more important than rugby players. The second most important reason indicated by rugby and soccer players for using contrast temperature is that it *decreases muscle soreness*, while, for netball players, *decreases pain*, and *reduces swelling* for hockey players.

The most important reason for the 266 club-, provincial- and national-level players (30% of total group) who use contrast temperature therapy is that it *decreases muscle soreness*. The second most important reason put forward by club- and provincial-level players is that contrast temperature therapy *reduces swelling*, while national-level players consider *faster removal of waste products from the muscles* as the second most important reason.

Massage

From the total group, 865 players (97%) responded to the section on massage as a recovery method. 372 (43%) mentioned that they use massage to varying degrees. If a massage is used, it is most often after matches (*sometimes: 29%, regularly: 11%, always: 5%*) or on non-training days (*sometimes: 32%, regularly: 9%, always: 3%*). The average number of massage sessions per week is 2.2. Most of the massage sessions are performed by a therapist and consist of a *deep massage*. One player added the following method to the list under *Other (please specify): compression garment*. Figure 6.13 shows the use of massage after matches and on non-training days.



[The letters indicate a significant difference on a 5%-level]

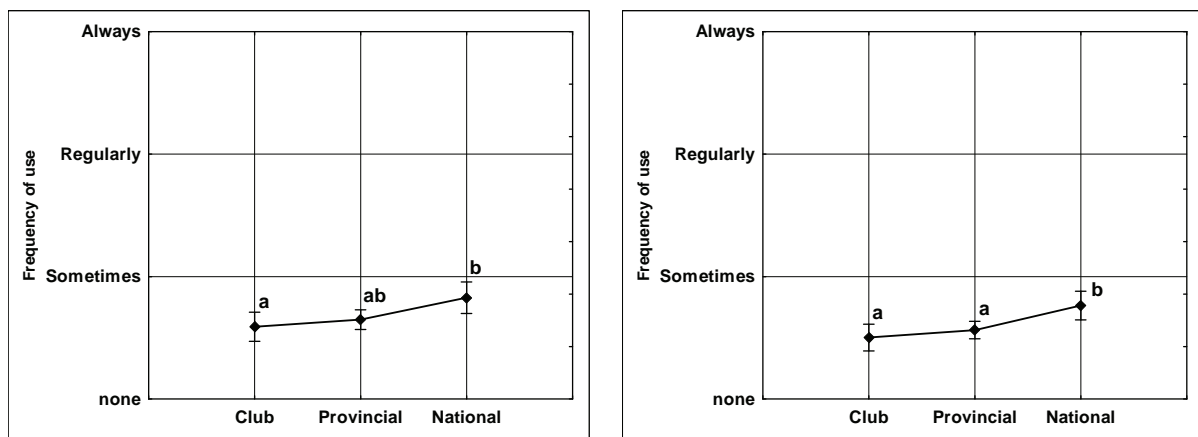
After matches

On non-training days

Figure 6.13: Use of massage after matches and on non-training days by players from the four sport codes

Hockey, netball and soccer players use massage mostly after matches, while rugby players use massage mostly on non-training days. Rugby and soccer players use a massage significantly more ($p < 0.05$) than hockey players on non-training days.

Figure 6.14 shows the use of massage after matches and on non-training days by players from the different levels of participation. Statistically significant differences ($p < 0.05$) were found between national-level players on the one hand and club- and provincial-level players on the other hand with regard to the use of massage after matches and on non-training days. National-level players used massage statistically significantly more ($p < 0.05$) than club- and provincial-level players after training sessions and on non-training days. National-level players also used massage significantly more ($p < 0.05$) than club-level players after matches.



[The letters indicate a significant difference on a 5%-level]

After matches

On non-training days

Figure 6.14: Use of massage after matches and on non-training days by players from different levels of participation

Although a number of players mentioned that they use massage for recovery purposes, it is not used on a regular basis. Hockey and rugby players have put forward their main reason for using massage as: *releases tight connective tissues*. The most important reason for netball players is that it *relieves pain*, while the most important reason for soccer players is that it *helps to relax*. Soccer players differed statistically significantly ($p < 0.05$) from rugby players with regard to the importance of using massage *to relax*. The second most important reason presented by hockey, netball and rugby players for using massage is that it *decreases muscle soreness*, while soccer players rate their second most important reason as: it *makes*

muscles more supple or flexible. Soccer players differed statistically significantly ($p < 0.05$) from netball players in terms of the importance of massage for making muscles more flexible. A statistically significant difference ($p < 0.05$) was found between netball and soccer players on the one hand, and rugby players on the other hand, in terms of the use of massage to *relieve pain* and to *reduce stress and anxiety*. Netball and soccer players rate the importance of massage for the abovementioned reasons higher than rugby players. A statistically significant difference ($p < 0.05$) also existed between rugby and soccer players in terms of the importance of massage for an *awareness of the body* and a *sense of caring touch*, with soccer players rating it as more important than rugby players.

The main reason for using massage reported by players from all levels is that it *releases tight connective tissues*. The second most important reason for provincial- and national-level players is that it *decreases muscle soreness*. Club-level players mentioned that it *relieves pain* as the second most important reason, and it *makes muscles more flexible* as the third most important reason. The third most important reason for provincial-level players is that massage *relieves pain*, while for national-level players it is that massage *reduces muscle spasms*.

Psychological strategies

Relaxation techniques

A total of 813 players (91%) responded to the questions on relaxation. Progressive muscle relaxation is used by 29% of the players: *sometimes* by 17% of the players, *regularly* by 7%, and *always* by 5% of the players. Soccer players use progressive muscle relaxation the most, and significantly more ($p < 0.05$) than players from the other three sport codes. Rugby players use progressive muscle relaxation the least and significantly less ($p < 0.05$) than netball players. Results showed a statistically significant difference ($p < 0.05$) between club- and provincial-level players in terms of the use of progressive muscle relaxation, with club-level players using progressive muscle relaxation more than provincial-level players.

A total of 826 players (93%) answered the question on breathing exercises. Breathing exercises is *never* used by 67% of the players. Breathing exercises is *sometimes* used by 17%, 10% use it *regularly*, and 6% use it *always*. Soccer players use breathing exercises the most and significantly more ($p < 0.05$) than players from the other three sport codes. Rugby players use breathing exercises the least and significantly less ($p < 0.05$) than netball players.

A total of 813 players (91%) responded to the question on imagery. Imagery is used by 43% of the players: 19% use imagery *sometimes*, 14% use it *regularly*, and 10% use imagery *always*. Netball players use imagery the most and statistically significantly more ($p < 0.05$) than rugby and soccer players. National-level players use imagery statistically significantly more ($p < 0.05$) than club- and provincial-level players.

Meditation is *never* used by 80% of the respondents. Of the players who use meditation, netball and soccer players use it statistically significantly more ($p < 0.05$) than rugby and hockey players. Autogenic training is *never* used by 92% of the respondents.

A total of 829 players (93%) answered the question on the use of or role of prayer in recovery. Responses from the four sport codes were as follows, field hockey: 206 (96%), netball: 201 (93%), rugby: 289 (91%), soccer: 132 (91%). Prayer is used by 72% of the players in the recovery process, with 44% of the players *always* using prayer, and 18% *regularly* using prayer.

Netball players use prayer statistically significantly more ($p < 0.05$) than hockey, rugby and soccer players. Rugby and soccer players use prayer statistically significantly more ($p < 0.05$) than hockey players. When compared to the abovementioned methods used for relaxation, prayer as a recovery strategy is used the most by all the players from the four sport codes, as seen in Figure 6.15.

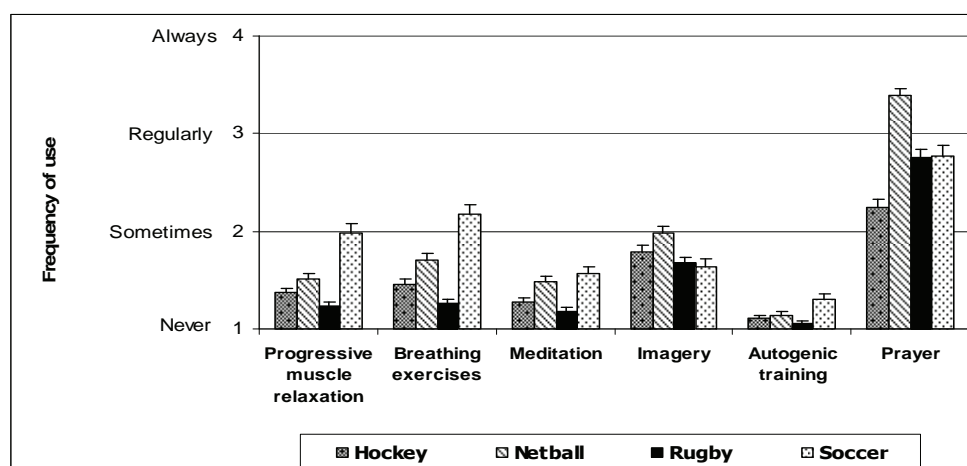


Figure 6.15: Use of relaxation techniques by players from four sport codes

With regard to level of participation, prayer is also used more by club-, provincial- and national-level players than the other methods. Figure 6.16 shows the use of the techniques by players from the different levels of participation.

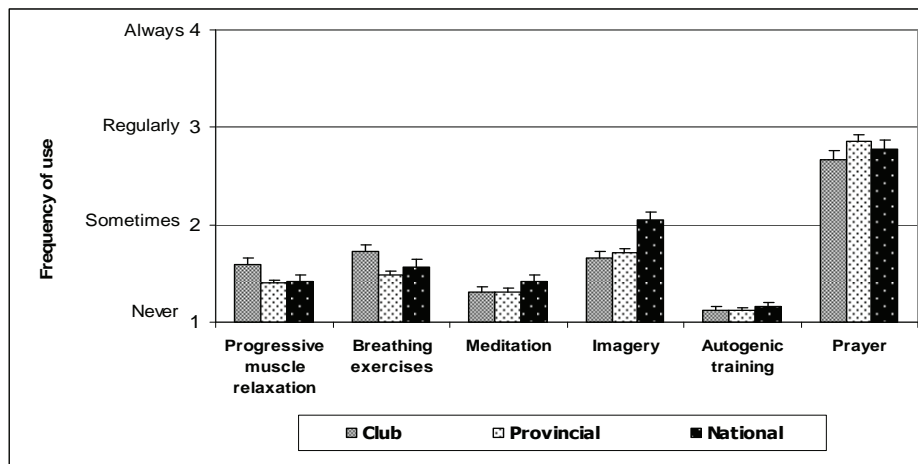


Figure 6.16: Use of relaxation techniques by players from different levels of participation

Apart from using the abovementioned methods for relaxation, players from hockey, netball, rugby and soccer put forward that the main reason for using the methods is because it *helps to focus on positives*. The second most important reason mentioned by players from all the sport codes is that it *helps with emotional recovery*. Reasons for using prayer that added by players were that it *makes the team feel as a unit*, *I'm thankful*, *confidence*, and *religion*.

The two main reasons reported by players from all levels for using the methods combined in the section on relaxation are that it *helps to focus on positives* and that it *helps with emotional recovery*. Provincial- and national-level players indicated that it *makes (them) feel good* as their third most important reason, while club-level players stated it *reduces stress and anxiety* as their third most important reason.

Music

From the total group, 852 players (96%) responded to the questions in the section on the use of music for recovery purposes. Music is *always* used by 12% of the players after a match, 14% *regularly* use music, and 13% *sometimes* use music. Of the total group, 61% of the players indicated that they *never* use music after matches. The most popular types of

music that were listened to by those who indicated that they do use music, are *rock* and *gospel*.

A number of players (n=77) added other types of music than those listed in the questionnaire. *House music* and *R&B* (or *RnB*) are mentioned by most of the players, followed by *Hiphop*, *Kwaito* and *dance beats*. *Calm music*, *chants* and *Gregorian music*, *love songs*, *panpipes*, *soul* and *traditional African music* are also mentioned.

Players use music for recovery purposes more after matches than after training sessions. Players from hockey, netball and soccer use music statistically significantly more ($p < 0.05$) than rugby players after training sessions and after matches. The main reason suggested by players from all four sport codes for using music is that it *helps (them) to relax*. The second most important reason for using music for netball players is that it *makes (them) feel energetic*. For rugby players it is that it *produces a positive attitude*, and for hockey and soccer players it is that it *makes (them) feel good*. The third most important reason soccer players reported for using music is that it *reduces feelings of anger*. A statistically significant difference ($p < 0.05$) was shown between soccer on the one hand and hockey and rugby players on the other hand in terms of the importance of using music to *reduce feelings of anger* and that music *can improve healing*. Soccer players consider the role of music to *reduce feelings of anger* and to *improve healing* more important than rugby and hockey players.

The main reason provided by players from all levels of participation for using music is that it *helps (them) to relax*. The second most important reason put forward by provincial- and national-level players for the use of music is that it *produces a positive attitude*, with the third most important reason being that it *makes (them) feel good*. Club-level players believe that it *makes (them) feel good* as their second most important reason, and it *produces a positive attitude* as the third most important reason. The only statistically significant difference ($p < 0.05$) between the different levels of participation for any of the main reasons for using music was found between club-level players and the other two groups in terms of using music *to fall asleep*. Club-level players use music more *to fall asleep* than provincial- and national-level players.

Added reasons stated for using music are that it *motivates*, is *used with visualisation*, it *changes the focus of the mind*, and it *releases the mind from training*.

Complementary and alternative medicine strategies

Results show that most of the players do not use aromatherapy: 93% never use it after training sessions, 92% never use it after matches, and 93% never use it on non-training days. Players who did report that they use aromatherapy, indicated that they mostly use *bath oils* and *fragrancing a room*. The most important reason for using aromatherapy is that it *helps (them) to relax*.

Acupuncture is *never* used by 77% of the 851 players who responded to this section, while 20% of the players *sometimes* use acupuncture, and 3% *regularly* use it. Rugby players used acupuncture significantly more ($p < 0.05$) than netball and soccer players. National-level players used acupuncture significantly more ($p < 0.05$) than club- and provincial-level players. The most important reason suggested by all players for using acupuncture was that it *relieves pain*.

Reflexology is *never* used by 92% of the respondents, while 95% of the players *never* use herbal therapy. Netball players use herbal therapy significantly more ($p < 0.05$) than rugby players. Magnetic fields is *never* used by 96% of the players, while 99% of the players indicated that they *never* use shiatsu.

Recovery methods the most used

In most sections of the questionnaire, players could mention their use of the specific recovery methods in various situations, namely, after training sessions, between training sessions, after matches and on non-training days. Results are shown for when these recovery methods were specifically used.

Recovery methods used after training

The recovery method that is used the most after training by all players from the four sport codes is an active cool-down. The recovery method that is used second most by hockey, netball and rugby players is the application of a strategy for fluid replacement, and thirdly the application of a strategy for food intake. The recovery method that soccer players use second most is music, and then a strategy for food intake. The fourth most used recovery method for hockey and netball players is music, for rugby players it is external cold, and for

soccer players it is a strategy for food fluid replacement. Figure 6.17 shows the five recovery methods that are mainly used after training by the players from the four sport codes.

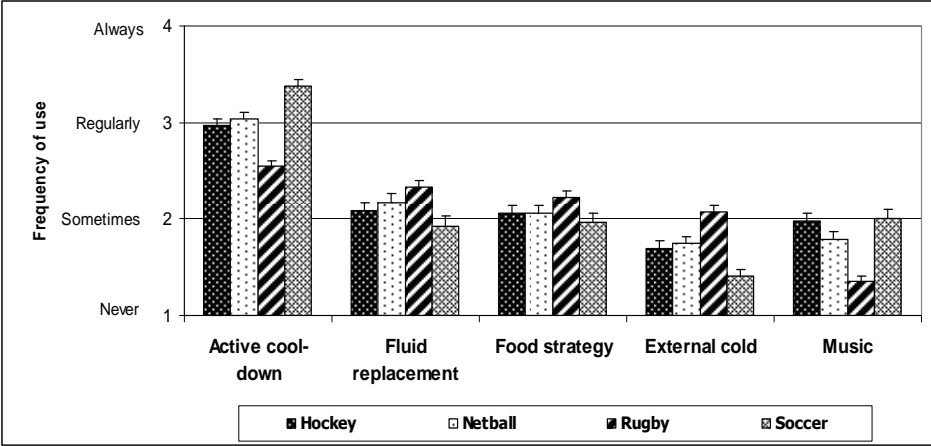


Figure 6.17: Recovery methods used most after training by players from four sport codes

Club-, provincial- and national-level players use the same five recovery methods the most after training, namely (in rank order) an active cool-down, a strategy for fluid replacement and food intake, external cold, and music, as seen in Figure 6.18.

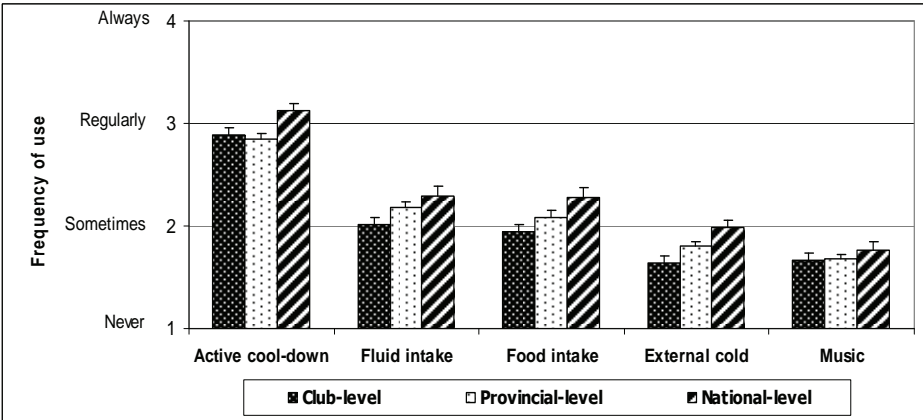


Figure 6.18: Recovery methods used most after training by players from different levels of participation

Although players reported that they use the methods to a certain extent, results show that an active cool-down is used most often by the players. The other recovery methods are not used regularly by club-, provincial- and national-level players after training sessions.

Recovery methods used after matches

Figure 6.19 shows the recovery methods that are used the most after matches by players from the four sport codes.

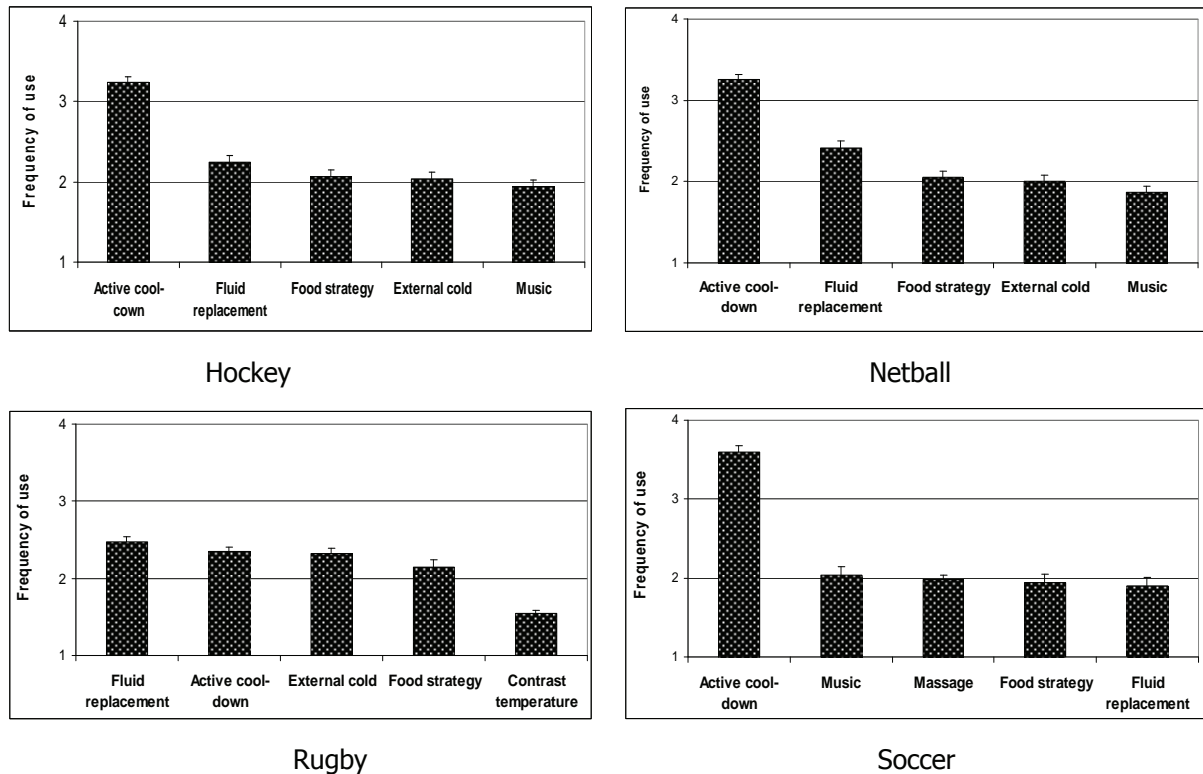


Figure 6.19: Recovery methods used most after matches by players from four sport codes

The recovery methods used the most after matches follow the same pattern in hockey and netball. An active cool-down is used the most, followed by a strategy for fluid replacement, a refuelling strategy, the use of external cold and then music, although only an active cool-down is used regularly. Rugby players use a strategy for fluid replacement the most, followed by an active cool-down, external cold, a refuelling strategy and then contrast temperature therapy. Results show that these recovery methods are not used regularly by rugby players. Soccer players use an active cool-down the most and regularly after matches. The other recovery methods that are used the most are music, massage, a refuelling strategy and a strategy for fluid replacement.

The two recovery methods used the most after matches are the same for the different levels of participation, namely, an active cool-down and a strategy for fluid replacement. Provincial-

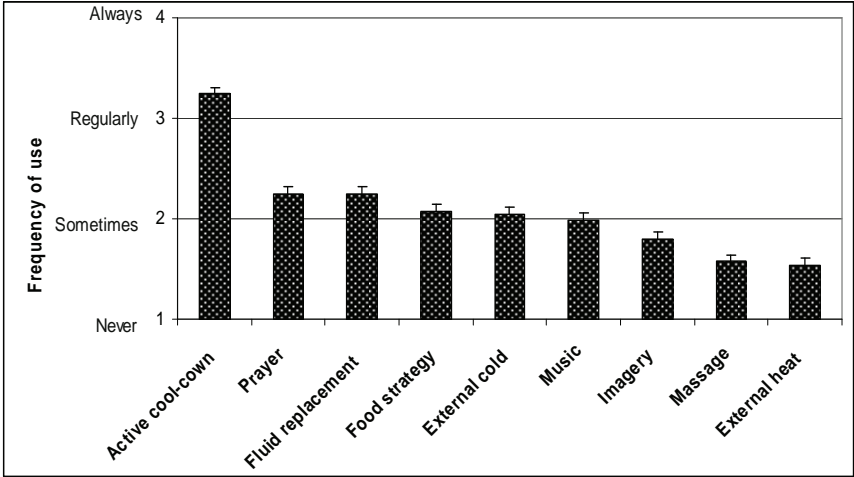
and national-level players use external cold third most, while club-level players use a strategy for food intake third most. A strategy for food intake is in the fourth place for provincial- and national-level players, while music is in the fourth place for club-level players.

Recovery methods used on non-training days

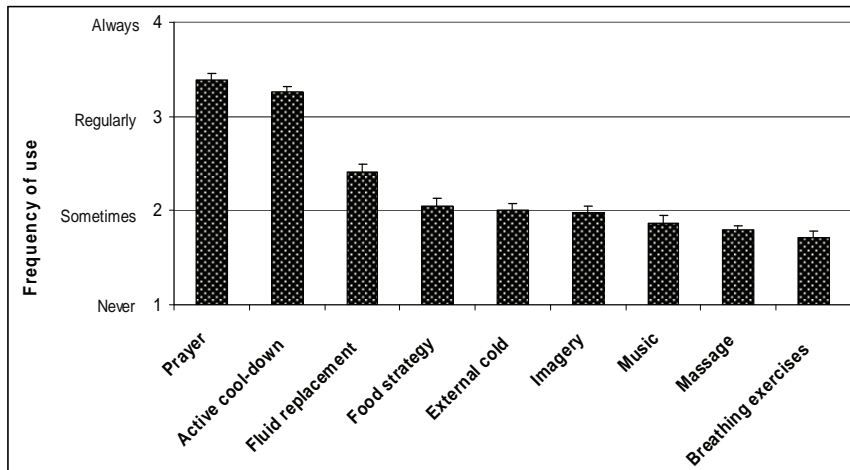
The recovery methods that players from different levels of participation mostly use on non-training days are (in rank order): massage, external cold, and contrast temperature therapy. These methods are not regularly used on non-training days.

Extent to which all recovery methods are used

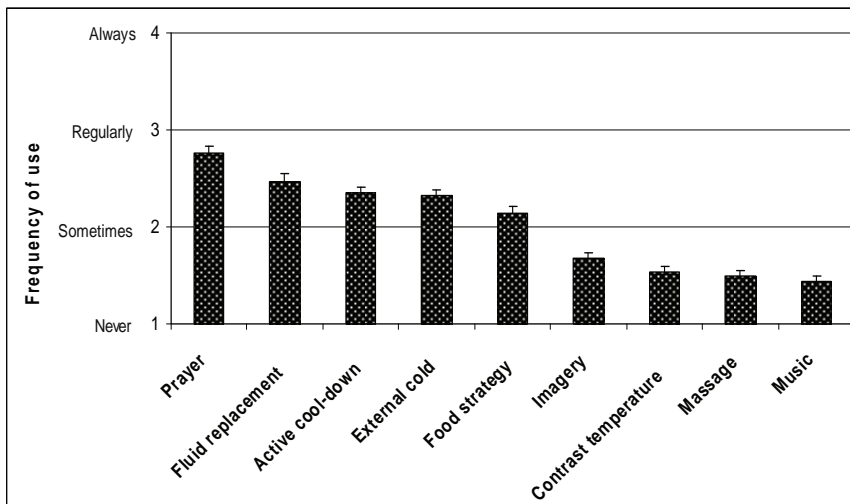
As mentioned earlier, players could indicate the extent to which they use some of the recovery methods in specific situations. These results were shown in previous sections. This section shows the results of the scores of all the recovery methods in the questionnaire to which the players could indicate their use. Only the methods which received the highest scores are shown in the graphs. Figures 6.20a to d show the results of the four sport codes.



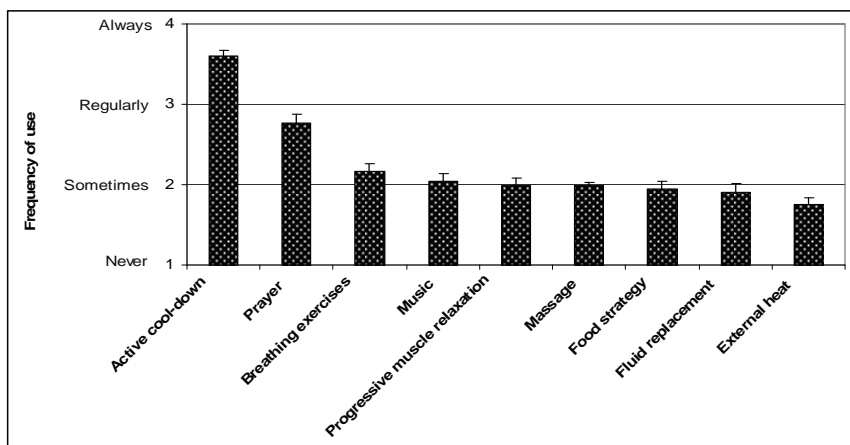
a. Hockey



b. Netball



c. Rugby



d. Soccer

Figure 6.20: Extent to which recovery methods are used by players from the four sport codes

When all the recovery methods are taken into account, hockey players reported that they use an active cool-down regularly, and then use prayer second most. This is followed by a strategy for rehydration and refuelling, external cold, music, imagery, massage, and external heat. Netball players use prayer the most, followed by an active cool-down, both are used regularly. Netball players also apply a strategy for rehydration and refuelling, external cold, imagery, music, massage, and breathing exercises. Rugby players reported that they use prayer the most, followed by a strategy for rehydration, an active cool-down, external cold, a strategy for refuelling, imagery, contrast temperature therapy, massage, and music. When all the recovery methods to which players could respond are taken into account, soccer players stated that they use an active cool-down the most, followed by prayer, breathing exercises, music, progressive muscle relaxation, massage, a strategy for refuelling and rehydration, and external heat.

Chapter Seven

Discussion and recommendations

Introduction

In this final chapter, the findings of the study are discussed in terms of the research questions that were asked. The research questions relate to the perceived importance of various recovery methods, the recovery methods that players actually use during the competitive phase of the year and the reason why players use the methods. This is followed by a model to guide athletes, coaches and trainers in terms of strategies and methods that could be applied for athletic regeneration. Finally, some recommendations and proposals regarding future research are made.

Perceived importance of various recovery methods

Players were asked to rate various recovery methods to indicate how important they perceive the contribution of each method to their regeneration. Strategies for regeneration were divided in this study into four main categories, namely natural strategies, physical strategies, psychosocial strategies, and complementary and alternative strategies. The methods that received the highest ratings from players from the total group in terms of perceived importance for regeneration are mostly from the natural- (active cool-down, nutrition, and sleep) and psychosocial strategies (music, socialisation, team and spiritual aspects). Netball and soccer players did not perceive any physical strategies as important. With regard to physical strategies, hockey players rated an ice bath amongst the most important methods, while rugby players rated an ice bath and massage amongst the most important recovery methods. Soccer players perceived psychosocial recovery methods as the most important for their regeneration, where most important methods were from the category psychosocial strategies.

Club-, provincial- and national-level players also perceived recovery methods from the natural and psychosocial strategies as the most important methods for their regeneration. The only recovery method from the physical strategies that was perceived as important, was an ice bath, rated by provincial- and national-level players, and a massage by a therapist, rated by national-level players.

A question that can be asked, is: are the recovery methods that players use, those methods which they perceive as the most important for their regeneration? The use of the various recovery methods will be discussed in detail in the following section, but it can be mentioned that players from the four sport codes and different levels of participation mostly use the recovery methods which they perceive as important for their regeneration. There are however, a few exceptions. Hockey players did not rate prayer amongst the most important recovery methods, although players reported that prayer is the method used second most, after an active cool-down. Although hockey players did not rate prayer as important to regeneration, it might form part of a post-match ritual and is therefore used. Netball players did not rate an ice bath amongst the most important recovery methods for regeneration, although players mentioned that it is used. An ice bath was seen as important to provincial- and national-level players from the total group. It might therefore be that, although an ice bath was not rated as important by players from the total netball group, it is used by provincial- and national-level netball players in specific situations (e.g., training camp or tournament). Rugby players did not rate an active cool-down amongst the most important recovery methods for regeneration, although players indicated that it is the recovery method third most used. Results show that rugby players differed from hockey, netball and soccer players in terms of the use of an active cool-down. Rugby players use an active cool-down more after training than after matches, while the other players use an active cool-down more after matches than after training. Due to the fact perhaps that rugby is a contact sport, players may feel more fatigued and sore after a match than after a training session. Therefore they might regard an active cool-down as not important or suitable to their specific post-match situation and needs. Imagery was only rated amongst the most important recovery methods by netball players, although hockey, netball and rugby players reported that they do use imagery.

Natural strategies

Players perceive recovery methods from the category natural strategies as important to their regeneration, and it is also these methods that are used most by players. Methods from the natural strategies are seen as specific methods that do not require any special devices or modalities (Bompa, 1999). It should therefore be relatively easy for players from all levels of participation to address natural strategies for regeneration. Pickett and Morris (1975: 49) wrote: "Next to the air we breathe, food and sleep are the two most crucial physical essentials for maintaining a sound and healthful state of living." Davis et al. (2002) mentioned nutrition and sleep as part of the basics that athletes have to address with regard

to regeneration, with Williams (2007) also emphasising nutrition and rest as key components of regeneration. With regard to the natural strategies emphasised in this study, players could respond to aspects pertaining to sleep, nutrition and an active cool-down.

Sleep

Sleep is perceived as the most important means of recovery for regeneration by rugby and soccer players and by players from the different levels of participation, while it is rated second most important by hockey and netball players.

With regard to sleep, most of the players (n=614, 75%) indicated that they sleep between six and eight hours per night which support the findings of a number of studies showing that individuals older than 18 years tend to sleep between six and eight hours during the week (Hicks et al., 1999; Hicks & Pellegrini, 1991; National Sleep Foundation, 2005). Although Ferrara and De Gennaro (2001) wrote that a mean of seven to eight hours should be enough for most people, Bompa (1999) and Calder (2003) stated that athletes require nine to ten hours of sleep, of which 80-90% should be during the night. Athletes are also advised to take a 20-minute nap during the day, often called a power nap or recovery break (Cable, 2005; Kenttä & Hassmén, 2002; Postolache et al., 2005). Players indicated that they take a nap to varying degrees, 47% taking a nap *sometimes* and 31% *never* take a nap. Players could be motivated to take a nap or micro-rest when at training camps or tournaments to reap the suggested benefits of a nap.

A number of players reported that they experience problems waking in the morning, which might be an indication of sleep deprivation. The fact that a number of players mentioned that they increase the amount of hours they sleep over weekends, may be an indication that they address their sleep debt over weekends. It should be remembered that most of the players who participated in the study are not from professional teams. Various factors under these circumstances make it difficult for athletes to sleep as well as they would like, such as studies and examinations, demands of work, and family commitments (Sivas, 1994).

Some players (41%) indicated that they experience problems falling asleep at night. It is difficult to make assumptions on why problems are experienced. A number of factors can play a role. Carney and Waters (2006) mentioned "worry" as a major contributor to pre-sleep cognitive arousal, while a strange setting (Lee, 1997), noise, light, extreme temperatures (Axt & Axt-Gadermann, 2005; Kawada & Suzuki, 1995; Öhrström & Skånberg, 2004),

caffeine and nicotine (Sierra, Jiminez-Navarro & Martin-Ortiz, 2002; Van Dongen et al., 2001; Zarcone, 1989) can all negatively affect the onset of sleep. Players could be educated with regard to factors that may affect their sleep negatively, as well as on the use of various methods to help them to relax at bedtime. Players mentioned that noise and light in terms of the sleep environment are the two factors that affect the quality of their sleep the most. National-level players indicated to a greater extent that light in the sleep environment affects the quality of their sleep, although the differences are not statistically significant. Hanton et al. (2005) reported from their study that disturbed sleep patterns were mentioned as a major environmental stressor by elite sport performers. Michealis (2005) reported on the specific efforts that were made for the Winter Olympics of 2006 to arrange optimal sleeping environments for their athletes competing in the Olympics. It is important for management staff to consider aspects in the environment which could affect sleep quality when players are at training camps, tournaments or on tour. The importance of making appropriate accommodation arrangements should therefore not be underestimated.

With reference to managing jet lag, most of the players reported that they do not know how to manage jet lag. National-level players reported to a greater extent that they know how to manage jet lag, although the differences are not statistically significant. It could be expected of national-level players to know how to manage jet lag because they might be more exposed to travelling and crossing time zones. Because a number of players at international level do not know how to manage jet lag, and due to the effects of jet lag on players, this is an area that could be addressed by management. Elite performers often spend a great deal of time travelling and poorly planned travel arrangements can have a negative effect on the physical and mental well-being of players, especially when jet lag becomes a concern. Waterhouse et al. (2002) emphasised the importance of optimum flight arrangements to try and minimise the effects of jet lag. Some recommendations to management staff are made, among others, to arrange flight times in such a manner that the amount of time spent before being able to take a full night's sleep at the new night time is made as short as possible.

The role of sleep in the physiological growth and repair of the body was mentioned as the main or most important role of sleep in the regeneration process by hockey, netball and rugby players and by all players from the different levels of participation. Although the body is continually in a process of revitalization, this process peaks during sleep in stages three and four. Physiological processes that cause this effect include the role of the endocrine

system that increases the secretion of growth hormones (Loehr & Schwartz, 2005; Walters, 2002). Rugby players were the only players who rate the role of sleep in increasing the secretion of growth hormones as important. The elevated secretion of growth hormones is often given as one of the reasons why athletes are encouraged to sleep during the day (take a nap) to stimulate the release of growth hormones. Gunning (2001) suggested that this could be useful for athletes who are going to perform strength training sessions after a nap. Sleep deprivation is regarded as a stressor that has significant effects on physiological growth and repair. It is believed that melatonin and growth hormone, released during the sleep cycle, function to stimulate and enhance the immune system. Sleep deprivation might therefore have a negative effect on tissue healing and recovery (Nadler et al., 2003b).

The other two functions of sleep rated as most important by the players were the role of sleep for emotional well-being as well as for maintaining body rhythms. Emotional well-being has an effect on every aspect of life. The study by Haack and Mullington (2005) showed that optimism-sociability decreased significantly over a period of sleep restriction. Bodily discomfort (ratings of generalised body pain, stomach pain, backache, headache, joint pain and muscular pain) increased. The authors stated that, because optimism and positive mood states are associated with better mental and physical health, it might be that chronic insufficient sleep could be involved in lowering psychosocial functioning and positive outlook.

Numerous other studies showed the effect of poor sleep on emotional well-being. Poor sleep is associated with depressed mood, reduced motivation, reduced ability to deal with emotions, increased levels of stress, anxiety, worry, frustration, irritability, and difficulty coping with new environmental stressors (Brassington, 2002; Lee, 1997; Scott et al., 2006; Youngstedt, 2005). With even minimal sleep loss, perceived exertion is increased and the threshold for containing anger is lowered. Lack of sufficient sleep therefore adds to the emotional challenges inherent in competition (Walters, 2002).

It is evident that sleep of good quality plays a vital role in the lives of athletes, and it is rated as important accordingly by the players who participated in this study. The players also emphasised the role of sleep in their physiological recovery as well as their emotional well-being. It is therefore important to educate players in terms of sleep hygiene, and assist elite players to get good quality sleep under various conditions.

Nutrition

Players from all sport codes and levels of participation perceived nutritional aspects as important for regeneration. Regular healthy meals were rated amongst the three most important aspects by all players in this study. This confirms the findings by Hanton et al. (2005) which showed that a nutritional regime is a key factor for many elite athletes, and emphasised the importance placed on diet. Poor provision of food was indicated as one of the major stressors by elite athletes in the study by Hanton et al. (2005). Armstrong (2006) stated that nutrition is viewed as one of the key factors to offset the performance decrements that occur in stressful environments, especially when athletes have to travel and compete in extreme environments.

Players from hockey, netball and rugby rated a strategy for fluid replacement amongst the ten most important recovery methods, and fluid replacement was also indicated as one of the recovery methods that these players used the most. Aspects with regard to refuelling are also rated as important by these players. Soccer players did not regard the application of a strategy for rehydration and refuelling as some of the most important recovery methods. It is not clear why the soccer players in this study do not rate rehydration and refuelling as important aspects in terms of regeneration. Armstrong (2006) emphasised the large energy requirements of competitive soccer, with elite players covering between 10 and 12 kilometres on average (Stølen et al., 2005). Play involves, as with hockey, netball and rugby, intermittent high-intensity exercise which reduces muscle glycogen stores (Williams, 2007). Reilly and Ekblom (2005) stated that, by the time a soccer game ends, those players who had played for the entire game are likely to have almost depleted their active-muscle and liver glycogen stores. The restoration of glycogen stores after exercise should be a priority for players. Maughan et al. (1997) wrote that, if players begin an event with muscle glycogen stores that are low as a result of inadequate glycogen repletion, performance will be impaired. Team sport players are advised to refuell effectively between matches, undertaken every four to seven days during the competitive season, as well as the conditioning sessions undertaken between matches. It has been shown that repetition of high-intensity exercise on successive days are difficult, but better restoration of muscle carbohydrate stores can enhance recovery (Burke et al., 2006). The time to recover between successive competitions or training sessions is often short (less than eight hours), and rapid glycogen synthesis becomes even more crucial under these circumstances (Burke et al., 2006; Jeukendrup & Gleeson, 2004), as in tournament situations.

The timing of dietary intake is important, with a number of researchers emphasising the window of opportunity after exercise (Armstrong, 2006; Jentjens & Jeukendrup, 2003; Jeukendrup & Gleeson, 2004). In this study, some players indicated that they drink sports drinks after matches, that they eat and drink within two hours after training (32% of respondents) and within two hours after matches (33% of respondents). For that reason there are some players who refuell within the suggested two hours after exercise. Athletes who have a strenuous competition schedule or train twice a day are advised to consume carbohydrate-rich foods of moderate to high GI within the first six hours after exercise (Calder, 2000a; Crosland, 2007; Williams, 2007). Regarding the question whether they use the GI of food to determine their fluid and food choices for recovery nutrition, most of the players indicated that they do not use the GI as a guideline. It might be that the players do not know the specific term, *glycaemic index*, or that they are not aware of the benefits of consuming high-GI foods for refuelling after exercise.

Although controversy surrounds the guidelines in terms of rehydration during and after exercise (Sawka & Noakes, 2007), team players are advised to rehydrate after exercise, especially when sweat losses are high (Armstrong, 2006; Finn & Wood, 2004; Maughan & Burke, 2004). Sawka et al. (2007) wrote in a position stand for the American College of Sports Medicine that full replacement of any fluid and electrolyte deficit should be an aim after exercise. The authors stated that the degree of action to be taken depends on the speed of rehydration that must be accomplished. It is suggested that, if time permits, consumption of normal meals and beverages should restore euhydration. Individuals needing rapid and complete recovery from dehydration can drink ~1.5 L of fluid for each kilogram of body weight lost. Players might feel uncomfortable if they eat solid foods soon after a training session or match and might therefore prefer liquid foods to refuell and rehydrate (Hawley & Burke, 1998; Volpe, 2007), since no difference has been reported in the rates of refuelling between liquid and solid forms of carbohydrate (Jentjens & Jeukendrup, 2003; Jeukendrup & Gleeson, 2004).

A number of players (37%) indicated that they combine carbohydrates and protein after a hard training session or match, and 37% indicated that they use vitamins and minerals. Results from the majority of studies indicated that combining protein and/or amino acid-mixtures with carbohydrate did not enhance the rate of glycogen synthesis when the amount of carbohydrate ingested was above 1g/kg BW/hour (Wright, Claassen & Davidson, 2004a), and that ingesting an adequate amount of carbohydrate is more important than adding

protein or amino acid mixtures to a recovery meal or drink (Jeukendrup & Gleeson, 2004). There may be other reasons for including protein and other nutrients such as vitamins and minerals in snacks and meals immediately after exercise. These nutrients are important in recovery processes such as repair and rebuilding, as well as immune responses. An immediate intake might be useful in promoting these activities (Hawley and Burke, 1998). It is often also difficult or unappealing to athletes to eat large meals after exercise to consume enough CHO (Burke, 1998; Hawley & Burke, 1998). It is therefore suggested that the athlete consume a moderate CHO intake in combination with protein and/or amino acids, which should result in similar muscle glycogen synthesis, when compared to the ingestion of a large amount of CHO only (Jentjens & Jeukendrup, 2003).

The most important reasons indicated for addressing nutritional aspects in recovery related to replacing fluid losses, having energy and being able to train hard again. These reasons link to the role of recovery nutrition in terms of rehydration and rapid glycogen synthesis to be able to perform well in the next training session or match. Rugby players rated the role of nutrition in muscle repair statistically significantly ($p < 0.05$) more important than players from the other sport codes. This might be due to the fact that rugby is a contact sport. Takarada (2003) showed that competitive rugby matches induce serious structural damage to muscle tissue, with the major cause being the direct impact of tackles and the repeated eccentric muscle contractions involved in the intermittent sprinting of the players. Muscle repair are therefore relevant issues to rugby players.

It should be noted that, although players rated nutritional aspects amongst the ten most important recovery methods for regeneration and also indicated that they apply strategies for rehydration and refuelling, results showed that these strategies are not applied on a regular basis by players from all the groups. Results indicated that national-level players apply these strategies more often. National-level players might experience a greater need for rehydrating and refuelling due to the intensity of competition at that level. They may also have members of management that regard these aspects as important, and the players might generally be looked well after.

Rugby players and national-level players perceived the use of supplements amongst the most important recovery methods to be used for their regeneration. Hespel et al. (2006) discussed the use of supplements in soccer and stated that the use of dietary supplements should not compensate for presumed dietary shortcomings. The authors also mentioned that

there are sound scientific evidence that some supplements can affect factors that determine performance in soccer. The effects of these supplements are, according to the researchers, generally small, but even small variations in performance can be the difference between loss and victory. As with rugby and players at international level, match outcomes can have major financial and career implications. Hespel et al. (2006) emphasised that, to counter the strong marketing pressures generated by the supplement industry, players should however be educated about effective procedures for supplement intake.

Active cool-down

Athletes are often advised to gradually recover from high-intensity exercise through a cool-down period (Harris & Elbourn, 2002; Hawley & Burke, 1998). It is suggested that an active cool-down could consist of stretching as well as up to 20 minutes of low-intensity aerobic exercise, with the intensity of the aerobic exercise no higher than 60% of the athlete's maximum heart rate (Bompa, 1999).

The use of an active cool-down was rated amongst the most important recovery methods by players from hockey, netball, soccer and all levels of participation. An active cool-down is also the recovery method that is used the most by hockey and soccer players, second most by netball players and third most by rugby players. As mentioned earlier, rugby players did not rate an active cool-down amongst the most important recovery methods for regeneration. Rugby players also use an active cool-down more after training than after matches, while the other players use an active cool-down more after matches than after training. It might be that due to the fact that rugby is a contact sport, players feel more fatigued and sore after a match than after a training session. They might therefore not regard an active cool-down as important or suitable to their specific post-match situation and needs.

Players indicated that slow jogging and stretching are most often used during an active cool-down. The most important reasons indicated by all the players for using an active cool-down were that it decreases muscle soreness. O'Connor and Hurley (2003) did a systematic review on interventions in the management of delayed onset muscle soreness (DOMS). They stated that, despite a limited evidence base, the weight of current evidence suggests that light concentric exercise has some short-term effects on muscle soreness. Reilly and Ekblom (2005) also reported on the efficacy of an active cool-down in university soccer players and

concluded that muscle soreness ratings had almost abated 48 hours after playing in individuals who used an active cool-down.

Hockey, netball and rugby players indicated that the second most important reason for using an active cool-down is that it speeds up the removal of waste products from the muscles. A number of studies investigated the effectiveness of active recovery versus passive recovery on lactate removal, and showed active recovery to be the best modality for enhancing lactic acid removal after exercise, compared to passive rest (Gupta et al., 1996; Sairyo et al., 2003; Watts et al., 2000). Although many studies focused on the effect of active recovery on lactate removal, Barnett (2006) indicated that lactate removal might not be a valid criterion for assessing recovery and the quality of recovery in athletes. The author mentioned that blood lactate returns to around resting levels at 90 minutes after high-intensity exercise, which is a shorter time-frame than the time between training sessions of elite athletes. Barnett (2006: 784) wrote: "any recovery modality that is undertaken on the basis of its effect on lactate removal seems superfluous."

Soccer players indicated that their second most important reason for using an active cool-down is that it helps them to relax and thirdly, that it also helps them to wind down. Reilly and Ekblom (2005) discussed this function of an active cool-down as a recovery method for soccer players. The authors mentioned that there is an elevated level of arousal of the central nervous system after a match. An active cool-down can damp activity in the nervous system, which can also promote sleep afterwards.

Hockey, netball and rugby players rated the role of an active cool-down in countering the negative effects of intense training on the immune system as their third most important reason for using an active cool-down. There are suggestions that an active cool-down might be beneficial to the immune system (Malm et al., 2004; Reilly & Ekblom, 2005; Wigernæs et al., 2000).

Although stretching seems to be a popular part of an active cool-down routine, there do not appear to be studies that have investigated the effect of stretching on recovery.

Physical strategies

Not many recovery methods from the category physical strategies were rated amongst the most important methods for regeneration by players who participated in this study. An ice bath was rated as important by hockey, rugby, provincial- and national-level players. Results show that external cold is amongst the top five recovery methods used by hockey, netball and rugby players, as well as players from all levels of participation. Contrast temperature therapy was not rated amongst the most important recovery methods, but rugby players indicated that they use contrast temperature therapy, although not regularly. Massage was only rated by rugby players and national-level players amongst the most important recovery methods, but players from all four sport codes and levels of participation indicate that massage is used at times.

Cryotherapy

Results show that players do use external cold for recovery purposes, but it is not used regularly. It should be noted that players were asked in the questionnaire to respond to questions on the use of external cold. Although players were specifically asked on the use of external cold for recovery purposes and in specific situations, the researcher cannot be absolutely sure that some players did not regard the use of external cold for the treatment of acute injuries as part of recovery.

Although netball players did not rate an ice bath amongst the most important recovery methods, players did mention that external cold is used. Results indicate that hockey and rugby players also do not use external cold regularly, although rugby players use it more compared to other players. Rugby players may, due to the fact that rugby is a professional sport, have better access to facilities where they can use cryotherapy after training and after matches, which might not be the case with the other sport codes. Rugby is also a contact sport and rugby players might look for methods which they believe might address the effects of contact on the body. National-level players use external cold statistically significantly ($p < 0.05$) more than club-level players after training sessions. Provincial and national-level players also use external cold statistically significantly ($p < 0.05$) more after matches than club-level players. Players at higher levels of participation often have better access to specialised facilities and might be more exposed to trainers focusing on aspects of recovery. Because results show that players do not use cryotherapy on a regular basis, it might therefore be that these cryotherapy methods are only applied in specific instances, like at a training camp or at a tournament.

The methods that players reported to use the most for cryotherapy, are (in rank order), ice packs, ice baths, cold shower, and activities in a cold swimming pool. A survey by Nadler et al. (2003) amongst 905 athletic trainers at high-school, college and professional levels, and at physical therapy clinics showed that ice also was the most commonly used modality for therapeutic use. In an athletic team setting, ice is normally put in a container such as a plastic container filled with water, in which athletes will stand to immerse their legs. Wilcock et al. (2006b) mentioned that the duration of immersion in performance research on cryotherapy varies from 15 to 20 minutes, but in a field setting immersion time may be as little as 30 seconds. The authors stated that this immersion method might be impractical for team sports, because of the time required to treat all the athletes.

Although the use of ice baths, cold water immersion and contrast temperature therapy has become popular in many sports, the use of cryotherapy for recovery is somewhat controversial. It is regarded by some as "anecdotal stuff that just becomes fashionable" (Fricker, 2004: 1), while Halson (2004: 1) claimed that "there is little evidence that ice baths really help uninjured athletes." Wilcock et al. (2006b: 758) cautioned against sudden severe cold immersion of a large portion of the body when they wrote: "... care should be taken when using cold immersion on athletes. Very cold temperatures may be best only in a localised manner to treat acute injuries and reduce inflammation, rather than being used as a recovery strategy." White and Ray (2007: 284) wrote on the preparation of the Springbok rugby team for the World Cup that Tim Noakes advised them against visiting the cryochambers in Poland by saying: "Listen Jake, with all due respect, there's no scientific proof that cryotherapy works. It's a thing that works on players psychologically, so they think they can recover."

The main reasons stated for using external cold by all the players are that it decreases muscle soreness, reduces inflammation, reduces swelling, and decreases pain. National-level players added the role of external cold concerning the faster removal of waste products and rated it statistically significantly ($p < 0.05$) more important than club-level players. There are few studies published that have focused on the effectiveness of cryotherapy for post-exercise recovery, and results from those that are published seem to be contradictory. Sellwood et al. (2007) reported that ice-water (5°C) immersion did not show any benefit for the prevention of DOMS and did not decrease pain and swelling, while Bailey et al. (2007) indicated that cold-water (10°C) immersion reduced muscle soreness in their study. Vaile et al. (2007) showed that cold-water immersion (15°C) and contrast temperature therapy

(alternating between 40°C-42°C and 8°C-10°C) improved the symptoms of DOMS compared to passive recovery. Wilcock et al. (2006a: 203) did a review of literature to assess the effect of post-exercise water immersion on exercise performance and concluded by stating that athletes who underwent intense exercise sessions that caused prolonged muscle fatigue (muscle damage) benefited from water immersion. Benefits were also observed with athletes who performed multiple bouts of strength and plyometric exercises and water-recovery sessions. Because the effect of water temperature on recovery is still unclear, the authors suggested that benefits from water immersion might be due to the hydrostatic pressure of the water. Whether water immersion provides greater recovery benefits than active recovery is also unclear. The researchers concluded by writing: "Therefore the best practice might be to use water immersion and associated water temperature according to the personal preference of the athlete. One should be aware that there are many limitations in the research. Performance parameters, exercise mode and intensity, water temperature, immersion duration, immersion depth, recovery timelines, and longitudinal effects of water immersion on performance are a few areas that require research." Barnett (2006) mentioned in his review article on recovery modalities that there are some indications that cryotherapy might have negative effects on adaptation to training.

Massage

As mentioned earlier, massage was only rated by rugby players and national-level players amongst the ten most important recovery methods, but players from all four sport codes and levels of participation indicated that massage is used. A massage was mostly applied by a therapist and consisted of deep tissue massage. Rugby players indicated that massage is used more on non-training days. Some researchers suggested that a massage should not be applied after training or after a match, because post-exercise massage could cause further trauma where training has caused tissue damage (Barnett, 2006). Holey and Cook (2003) wrote that there are opinions that an intense, vigorous massage might stress the body like a training session and that activity should therefore be reduced slightly over the following 24 to 48 hours. Barnett (2006: 787) also cautioned about the use of massage between training sessions and wrote: "If massage reduced perceived soreness without accompanying physiological and performance recovery, the athlete may attempt training loads beyond current capacity. This may lead to an inappropriate level of stress, undesirable levels of fatigue and potentially greater risk of injury."

Players mentioned a variety of reasons for using massage as a recovery method. Hockey and rugby players use massage mainly to release tight connective tissues and to decrease muscle soreness. The most important reason for netball players is that it relieves pain and secondly it decreases muscle soreness. For soccer players, the most important reason is that it helps them to relax, and secondly that it makes muscles more supple or flexible. The main reason for using massage indicated by players from all levels of participation was that it releases tight connective tissues, and that it also decreases muscle soreness. As with the use of cryotherapy, it seems as if research results on the benefits of massage for post-exercise recovery purposes are also contradictory. Results from the study by Jönhagen et al. (2004) demonstrated that a sports massage did not have any local effects in reducing DOMS of the quadriceps muscle, while Mancinelli et al. (2006) showed that a post-exercise massage decreased perceived soreness of the leg in the experimental group. O'Connor and Hurley (2003) stated that there is some evidence that massage can be used as intervention in the management of DOMS, while Hilbert et al. (2003), Dawson et al. (2004) and Reilly and Ekblom (2005) reported that massage did not alleviate physiological symptoms of muscle strength loss, swelling or soreness faster than in the control conditions. It has been stated that the effects of massage might have been more psychological than physiological. Possible explanations for the decreases in muscle soreness were indicated as improved sleep patterns, increased endorphin and serotonin levels, and decreased levels in stress hormones following treatment. A qualitative review of the participants' comments in one study indicated that the massaged leg felt more relaxed, felt looser when running, felt better while weight lifting, and felt better when walking downstairs. The researchers mentioned that massage might have positive effects on perceptions of recovery.

Tiidus (1997) concluded after a review of literature that manual massage did not have a demonstrated effect on muscle damage caused by eccentric muscle action, or on the retention and recovery of muscle strength and performance following eccentric muscle damage, or reduction of delayed onset muscle soreness, or the recovery of muscle strength and performance following anaerobic exercise. Robertson et al. (2004) stated that most of the claims that massage can aide recovery and optimise performance are anecdotal or come from research flawed by methodological variations and poor experimental control. According to the authors, literature does support the psychological benefits from massage, but physiological and performance benefits have not been consistently observed. Hemmings (2001: 165) wrote: "recent research seems to demonstrate massage having positive effects on perceptions of recovery." Calder (1996) stated that a major benefit of massage lies in the

relaxation that athletes experience when massaged, which can make them feel less fatigued and more relaxed, with a corresponding improvement in mood state.

There are indications in literature that massage could be used to release tight connective tissues. Myofascial release through adapted massage techniques is becoming popular with therapists working in the athletic environment. Connective tissues or fascia bonding, which is either stretched/contracted ('locked long') or shortened/contracted ('locked short') is manipulated, which might be beneficial in the management of musculoskeletal pain (Holey & Cook, 2003; Myers, 2001).

Soccer players reported that they use massage for relaxation purposes. There are some reports in literature stating that massage might help players to relax (Hemmings, 2001; Moyer et al., 2004; Tiidus, 2000). Goats (1994b: 155) wrote that "manual therapy is a well documented aid to relaxation", and stated that physical relaxation might accelerate physical repair. The psychological benefits of sports massage are reported as enhanced emotional well-being, calmness, improved mood, relaxation and reduced anxiety.

Despite inconclusive evidence on the benefits of massage for recovery, massage has been popularly used by athletes and will probably remain a sought after therapy method.

Psychosocial strategies

A number of methods from the category psychosocial strategies, namely socialising with friends, team communication (players and coach), prayer, music, and imagery were rated by various groups amongst the most important means of recovery for regeneration.

Relaxation techniques

Only players from soccer rated breathing exercises and progressive muscle relaxation amongst the ten most important methods used for regeneration. Imagery was only rated as important by netball players, although players from hockey, netball, rugby, and players from different levels of participation indicated that they use imagery in some instances. Netball players use imagery the most, and statistically significantly more ($p < 0.05$) than rugby and soccer players. Whitehead and Basson (2005) reported from their study on the use of imagery by athletes that players from team contact-sports (rugby) used imagery more than players from non-contact sports. This trend was not found in the current study. National-

level players use imagery statistically significantly more ($p < 0.05$) than club- and provincial-level players. A question can be asked if the players accurately reported on the use of imagery for regeneration purposes specifically.

Research on the benefits of breathing exercises, progressive muscle relaxation and imagery in terms of regeneration is difficult to find in literature. Milne et al. (1999) stated that relaxation techniques can be used for jet lag to assist with re-establishing sleep patterns. In a review of research projects which focused, amongst other, on the effect of progressive relaxation on athletic performance, Onestak (1999) stated that progressive relaxation procedures appeared to be effective in reducing anxiety levels and alleviating both the psychological and physiological indices of anxiety. Weinberg and Gould (2003) mentioned that imagery after practices and competitions appeared to be underutilised and stated that athletes reported using imagery more before competitions than after competitions. There are some indications that imagery can be used for rehabilitation purposes (Weinberg & Gould, 2003), especially for soft tissue injuries (Morris et al., 2004). A variety of benefits, including faster healing, have been identified. When imagery is used for rehabilitation purposes, the focus tends to be on the motivation to recover and to rehearse rehabilitation exercises (Weinberg & Gould, 2003). Shaw et al. (2005) referred to research indicating that imagery aided people's ability to cope with pain, while Blach and Blach (2000) stated that imagery has been used successfully to stimulate the immune system. Seeing the value of imagery for rehabilitation purposes, it could be possible that the athlete's regeneration process could also benefit from imagery.

Prayer

Players from netball, rugby and soccer, as well as players from all levels of participation rated prayer as the most important or second most important method for regeneration. Prayer is also used the most by netball and rugby players, followed by an active cool-down for netball players and fluid replacement for rugby players. Prayer is used second most by soccer players, following an active cool-down. Prayer was not rated amongst the most important methods by the hockey players, while results show that this method is used second most by hockey players. Prayer activity seems to be present throughout various levels of sport participation, from professional sport to interscholastic sport. A study by Todd and Brown (2003) showed that 76% of the Division I and Division III athletes indicated that they use prayer in the athletic setting. As in the current study, no differences were found in the use of prayer between different levels of participation.

The therapeutic potential of spirituality is more acknowledged every day. Spirituality is attracting attention as a moderator of stress, with Ridnour and Hammermeister (2008) indicating that spiritual well-being may be a construct that is useful in developing an enhanced coping-aptitude necessary for excellence in sport. The use of prayer in coping with the uncertainties in sport is prevalent among athletes and more so for athletes playing elite sport. Jones (2003) mentioned that many people reported using prayer as a stress management technique. This is supported by the study by Plaatjie (2006) where soccer players indicated that they use prayer as a post-match coping strategy. Matches elicit intense emotions and players might therefore use prayer as a post-match coping strategy. In this study, some players mentioned that prayer helped them with emotional recovery.

Research by Turman (2003) showed that athletes used prayer during post-game interaction as a technique in promoting team cohesion, where athletes described team prayer as one of the most effective strategies for allowing separation, animosity and individual prejudices to be wiped away. Watson and Czech (2006) confirmed this by showing that athletes use prayer, amongst other, to establish a strong bond of attachment between teammates. In the current study, some players confirmed this by writing that "praying together make the team feel as a unit."

Studies on the relationship between religion and health have linked prayer to positive health outcomes (Hoeger & Hoeger, 2007). Lee and Newberg (2005) wrote that there are indications that prayer may be associated with reduced muscle tension, improved neuro-immunologic parameters, psychological and spiritual peace and a greater sense of purpose.

Music

Players from hockey, netball, soccer, club-, provincial- and national-level players perceived music as one of the most important methods for regeneration. Although rugby players did not rate music amongst the most important recovery methods, players did indicate that it is used at times. Players use music for recovery purposes more after matches than after training sessions. Players from hockey, netball and soccer use music statistically significantly more ($p < 0.05$) than rugby players after training sessions and after matches.

Most of the reasons for using music reported by the players relate to subjective feelings and mood states. The main reason indicated by players from all four sport codes and levels of participation for using music was that it helps them to relax. The second most important

reason for using music for netball players was that it makes them feel energetic. For rugby players and provincial- and national-level players it was that music produces a positive attitude, and for hockey and soccer players it was that it makes them feel good. Soccer players also indicated that music reduces feelings of anger. Club-level players also use music to fall asleep, and statistically significantly more ($p < 0.05$) than provincial- and national-level players.

Music has been used throughout history for therapeutic purposes and as a technique to enhance the psychophysical state of participants in sport and exercise (Karageorghis & Terry, 1997). It is suggested that music reduces the perception of pain, can enhance feelings of being energetic, helps create a positive frame of mind, helps with release of anger and encourage relaxation. Music can also develop the positive mood states of calmness, happiness, reduced tension and reduced depression (Blach & Blach, 2000; Jeffreys, 2005; Le Roux, 2006; Stevens & Lane, 2000). Milne et al. (1999) mentioned that travel stress can also be minimised when athletes listen to their personal music. With reference to the effect of music therapy on insomnia, Le Roux (2006) wrote that music can be more soporific than the taking of any sleeping tablets.

The most popular types of music that were listened to by those who indicated that they did use music, were *rock* and *gospel*. Some players added other types of music than those listed in the questionnaire, e.g., *house music*, *R&B (or RnB)*, *kwaito*, *dance beats*, *calm music*, *chants and Gregorian music*, *love songs*, *panpipes*, *soul*, and *traditional African music*. Music preferences are diverse and for music to have a positive effect, it needs to be a pleasant and meaningful experience for the listener. The athlete's preferences must therefore be taken into account when music is used for regeneration purposes. Athletes should be encouraged to create a bank of music they like which generate a range of moods and atmospheres, to produce a stimulating or calming effect (Calder, 2000a).

Social aspects and communication

Players from all groups rated socialising with friends amongst the most important methods for regeneration. Social support is an important resource and literature has shown the beneficial role of social support for the emotional well-being of athletes (Rosenfeld & Richman, 1997). Robbins and Rosenfeld (2001) indicated that friends, teammates, coaches, and parents were most commonly listed by athletes as providers of social support. Social support is seen as a protective or a stress-buffering influence that leads to better coping

skills regarding stress (Rees & Hardy, 2004). Support is given, amongst others, by listening, caring and comforting, motivating, confirming perspectives of a situation, and providing personal assistance or help. Some players also make use of social support for companionship and fun (Donahue, Miller, Crammer, Cross & Covassin, 2007; Robbins & Rosenfeld, 2001).

Discussions with teammates and coaches after matches or training sessions were perceived as important by hockey, netball and soccer players but not by rugby players. Sullivan and Gee (2007) showed that intra-team communication, interpersonal acceptance and support are important functional interactions within all sport teams, although elite teams are more task oriented and rely less on these aspects. Sherman, Fuller and Speed (2000) reported that the female team players in their study expressed a greater preference for democratic behaviour and positive feedback from the coach. Dirks (2000) mentioned that teams are highly vulnerable to the coach who controls many resources. This might be more so at amateur levels than at professional levels, which might explain the difference between rugby players and the rest. It might also be that there are other unique processes occurring in the professional environment of rugby players that differ from hockey, netball and soccer. Sherman et al. (2000) mentioned that the motivation, goals and attitudes of athletes competing in professional systems are in contrast with the status and ideals of amateur athletes. This does not mean that intra-team communication is unimportant to rugby players. Research does indicate that improving team communication can also be a method of improving team performance (Sullivan & Gee, 2007), and that competitive subjective performances of individuals in professional sport teams are linked to the ongoing mood of the team (Totterdell, 2000).

Debriefing after a match can assist in dealing with the emotional demands of competition. Hogg (2002) explained that the outcome of a match can elicit strong mental and emotional responses in athletes, which should be addressed in some way to give athletes an opportunity to process troubled feelings and thoughts. An effective debriefing process can consist of interaction with teammates and feedback from the coach (Fuller & Paccagnella, 2004; Jeffreys, 2005). Discussion with teammates and the coach might fulfil this function for hockey, netball and soccer players. Rugby players might have other systems in place where this function is performed.

Complementary and alternative strategies

Methods from the category complementary and alternative strategies (acupuncture, reflexology, aromatherapy, shiatsu) received the lowest ratings from the total group. Cohen et al. (2005) and Johnson and Blanchard (2006) mentioned the substantial increase internationally in the popularity of alternative medicine for a variety of illnesses and symptoms as well as for preventative health practices and general self-care. MacLennan et al. (2006) identified an increase in CAM use in Australia, while Johnson and Blanchard (2006) found that 58% of the undergraduates in their survey had used at least one type of CAM during the previous 12 months. White (1998) stated that many athletes use CAM when conventional medicine, according to them, fails to relieve their musculoskeletal symptoms. In this study, athletes did not perceive complementary and alternative therapies as being important to their regeneration.

Extent to which recovery methods are used

The results of the current study revealed some similarities in the recovery methods that hockey, netball, rugby and soccer players use in the regeneration process. There might be an impression that players use the recovery methods extensively but results show that this is not the case. Players could indicate in the questionnaire if they use a specific method and the extent to which they use it by marking *sometimes*, *regularly* or *always*. Results show that the only recovery method that is used on a regular basis is an active cool-down after training and matches by hockey, netball and soccer players, and prayer in some instances. All the other methods are not applied regularly.

There may be various reasons for this. As shown earlier, the highest number of hours per week spent training indicated by rugby and national-level players are between nine and ten hours. It might therefore be that most of the players from the other groups do not have more than one training session per day and that they therefore do not regard recovery methods as important. Barnett (2006) examined the effectiveness of recovery modalities as part of the between-training recovery of elite athletes and questioned the use of recovery modalities in this instance. He suggested that, because training sessions are usually separated by more than four hours, recovery methods that are considered must be more effective than simple rest, which is considered as a natural means of recovery.

Another reason may be that players simply are not serious about regeneration and do not regard it as a high priority. It might also be that players rated methods as important, but do not have the knowledge to know what to do if they want to use a specific method. Another reason could be monetary related, due to the fact that money has to be paid for specific services (e.g., massage) and players might not want to pay for services related to their regeneration. This study revealed that players regard social aspects as highly important to their regeneration. Specific questions on social aspects and debriefing were not asked in this study, but it might be that these aspects have higher priority with team athletes.

A model for the regeneration of elite team athletes

The aim of this study was to develop a model for the psychophysiological regeneration of elite team players that could serve as a guideline for team players within the South African context. The research process involved two phases for the development of the model. During phase one the researcher tried to gain insight into the field of regeneration for team players by attempting to answer the following types of questions: What does regeneration entail for the team player? What suggestions for regeneration of team players are found in literature? What "evidence" is found in scientific literature? The researcher also communicated with a number of coaches, trainers, sport scientists, physiotherapists and team managers at club-, provincial-, national- and international level to gain insight into the regeneration strategies that are applied by team players. The following are some of the main conclusions that the researcher has drawn from phase one:

- There is general consensus that athletes should optimally balance training and competition stress with adequate regeneration. Increasing emphasis is placed on the time between training sessions and competitions to enhance the regeneration process by means of the application of recovery methods.
- The field of regeneration for team players is truly multi-dimensional and complex. Team players train and compete under unique circumstances. Players at elite level usually participate in a long competitive phase of several months. They have to cope with group dynamics in a team setting involving coaches, teammates, trainers and management, handle the pressures of team selections, and compete and perform at their best on a weekly basis. The type of training (e.g., intermittent) and training culture (e.g., amount of hours training per day or week) of team players differ from

endurance-trained athletes. Team players also face physical bodily contact of varied intensities (e.g., rugby player being tackled or soccer player competing for possession).

- Research on athletic regeneration tends to focus to a great extent on endurance-trained athletes, individual athletes, untrained or moderately trained subjects, or recreational team players. There is limited published research on the regeneration of elite team players.
- There is a wide variety of recovery methods that are suggested to athletes to enhance the regeneration process.
- Research is lacking with regard to many of the recovery methods that athletes are advised to follow. Questions that need answers are, for example: Does a specific method do what it is suggested to do? What are the guidelines for the use of recovery methods in terms of dosage, directions for use, indications, contra-indications (e.g., suggestions that some of the methods, if applied immediately, might interfere with and actually weaken the natural ability of the body to restore itself)?

Phase two of the research process investigated the current situation with regard to the recovery strategies that are used for regeneration by elite South African hockey, netball, rugby and soccer players. A questionnaire, specifically designed for the study, was used for data collection. Players reported their perceptions on the importance of a number of recovery methods for their regeneration and also indicated which recovery methods they use and why they use the specific methods. Comparisons were made between players from the different sport codes as well as players from different levels of participation. Some main observations are:

- A number of recovery methods were rated consistently as important by players from all four sport codes and levels of participation, especially those relating to sleep, nutrition, social interactions, and religion/spiritual aspects.
- There are indications that players participating in this study generally do not have planned strategies for applying recovery methods regularly.
- Players from higher levels of participation seem to have more of a strategy for applying recovery methods, although it is not applied regularly.

The psychophysiological model for regeneration proposed in this study emphasises a multi-dimensional holistic approach to the regeneration of team athletes. Players experience stress in many areas (e.g., physical, emotional, social) and different regeneration strategies are needed to address these areas. This necessitates a focused and planned strategy for regeneration. Focusing on the regeneration process does not mean just the absence of activity. Players need a specific programme and specific guidelines to help accelerate the regeneration process through planned measures and activities and actively seize opportunities for regeneration.

Traditional models used in the athletic environment are often pyramid-shaped, for instance, the training factors pyramid (Bompa, 1999), the performance pyramid (Cook, 2001) and some earlier versions of the food guide pyramid (Bean, 2006; Williams, 2002). This implies a most important base or foundation which emphasises a high volume of a specific aspect, followed by a next aspect, required to a lesser degree and less important, and so forth, with each level building on the other. Often, a higher level cannot be accessed if there is not competency at the previous level. The proposed model attempts to communicate an integrated approach towards the regeneration process. The various components of the model will be discussed in more detail.

The proposed model for regeneration is shown in Figure 7.1 and will be discussed in more detail.

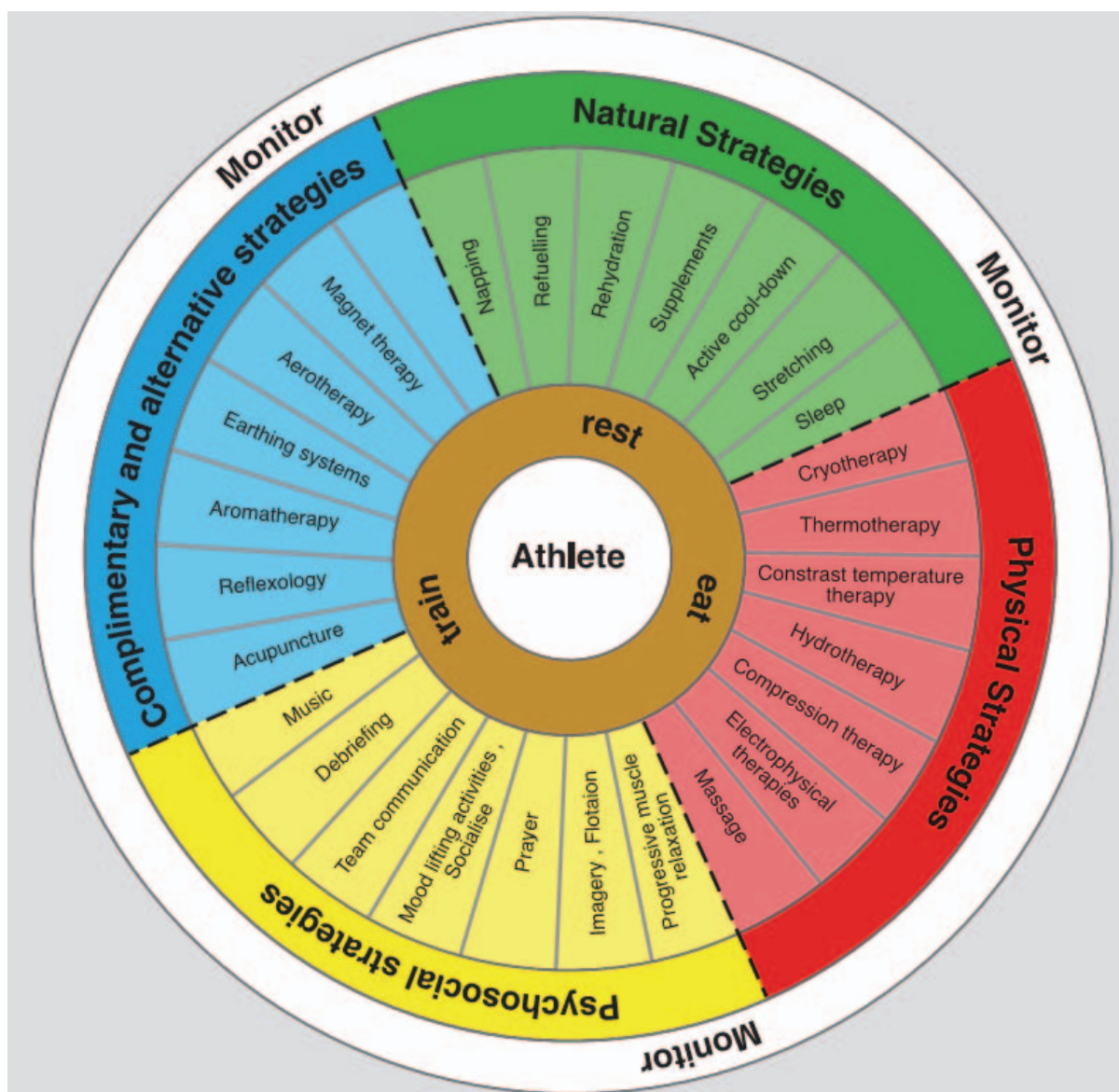


Figure 7.1: A proposed model for the psychophysiological regeneration of elite team athletes

In the proposed model, the player is in the centre and involved in the basics or core components, namely training, rest and nutrition, common to all players in a team situation. The core elements are seen as a periodised approach to training, adequate daily nutrition, and periods of rest, including quality sleep. A periodised approach to training, regarded as a pedagogical aspect of regeneration, should emphasise adequate rest and days off from

training to aid in the regeneration process. Players should be motivated to also take a complete break from their sport during the transition phase of the year. At the most basic level, strategies for regeneration focus on the aspects that cause physical and emotional energy to be replenished. A number of key questions with regard to the core components could be asked:

- Are training programmes planned and managed according to the principles of periodisation?
- Do players need guidance with regard to sound nutritional practices for their specific circumstances and needs?
- Do players have a day off from training during a micro-cycle?
- Do players value periods of rest and manage it well?
- Do coaches and players understand and value the need for a complete break from their sport at some stage during the training year?

Adding to these core elements, various regeneration strategies with a variety of recovery methods are presented which could be applied throughout the training year. Four major categories of regeneration strategies are proposed, namely, natural strategies, physical strategies, psychosocial strategies, as well as complementary and alternative strategies. A few aspects with regard to the regeneration strategies and recovery methods are mentioned:

- Equal emphasis is placed on all regeneration strategies, and their interaction and interdependence in the sporting context is acknowledged. It supports the notion that athletes' thoughts, feelings and spirit affect their endocrine-, autonomic-, cardio-respiratory-, gastro-intestinal- and immune systems, and vice versa.
- Players should be encouraged to use a variety of recovery methods from the different categories. It is suggested that an individual modality is insufficient for optimal regeneration and that the integrated use of several methods could produce a complementary effect.
- Players and coaches should plan for and implement different methods shortly after training sessions and matches, a longer time after training sessions and matches, as well as on non-training days.
- The use of recovery methods is specific to the individual player. A method that helps one player might be stressful for another. Personal preference of players should play a role in the choice of recovery methods and should be presented with a variety of recovery methods to give the players alternatives to use, depending on their specific situation, needs, and the availability of facilities, services and finances.

- Although a number of recovery methods have to be applied by a therapist, there are many methods that could be self-administered and players can be assisted to shed dependence on a trainer or therapist.

The proposed model is embedded within the parameters of our current limited knowledge of regeneration strategies and methods to enhance the regeneration process. There is currently no “gold standard” for recovery and regeneration, and the model that is proposed is based on logic, current scientific evidence and existing behaviours of athletes.

The regeneration process can commence as soon as the training session or game ends, focusing on natural strategies. Aspects from an active cool-down could be performed. The choice of activity (e.g., low-intensity, land-based aerobic activity, thermoneutral pool session, stretching) will depend on the specific circumstances and facilities, needs of the players and the goal of the activity (e.g., debriefing, social interaction, physical aspects). Refuelling and rehydration strategies should be of highest priority. Results from the current study show that, although players rate nutritional aspects as important to their regeneration, they do not regularly apply specific strategies after training and after matches. Players should be educated and assisted in terms of practical and effective strategies to address their refuelling and rehydration needs soon after the training session or match. The importance of brief post-training or post-match discussions and team interactions is emphasised.

Players could be educated with regard to the benefits of good quality sleep and measures (e.g., music, relaxation techniques, sleep routine, sleep environment) that could be taken to enhance the quality of their sleep, and therefore positively affect the regeneration process. Players could be informed about the benefits of a short daytime nap. Results from the current study show that most of the players, even at elite level, do not know how to manage jet lag. For elite players that travel a lot, measures to cope with jet lag become a priority.

Although the effects of various physical strategies (e.g., hydrotherapy, contrast temperature therapy, cryotherapy, massage) as well as alternative strategies (e.g., acupuncture, reflexology, aerotherapy) in team sport are inconclusive and in many instances debatable, many team players do believe in the supposed benefits of many of these methods and will continue to use them. Until more research data are available on the positive and/or negative effects of using these methods, options could be given to players.

This study revealed that players from all the sport codes and levels of participation regard social aspects as important to their regeneration. Coaches could be made aware of the importance of the debriefing process and assisted with the effective management of the process. Although efforts should be made to address social aspects and enhance team cohesion and communication between the players, coach and management, members of a full-time squad or players at a training camp see the same people at the same place every day and for many hours, which can become a source of stress to players. Team players might therefore need a change in environment and also be educated in the use of recovery methods during this time that could enhance emotional aspects of regeneration. Getting out in nature, listening to music, practising relaxation techniques, imagery, or talking through emotions could be beneficial for regeneration during this time. These methods could also help the player with regeneration in the emotional domain after a bad performance in a match or training session.

The proposed model could be used as an educational tool. Coaches might assume that players know how to address their regeneration needs and know how to best apply recovery methods, although it might not be the case. The model could be presented as a "recovery wheel" to players. The model could give an outline to players of the regeneration categories and be a visual aid to players with regard to regeneration strategies. Players could develop an understanding of the regeneration process as multidimensional and that it could be enhanced through the use of a variety of recovery methods, as shown in the model. Coaches and trainers also need to be honest about their knowledge and perceptions of the regeneration process and recovery methods. Do they know and understand the basics of regeneration? Are they familiar with a variety of recovery methods? How do they approach the concept of regeneration with the athletes? Are they as passionate and enthusiastic about regeneration as they are about their training programmes? Do they model good regeneration strategies in their own lives?

The model could be used as an assessment tool to establish what perceptions players might have with regard to regeneration strategies and the importance of various recovery methods. The model could be used to assess which methods players actually use for regeneration purposes. Players could be asked to indicate their use of the various methods by marking them on a copy of the model. Players could also use a four- or five-point scale to indicate how often they use the methods. They could also indicate how important they rate the contribution of each method to their regeneration. A completed model could be used for

profiling and could give a coach insight into which areas players believe in, which recovery methods they mostly use, and for which areas they might need some guidance. Players could actively participate in planning their regeneration strategies according to their personal preference. Players could each receive a blank model sheet (Figure 7.2) and a list of recovery methods that could be used. Players could choose recovery methods which they would like to place around/on the model and use on a weekly basis for regeneration purposes. This process focuses on players as individuals and their regeneration needs. Players therefore have a variety of options from which they could choose to compile their own "regeneration packages". This process should empower players and give them the opportunity to take responsibility for their own regeneration, instead of always relying on trainers to organise specific opportunities to apply one or two methods. Players should be self-aware to identify their specific sources of stress and choose methods accordingly to address the problem.

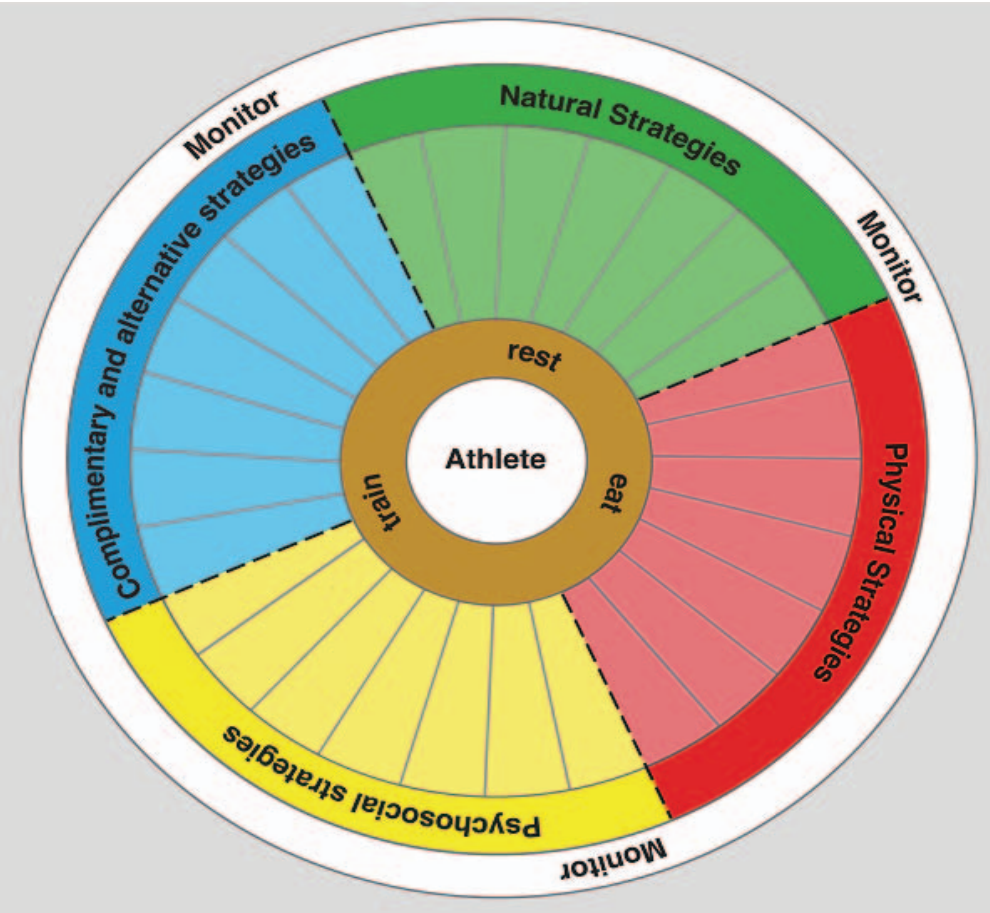


Figure 7.2: Blank model sheet for players to select recovery methods and manage their regeneration process

Emphasis on regular monitoring of players forms the final section of the model and encircles the regeneration process. Players could be encouraged to experiment with recovery methods and keep personal records to document their subjective perceptions of the benefits of the methods. The fatigue and regeneration status of players should also be monitored on a regular basis, using available invasive and non-invasive techniques, as described in previous chapters.

Limitations, recommendations and future research

It is important to acknowledge that there are some limitations in the present study.

- This study is the first to examine the use of recovery methods by elite team sport players which made it impossible to compare results to similar studies.
- Players completed a self-report questionnaire anonymously and it was not possible to verify if players gave accurate responses. Although various efforts were made to reduce social desirability, it might have affected responses of some players.
- As mentioned earlier, there is a wide variety of recovery methods that players could use for regeneration purposes. The researcher could only include a limited number of methods in the questionnaire and had to include some methods and exclude others. The researcher concluded, in retrospect, that specific questions on compression therapy and some social aspects could have been included as separate sections in the questionnaire.
- Compared to the hockey, netball and rugby players, the soccer players might have been less well presented in the study.

Many studies in the field of regeneration and strategies to enhance the regeneration process have been done on endurance athletes such as cyclists, runners and swimmers. Team players train and compete under unique circumstances which should be acknowledged and addressed in research. Future research in the area of regeneration should continue to examine specific strategies and methods players could use to promote the regeneration of team players specifically. A number of questions are stated and suggestions made that could guide future research.

- Comparisons could be made between individual athletes and team players with regard to the recovery methods that are used and the reasons for using the specific methods.

- The need to monitor players regularly has been emphasised in literature. Team players could be monitored during the different phases of the training year to assess fatigue and regeneration states of the players as well as the effectiveness of various strategies and recovery methods.
- The focus of training programmes is different in the various phases of the training year. Are the regeneration needs of team players also different during the preparatory phase and the competitive phase of the year?
- There is a need to identify markers of regeneration specifically for team players.
- Results from this study showed that team players regard various social aspects as important to their regeneration. The role of psychosocial aspects could be addressed in research specifically focusing on regeneration in team players.

The effects of various recovery interventions in team sport are inconclusive and in many instances debatable. More research is needed in terms of the effect of recovery methods to assess the most effective methods specifically for team players.

- There is a lack of studies performed in field situations. Interpretation of the effects of recovery interventions leaves questions when the experimental conditions in a laboratory setting differ from the real training and competition circumstances of elite team players.
- Where recovery methods are applied in a team setting, trainers and coaches often have to work with groups of between 12 and 25 players. It would therefore benefit team players if some effective recovery methods for use within a group setting could be identified.
- What role does the temperature of the water (e.g., ice bath) play in recovery versus the hydrostatic pressure of the water? If players could benefit from the hydrostatic pressure then a team-recovery session in a thermoneutral pool could have various advantages for the team as a group.
- Many studies compare a recovery method or various methods to passive rest immediately after an exercise session. Should the effectiveness of a recovery method for team players be compared to a rest period of between four and six hours during which refuelling and rehydration aspects as natural strategies were addressed effectively?
- Is there a “window of opportunity” with regard to the physical strategies that should be used for regeneration purposes?

- It is in many instances unclear how often the same recovery method can be applied in the same form during a micro-cycle. Can some of the recovery methods be “overused” and eventually become ineffective?
- What role can alternative methods such as aerotherapy play in the regeneration of players? The role of music as recovery method in the regeneration process of team players can also be investigated.
- There are indications that mental imagery could be used for regeneration purposes. Can guidelines be developed for the use of imagery as a recovery method?
- Team players participate in intense resistance training and are exposed to heavy impact forces and many eccentric muscle contractions. Muscle soreness and pain seem to be a constant problem for team players. What are the best recovery methods to apply to address this problem after training and after matches?

Results from this study suggest that there is a need for athlete and coach education with regard to the use of recovery methods in the regeneration process of team players.

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Appendix A

Letters with information to coaches and players



UNIVERSITEIT • STELLENBOSCH • UNIVERSITY
jou kennisvennoot • your knowledge partner



Dear Mr, Manager, and Players from

Research project: Recovery and team athletes

I am currently doing research on the recovery techniques that team athletes might apply. I compiled a questionnaire which is completed by elite netball, rugby, hockey and soccer/football teams throughout the country. Players complete the questionnaire anonymously and no individual player or teams will be identified. The questionnaire consists of statements on possible recovery techniques that could be used, as well as possible reasons why the players might use them, with players responding by marking their choice in a block.

It should take approximately 20 minutes to complete the questionnaire. Please view the completion of the questionnaire as a serious matter because it is part of a PhD-study. I would also like to present and publish the results.

I am still busy collecting data for this project, and will send you a summary of the main results when finished with the project. I believe this project can help us to improve our knowledge and understanding of the recovery techniques that could assist team sport players in their regeneration during the competitive phase of the year.

Regards

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Beste Mnr , Spanbestuur en Spelers van die

Navorsingsprojek: Hersteltegnieke van spansportspelers

Ek is verbonde aan die Universiteit Stellenbosch en tans besig met navorsing oor hersteltegnieke (*recovery*) wat elite spansportspelers toepas. Ek het 'n vraelys opgestel wat landwyd ingevul word deur elite netbal-, rugby-, hokkie- en sokkerspelers. Spelers vul die vraelyste anoniem in en daar sal geen identifisering van individuele spelers of spanne plaasvind nie. Die vraelys bevat stellings oor moontlike hersteltegnieke wat gebruik kan word, asook moontlike redes waarom sportmense dit gebruik. Spelers merk net blokkies wat op hulle van toepassing is.

Sou u en spelers van die bereid wees om aan die navorsingsprojek deel te neem? Die invul van die vraelys behoort ongeveer 20 minute te neem. Ek sal dit waardeer as u die invul van die vraelyste met die nodige erns hanteer aangesien dit deel vorm van 'n PhD-studie. Ek sal ook graag die resultate wil publiseer. Ek onderneem om die hoofresultate van die studie met die deelnemers te deel deur 'n skriftelike verslag aan u te stuur nadat die projek afgehandel is.

Ek glo ons kan met hierdie studie 'n bydrae lewer tot beter kennis en insig in hersteltegnieke wat vir spansportspelers van waarde kan wees gedurende die kompetisiefase van die jaar.

Vriendelike groete

Ranel Venter
Departement Sportwetenskap
Universiteit Stellenbosch

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Appendix B

Consent form

CONSENT TO PARTICIPATE IN RESEARCH

A model for the psychophysiological regeneration of elite team athletes.

You are asked to participate in a research study conducted by ms R. Venter (M.-degree in Human Movement Studies), from the Department of Sport Science at Stellenbosch University. Results from this study will contribute to a PhD dissertation. You were selected as a possible participant in this study because of your involvement in team sport at an elite level.

1. PURPOSE OF THE STUDY

This study wants to assess the current recovery strategies used by elite team athletes, and the reasons why the athletes choose to use the strategies.

2. PROCEDURES

If you volunteer to participate in this study, you would be asked to do the following:

Complete a 20-minute questionnaire once only on recovery strategies used by athletes. The completion of the questionnaire will take place in a team setting at a venue and a time as indicated by your coach to be the best suited for your circumstances.

3. POTENTIAL RISKS AND DISCOMFORTS

Measures will be taken to arrange the time and place for completion of the questionnaire as suitable and convenient as possible. There are no foreseen risks involved in participation in this study.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

After completion of the research, the researcher will communicate, in writing, the main findings of the study to your coach or manager. There is currently a lack of knowledge on the concept of recovery amongst team athletes in the South African context. Your participation in the study will help to broaden the knowledge base and will assist in the implementation of practical models to address recovery in team athletes.

5. PAYMENT FOR PARTICIPATION

No subject will receive any payment for participation in the study.

6. CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Questionnaires will be completed anonymously. Questionnaires will be destroyed after processing.

The researcher plans to publish the results of the study in a peer reviewed journal. Questionnaires are completed anonymously and no subject would be identified.

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind.

8. IDENTIFICATION OF INVESTIGATOR

If you have any questions or concerns about the research, please feel free to contact:

ms Ranel Venter
Department of Sport Science
Stellenbosch University

Tel.: 021-808 4915 (w) or 021-808 4721 (w) or 021-9199241 (h)
E-mail: rev@sun.ac.za

SIGNATURE OF RESEARCH SUBJECT

The information above was described to me, _____

by ms R. Venter or a research assistant in English/Afrikaans and I, _____, am in command of this language. I was given the opportunity to ask questions and these questions were answered to my satisfaction.

I hereby consent voluntarily to participate in this study. I have been given a copy of the form explaining the research project.

Name of Subject/Participant

Date

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to the participants. They were encouraged and given ample time to ask me any questions. This conversation was conducted in Afrikaans/English and no translator was used.

Signature of investigator

Date

Appendix C
Regeneration and Recovery Questionnaire



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jou kennisvennoot • your knowledge partner



Dear Player

Thank you for your willingness to participate in this research project. The purpose of the study is to do an analysis of the psychophysiological regeneration strategies of selected South African elite team athletes, which might lead to guidelines on effective regeneration strategies for team sport athletes.

It should take about 20 minutes to complete the questionnaire.

There are no right or wrong answers. Please be objective and honest in answering the questions.

Thank you for your cooperation.

Beste Speler

Dankie vir u bereidwilligheid om aan hierdie navorsingsprojek deel te neem. Die doel van die studie is om 'n analise te maak van die sielkundig-fisiologiese herstelstrategieë van geselekteerde Suid-Afrikaanse spansportpelers, wat kan aanleiding gee tot die daarstelling van riglyne vir effektiewe herstelstrategieë vir spansportspelers.

Die invul van die vraelys behoort ongeveer 20 minute te neem.

Daar is nie regte of verkeerde antwoorde nie. Wees asseblief eerlik en objektief met die invul van die vraelys.

Baie dankie by voorbaat.

Ranel Venter

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REGENERATION AND RECOVERY QUESTIONNAIRE

SECTION A: BIOGRAPHIC INFORMATION

1. **Age:** years

2. **Gender:**

Male	
Female	

3. **Sport:**

Hockey	Netball	Rugby	Soccer

5. **Highest level of participation (currently):**

Club	Regional/Provincial	National

6. **How many hours per week do you typically spend training for your sport during the competitive season?**

less than 4 hours	
4 - 5 hours	
6 - 7 hours	
8 - 9 hours	
9 - 10 hours	
10 - 12 hours	
more than 12 hours	

8. **Do you have a rest day/day off from training during the week?**

Yes	
No	

SECTION B: RECOVERY METHODS

Athletes can use a number of recovery techniques or methods to assist them with their physical and psychological regeneration during the competitive season. The following are examples of such methods. Please indicate how important you rate the contribution of **each** of these to recovery and regeneration by making an **X** in the corresponding block.

NF = Not familiar with technique

1 = Not important at all

5 = Extremely important

Active cool-down	NF	1	2	3	4	5
Active cool-down in cold swimming pool	NF	1	2	3	4	5
Active cool-down in heated swimming pool	NF	1	2	3	4	5
Acupuncture	NF	1	2	3	4	5
Aromatherapy	NF	1	2	3	4	5
Breathing exercises	NF	1	2	3	4	5
Cold shower	NF	1	2	3	4	5
Contrast temperature (hot+cold)	NF	1	2	3	4	5
Daytime naps	NF	1	2	3	4	5
Discussion with coach after training/match	NF	1	2	3	4	5
Discussion with teammates after training/match	NF	1	2	3	4	5
Eat shortly after training /match	NF	1	2	3	4	5
Fluid intake	NF	1	2	3	4	5
Get out in nature	NF	1	2	3	4	5
Go to an entertainment centre/fun park or mall	NF	1	2	3	4	5
Ice bath	NF	1	2	3	4	5
Imagery/visualisation	NF	1	2	3	4	5
Massage by teammate	NF	1	2	3	4	5
Massage by therapist	NF	1	2	3	4	5
Meditation	NF	1	2	3	4	5
Music	NF	1	2	3	4	5
Prayer	NF	1	2	3	4	5
Progressive muscle relaxation	NF	1	2	3	4	5
Reflexology	NF	1	2	3	4	5
Regular healthy meals	NF	1	2	3	4	5
Sauna	NF	1	2	3	4	5
Self-massage	NF	1	2	3	4	5
Shiatsu	NF	1	2	3	4	5
Sleep	NF	1	2	3	4	5
Snacks after training/match	NF	1	2	3	4	5
Socialise with friends	NF	1	2	3	4	5
Supplements	NF	1	2	3	4	5
Watch amusing video/movies to lift mood	NF	1	2	3	4	5

SECTION C: ACTIVE COOL DOWN

1. Do you perform an active cool down after training sessions?	Yes			No
	Sometimes	Regularly	Always	
2. Do you perform an active cool down between training sessions?	Yes			No
	Sometimes	Regularly	Always	
3. Do you perform an active cool down after matches ?	Yes			No
	Sometimes	Regularly	Always	
<p>If you answered No to all the statements, please proceed to Section D. ⇨</p> <p>If you answered Yes to any of the questions, please proceed to the following sections. ⇩</p>				
<p>Make an X in the box(es) to indicate your response.</p> <p><i>The active cool down I perform consists of...</i></p>				
Slow jogging				<input type="checkbox"/>
Stretching				<input type="checkbox"/>
Low-intensity activities in a cold swimming pool				<input type="checkbox"/>
Low-intensity activities in a heated swimming pool				<input type="checkbox"/>
Low-intensity cycling				<input type="checkbox"/>
Other (Please specify)				
<p>Reasons why an active cool down could be performed are listed below. Please read the list and then rate the reasons why you personally perform the active cool down by allocating a score from 1 to 5 to each item.</p> <p>1 = least important reason 5 = most important reason</p> <p><i>I perform an active cool down, because it...</i></p>				
Speeds up removal of waste products from muscles				<input type="checkbox"/>
Helps me to wind down				<input type="checkbox"/>
Gives me time to socialise with team mates				<input type="checkbox"/>
Helps me to relax				<input type="checkbox"/>
Decreases muscle soreness				<input type="checkbox"/>
Assists in countering the negative effects of intense training on the immune system				<input type="checkbox"/>
Gives me time to reflect on the training session or match				<input type="checkbox"/>
Makes me feel good				<input type="checkbox"/>
Is something the coach told me to do				<input type="checkbox"/>
Other (please specify)				

SECTION D: EXTERNAL COLD

1. Do you apply external cold after training sessions?	Yes			No
	Sometimes	Regularly	Always	
2. Do you apply external cold between training sessions?	Yes			No
	Sometimes	Regularly	Always	
3. Do you apply external cold after matches ?	Yes			No
	Sometimes	Regularly	Always	
4. Do you apply cold on non-training days ?	Yes			No
	Sometimes	Regularly	Always	
If you answered No to all the statements , please proceed to Section E. ⇨ If you answered Yes to any of the questions , please proceed to the following sections. ⇩				
Make an X in the box(es) to indicate your response. <i>The external cold applications after training or a match consists of...</i>				
Ice packs or ice bags				
Cryocuff or cold water circulating unit				
Cooling jacket				
Ice massage				
Activities in cold swimming pool				
Cold water whirlpool				
Sitting, standing or lying in cold water				
Sitting, standing or lying in ice water				
Cold shower				
Other (please specify)				
Reasons why the application of cold could be used are listed below. Please read the list and then rate the reasons why you personally apply cold by allocating a score from 1 to 5. 1 = least important reason 5 = most important reason <i>I apply external cold, because it...</i>				
Assists in faster removal of waste products from the muscles				
Reduces swelling				
Reduces inflammation				
Helps me to relax				
Decreases muscle soreness				
Decreases pain				
Makes me feel good				
Reduces muscle spasms				
Will increase muscle performance				
Is something my coach told me to do				
Other (please specify)				

SECTION E: HEAT APPLICATION

1. Do you apply external heat after training sessions?	Yes			No
	Sometimes	Regularly	Always	
2. Do you apply external heat between training sessions?	Yes			No
	Sometimes	Regularly	Always	
3. Do you apply external heat after matches ?	Yes			No
	Sometimes	Regularly	Always	
4. Do you apply heat on non-training days ?	Yes			No
	Sometimes	Regularly	Always	
<p>If you answered No to all the statements, please proceed to Section F. ⇨</p> <p>If you answered Yes to any of the questions, please proceed to the following sections. ⇩</p>				
<p>Make an X in the box(es) to indicate your response.</p> <p><i>The external heat applications after training or a match consists of...</i></p>				
Warm water whirlpool				
Activities in a heated swimming pool				
Hot bath				
Hot shower				
Sauna				
Ultrasound				
Hot water bottle				
Other (please specify)				
<p>Reasons why the application of heat could be used are listed below. Please read the list and then rate the reasons why you personally apply heat by allocating a score from 1 to 5.</p> <p style="text-align: center;">1 = least important reason 5 = most important reason</p> <p><i>I apply external heat, because it...</i></p>				
Assists in faster removal of waste products from the muscles				
Reduces swelling				
Reduces inflammation				
Helps me to relax				
Decreases muscle soreness				
Decreases pain				
Helps me to feel good				
Makes stretching more effective				
Reduces muscle spasms				
Will increase muscle performance				
Is something the coach told me to do				
Other (please specify)				

F: CONTRAST TREATMENT (HEAT AND COLD)

1. Do you apply contrast treatment (cold and heat) after training sessions?	Yes			No
	Sometimes	Regularly	Always	
2. Do you apply contrast treatment (cold and heat) between training sessions?	Yes			No
	Sometimes	Regularly	Always	
3. Do you apply contrast treatment (cold and heat) after matches ?	Yes			No
	Sometimes	Regularly	Always	
4. Do you apply contrast treatment on non-training days ?	Yes			No
	Sometimes	Regularly	Always	
If you answered No to all the statements , please proceed to Section G. ⇨ If you answered Yes to any of the questions , please proceed to the following sections. ⇩				
Make an X in the box(es) to indicate your response. <i>The contrast treatment after training or a match consists of...</i>				
Hot and cold showers				
Heated pool and cold shower				
Cold pool and hot shower				
Heated pool and cold pool				
More time spent on heat application than cold application				
More time spent on cold application than heat application				
Start and finish with cold				
Start and finish with heat				
Other (please specify)				
Reasons why contrast treatment could be used are listed below. Please read the list and then rate the reasons why you personally apply contrast treatment by allocating a score from 1 to 5. 1 = least important reason 5 = most important reason <i>I apply contrast treatment, because it...</i>				
Assists in faster removal of waste products from the muscles				
Reduces swelling and inflammation				
Creates a pumping action in the muscles				
Helps me to relax				
Decreases muscle soreness				
Decreases pain				
Makes me feel good				
Reduces muscle spasms				
Is something the coach told me to do				
Other (please specify)				

SECTION H: AROMATHERAPY

1. Do you use aromatherapy after training sessions?	Yes			No
	Sometimes	Regularly	Always	
2. Do you use aromatherapy between training sessions?	Yes			No
	Sometimes	Regularly	Always	
3. Do you use aromatherapy after matches ?	Yes			No
	Sometimes	Regularly	Always	
4. Do you use aromatherapy on non-training days?	Yes			No
	Sometimes	Regularly	Always	
<p>If you answered No to all the statements, please proceed to Section I. ➡ If you answered Yes to any of the questions, please proceed to the following sections. ⚓</p>				
<p><i>Make an X in the box(es) to indicate your response.</i> Aromatherapy after training or a match consists of...</p>				
A bath with oils added				
Showering with oils on a face-cloth or sponge				
Fragrancing a room				
Other (please specify)				
<p>Reasons why aromatherapy could be used are listed below. Please read the list and then rate the reasons why you personally use aromatherapy in recovery by allocating a score from 1 to 5. 1 = least important reason 5 = most important reason</p>				
<i>I use aromatherapy, because it...</i>				
Helps me to relax				
Makes me feel good				
Relieves stress and anxiety				
Helps me to sleep better				
Helps me to concentrate				
Activates the mind				
Is something the coach told me to do				
Other (please specify)				

SECTION I: MUSIC THERAPY

1. Do you use music as therapy after training sessions?	Yes			No
	Sometimes	Regularly	Always	
2. Do you use music as therapy between training sessions?	Yes			No
	Sometimes	Regularly	Always	
3. Do you use music as therapy after matches ?	Yes			No
	Sometimes	Regularly	Always	

If you answered **No to all the statements**, please **proceed to Section J.** ⇨
 If you answered **Yes to any of the questions**, please **proceed to the following sections.** ⇩

Make an X in the box(es) to indicate your response.

The type of music I use is ...

Easy listening baroque	
Other classical music	
Rock	
Nature sounds (waves, birds, etc.)	
Gospel/religious/spiritual	
Jazz	
Rap	
Vocal/singing	
Non-vocal/instruments	
Other (please specify)	

Some of the reasons why music therapy could be used are listed below. Please read the list and then rate the reasons why you personally use music by allocating a score from 1 to 5.

1 = least important reason

5 = most important reason

I use music, because it...

Helps me to relax	
Makes me feel energetic	
Helps me to fall asleep	
Reduces feelings of anger	
Reduces stress and anxiety	
Produces a positive attitude	
Helps me to concentrate	
Can improve healing	
Makes me feel good	
Is something the coach told me to do	
Other (please specify)	

SECTION J: COMPLIMENTARY AND ALTERNATIVE THERAPY

1. Do you use acupuncture ?	Yes			No	
	Sometimes	Regularly	Always		
2. Do you use reflexology ?	Yes			No	
	Sometimes	Regularly	Always		
3. Do you use herbal therapy ?	Yes			No	
	Sometimes	Regularly	Always		
4. Do you use therapies involving magnetic fields ?	Yes			No	
	Sometimes	Regularly	Always		
5. Do you use shiatsu ?	Yes			No	
	Sometimes	Regularly	Always		
<p>If you answered No to all the statements, please proceed to Section K. </p> <p>If you answered Yes to any of the questions, please proceed to the following sections. </p>					
<p>Some of the reasons why the abovementioned therapies could be used are listed below. Please read the list and then rate the reasons why you personally use it by allocating a score from 1 to 5 for each therapy.</p> <p style="text-align: center;">1 = least important reason 5 = most important reason</p> <p><i>I use it, because it...</i></p>					
	Acupuncture	Reflexology	Herbal therapy	Magnetic fields	Shiatsu
Helps me to relax					
Prevents illness					
Makes me feel energetic					
Helps me to fall asleep					
Reduces stress and anxiety					
Has a positive effect on the immune system					
Helps me to concentrate					
Balances energy fields					
Relieves pain					
Gives a personal touch					
Is something the coach told me to do					

SECTION K: RELAXATION

1. Do you use progressive muscle relaxation ?	Yes			No
	Sometimes	Regularly	Always	
2. Do you use breathing exercises ?	Yes			No
	Sometimes	Regularly	Always	
3. Do you use meditation ?	Yes			No
	Sometimes	Regularly	Always	
4. Do you use imagery/ visualisation ?	Yes			No
	Sometimes	Regularly	Always	
5. Do you use autogenic training ?	Yes			No
	Sometimes	Regularly	Always	
6. Do you use prayer ?	Yes			No
	Sometimes	Regularly	Always	
<p>If you answered No to all the statements, please proceed to Section L. ⇨</p> <p>If you answered Yes to any of the questions, please proceed to the following sections. ⇩</p>				
<p>Reasons why the abovementioned therapies could be used are listed below. Please read the list and then rate the reasons why you personally use it by allocating a score from 1 to 5.</p> <p style="text-align: center;">1 = least important reason 5 = most important reason</p> <p><i>I use it, because it...</i></p>				
Helps me to relax				
Helps with emotional recovery				
Prevents illness				
Helps me to fall asleep				
Reduces stress and anxiety				
Has a positive effect on the immune system				
Helps me to focus on positives				
Lowers heart rate				
Helps me to switch off				
Makes me feel good				
Lowers blood pressure				
Creates an awareness of muscle tension				
Is something the coach told me to do				
Other (please specify)				

SECTION M: SLEEP

1. Do you have a regular sleep routine? (Going to bed and getting up at more or less the same time)	Yes			No
2. How many hours per night do you sleep during the week?	Less than 6	6 to 8 hours	More than 8 hours	
3. How many hours per night do you sleep during weekends?	Less than 6	6 to 8 hours	More than 8 hours	
4. Do you take a nap during the day?	Yes			No
	Sometimes	Regularly	Always	
5. Do you experience problems falling asleep?	Yes			No
	Sometimes	Regularly	Always	
6. Do you experience problems waking in the morning?	Yes			No
	Sometimes	Regularly	Always	
Please proceed to the following sections. ↓				
Make an X in the box(es) to indicate your response to the statements below.				
I drink sleeping pills to sleep better				
I use alcohol to sleep better				
Caffeine before bedtime keeps me awake				
I know how to manage jet lag				
I take a warm bath before bedtime to sleep better				
I am affected by the colour of the room in which I sleep				
I am affected by noise in the environment when I sleep				
I am affected by light in the environment when I sleep				
I use melatonin for jet lag				
I do something to relax before going to sleep				
Exercise before bedtime interferes with my sleeping pattern				
I have trouble falling asleep after sexual activity at night				
<p>Some of the reasons why sleep can be important in recovery are listed below. Please read the list and then rate the reasons why you personally think it is important by allocating a score from 1 to 5.</p> <p style="text-align: center;">1 = least important reason 5 = most important reason</p> <p><i>Good quality sleep ...</i></p>				
Helps maintain normal body rhythms				
Is essential for growth and repair of the body				
Is important for memory processing				
Increases the secretion of growth hormone				
Is important for emotional well-being				
Plays a role in countering depression due to a lack of sleep				
Other (please specify)				

THANK YOU