Monitoring accumulative fatigue and recovery status in elite field hockey players during different phases of a competitive season

by
Louise Adriana De Villiers

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Supervisor: Dr R. Venter

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DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: 26 November 2014

SUMMARY

There is a lack of research in the sport of field hockey, specifically where monitoring of fatigue and recovery is concerned. The primary aim of the study was thus to monitor the accumulative fatigue and recovery state of elite field hockey players during the different phases of a competitive season.

The specific objectives of the study were to determine the changes in heart rate recovery of elite hockey players; to determine the changes in perceptual fatigue; to determine the relationship between players' perceptions of recovery and stress; and to determine the relationship between the objective and subjective measures of recovery and fatigue over different phases during a competitive season.

Elite female hockey players (n = 15) from Stellenbosch University were monitored over 23 weeks. This group comprised of players from the first team (Maties) and second team (VICS) of the club. The following tests were administered: the Heart rate Interval Monitoring System (HIMS) test with the use of SUUNTO heart rate monitors and SUUNTO Team Manager, the Perceptual Fatigue questionnaire (on a weekly basis), and the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport 76) (during each phase of their normal competition cycle).

There were a number of significant findings ($p<0.05$) relating to the aim and objectives of the study. One of the main findings was that there were significant differences between the phases with regard to the measured variables. Players experienced

significantly more Fatigue, Lack of Energy and Pressure during the first Competition phase. With regard to the HIMS, players performed the best during the second Competition phase, following the university holidays.

Even though not all the differences were statistically significant, collectively the results indicate that these monitoring tools can be used for teams. An added advantage with all three monitoring tools is that each person can be used as their own baseline. In a team setting it gives the coach and support team the opportunity to individualise training programmes and recovery methods.

Keywords: Hockey; Heart rate Interval Monitoring System; Perceived Fatigue; RESTQ-76 Sport.

OPSOMMING

Daar is ‘n tekort aan navorsing in hokkie, en spesifiek in die monitering van vermoeienis en herstel by spelers. Die hoofdoel van die studie was dus om akkumulerende vermoeienis en die hersteltoestand van elite hokkiespelers gedurende verskillende fases van die kompetisie seisoen te monitor.

Die spesifieke doelwitte van die studie was om die verandering in hartspoed herstel van die hoë vlak spelers te bepaal; om veranderinge in perseptuele vermoeienis te bepaal; om die verwantskap tussen die spelers se persepsies van herstel en stress te bepaal; om die verwantskap tussen die objektiewe en subjektiewe van herstel en vermoeienis oor die verskillende fases tydens die kompetisie seisoen te bepaal.

Elite vroue hokkie spelers (n = 15) van Stellenbosch was oor 23 weke gemonitor. Hierdie groep het uit spelers van die eerste span (Maties) en die tweede span (VICS) van die klub bestaan. Die volgende toetse was uitgevoer: Die Hartspoed Interval Monitering Sisteem (HIMS) toets met behulp van die SUUNTO hartspoed monitors en die SUUNTO span administrasie sisteem; en die Perseptuele Vermoeienis vraelys was op ‘n weeklikse basis voltooi, terwyl die Herstel Stres vraelys vir Sportmense (RESTQ-Sport 76) gedurende elke fase van hul oefensiklus voltooi is.

Daar was ‘n aantal betekenisvolle bevindings ($p<0.05$) wat verband hou met die doel en doelwitte van die studie. Een van die hoof bevindings was dat daar betekenisvolle verskille tussen die fases was met betrekking tot die veranderlikes. Spelers het

beduidend meer Vermoeienis, Gebrek aan Energie en Druk gedurende die eerste Kompetisie fase ervaar. Met betrekking tot die HIMS het spelers die beste presteer gedurende die tweede Kompetisie fase, na afloop van ‘n rus periode gedurende die universiteitsvakansie.

Hoewel al die verskille nie statisties beduidend was nie, is daar aangedui dat die moniterings instrumente geskik is vir gebruik by spanne. ‘n Verdere voordeel by al drie moniterings instrumente is dat elke persoon as sy eie basislyn kan dien. In ‘n spanopset bied dit aan die afrigter en ondersteuningspan die geleentheid om oefening en herstelmetodes te individualiseer.

Sleutelwoorde: Hokkie; Hartspoed Interval Moniterings Sisteem; Perseptuele Vermoeienis; RESTQ-76 Sport.

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DEDICATION

I dedicate this study to my parents. Mom and Dad, thank you for always being there and supporting me. I am forever grateful.

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CHAPTER ONE

PROBLEM STATEMENT

A. INTRODUCTION

Overtraining is regarded as the result of an imbalance between the physical overloading and stress, and the recovery of an athlete (Gould & Dieffenbach, 2002; Kellmann, 2002b). Most elite team athletes' competitive season involves different cycles of training, tapering, and competing from one week to the next. Top university players may have additional commitments such as national team training, inter-provincial league tournaments, or representing their country in international competitions. The combination of the heavy training load, paired with the high frequency of matches can lead to overtraining if not managed correctly (Venter, 2008).

A proper balance needs to be found between stress and adequate recovery. If this balance is not maintained, signs of overtraining can occur which is often overlooked as underperformance. Players' training programmes and training loads are then changed to improve performance, without addressing the real reason (Kellmann, 2002b).

When coaches work with teams, the individuality of players, with regard to their training adaptations and recovery preference, is often overlooked because they get

lost in the group. No two players will react exactly alike to training loads or training programme adaptations (Smith & Norris, 2002). For the same reason both the athlete and coach should pay special attention to the recovery programme. An activity might help to relax one athlete, while it might not have the same effect on his/her teammate, instead it might cause him/her a greater level of discomfort and cause their stress levels to increase (Kellmann, 2002b).

Different phases of the training season will lead to different types and degrees of stressors and adaptations (Bompa, 1999), which will also have different effects on different people. It is, therefore, essential to monitor athletes during a training year.

B. AIM OF THE STUDY

The primary aim of the study was to monitor accumulative fatigue and recovery status of elite field hockey players during different phases of a competitive season.

Objectives for the study were to determine:

1. The changes in heart rate recovery of elite field hockey players during different phases of a competitive season.
2. The changes in perceptual fatigue scores of elite field hockey players during different phases of a competitive season.

3. The relationship between players' perceptions of recovery and stress during different phases of a competitive season.
4. The relationship between the objective and subjective measures of recovery and fatigue during different phases of a competitive season.
5. The differences between first and second team players with regard to the variables.
6. To compare the recovery stress profiles of two players from the group to determine individuality within a group setting.

C. SUMMARY AND LIMITATIONS IN LITERATURE

From the literature it is clear that there is limited research on the monitoring of fatigue and recovery of hockey players. Furthermore, the research on the recovery state of hockey players is also limited. There is also a paucity of publications on comparisons between physiological recovery results (of heart rate recovery) with the results of psychological questionnaires, which limits the option to compare results. Information gained from this research project should provide coaching staff with guidelines to monitor hockey players during a competitive season.

In Chapter Two, the Theoretical Background for the context of the study will be given. Chapter Three describes the Research Methodology, whereas Chapter Four presents the research results. Finally, Chapter Five presents a discussion of the results, limitations of the study and suggestions for further research.

CHAPTER TWO

THEORETICAL BACKGROUND

A. PERIODISATION OF TRAINING

The goal for training is to provide athletes with training loads that will improve their performance. Training is successful when it involves the overloading principle without involving excessive overload and inadequate recovery (Meeusen *et al.*, 2013). Increasing capabilities of athletes are a result of a combination of many factors, for example “training, genetics, health status, psychology, physiology, biomechanics and skill” and each of these play a different role in order to contribute to the end result (Holmes, 2011: 16). The basic principle of training focuses on the physiological breakdown that occurs during training, followed by adequate rest and recovery, which will ultimately lead to an increase in performance (Lambert & Borresen, 2006). For athletes to be able to reach their highest performance levels requires occasional training loads that will push their bodies’ adaptation capabilities to their limits (Bosquet, Merkari, Arvisais, & Aubert, 2008). When an imbalance occurs between the training load and the recovery that follows, it can result in symptoms of fatigue (Lambert & Borresen, 2006).

Periodisation is a planning framework that enables a coach to methodically plan a team or athletes’ training year (Norris & Smith, 2002). Bompa (1999) explains that there are different phases during a year, each with its own training function. There

are three main training phases: Preparatory, Competitive and Transition; each with its own sub-phases as illustrated in Figure 2.1.

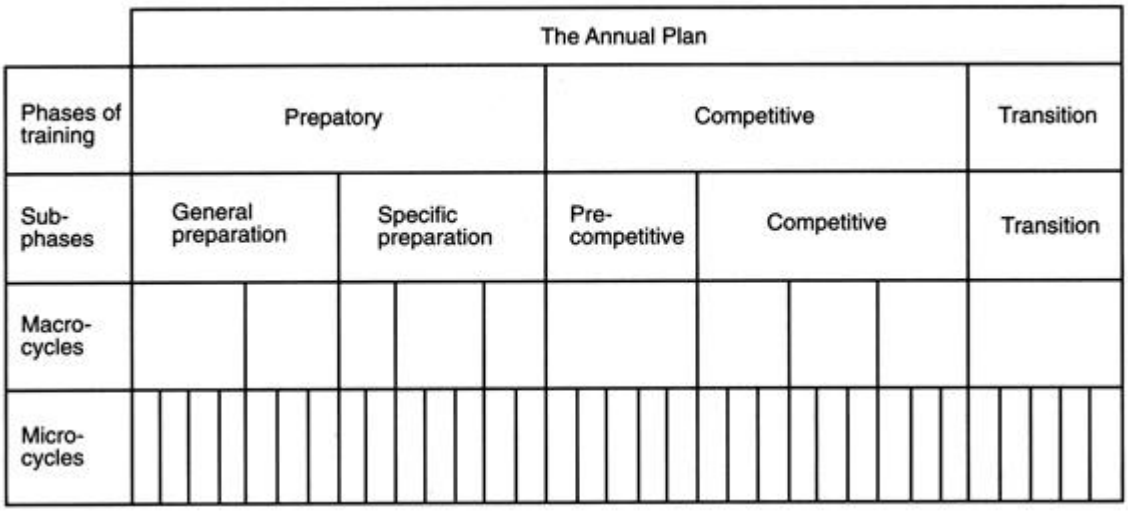


Figure 2.1 Bompa's annual periodisation plan (Bompa & Haff, 2009).

The Preparatory Phase is traditionally the time when the majority of the physical training load is completed to enable athletes to meet the physiological requirements of the competitive season (Bompa & Haff, 2009; Di Fronso, Nakamura, Bortoli, Robazza, & Bertollo, 2006). Training involves technical, tactical, physical and psychological preparation. During this phase, high training volumes are essential and ensuring adequate training are important as any deficits in this phase will have visible effects during the Competition phase (Bompa, 1999).

During the Competitive phase the players need to maintain the general physical training aspects that they have acquired during the Preparation phase, along with prefecting training factors such as technique and tactics in order to perform at the highest level possible (Bompa, 1999). The Transition phase involves resting and

physiological recovery. This phase links two annual plans and is often known as the off-season. During this phase the athlete still trains, but only two to four sessions per week as it is not desirable to go from high intensity training to passive rest as it can be harmful to the athlete's body (Bompa, 1999).

There is a thin line between doing too little and doing too much and according to Coutts, Reaburn, Piva and Rowsell (2007) 7 – 30% of all elite athletes may show signs of overtraining at any given time. Thus, in order for optimal training to take place, there needs to be a balance between the training stimulus and ensuring proper recovery (Lamberts & Lambert, 2009). Too much training or a too high training load can lead to overtraining or overreaching, but when individuals undergo the proper training, optimal performance can occur (Buchheit, 2014). During exercise, physiological changes occur, which should return to normal after the exercise (Lambert & Borresen, 2006). It is important for coaches to closely monitor athletes in order to establish at which point these physiological changes become defective (Coutts, Slattery, & Wallace, 2007). Determining a balance between the training and recovery of stressors remain difficult and as a result a few methods have been established to monitor the athlete (Hartwig, Naughton, & Searl, 2009).

B. RECOVERY AND FATIGUE

Functional overreaching is a result of a deliberate increase in an athlete's training loads which can lead to short term decrements in performance, but that are not accompanied by other negative symptoms, in order to ultimately enhance performance (Lambert & Borresen, 2006; Thiel *et al.*, 2011). However, when non-functional overreaching occurs, there is an imbalance between training and recovery, which can lead to overtraining (Coutts & Reaburn, 2008; Lambert & Borresen, 2006). When coaches are misinformed, they can incorrectly interpret the symptoms that are associated with overreaching and the decrease in performance as a result of too little training which then leads them to increase the intensity of training, with less recovery, which in turn leads to overreaching or overtraining (Lambert & Borresen, 2006).

Various factors can lead to overtraining, such as too high demands on athletes and increasing the training load too rapidly; increasing the training load too quickly after an injury or illness; too high volumes of training when initially starting endurance training; inadequate recovery; too many competitions; lack of confidence in the coach (Lambert & Borresen, 2006; Norris & Smith, 2002). However, if a coach can monitor the subtle symptoms associated with fatigue and detect it before it becomes too serious, the chances are that the athlete will be able to maintain larger volumes of training, will be higher (Lambert & Borresen, 2006). Despite coaches recognising the crucial role that recovery plays, they often have a very limited knowledge of both recovery modalities and monitoring tools (Kellmann, 2010).

When overtraining does occur, athletes often experience a decrease in performance paired with the inability to continue training. Overtraining should be managed as soon as possible in order to avoid further physical and psychological damage which could lead to staleness and burnout in the athlete (Gould & Dieffenbach, 2002).

Under-recovery occurs when recovery demands are not fulfilled. One of the basic ways that athletes are able to perform optimally is if they are fully recovered after each training session and competition. This is achieved by balancing training stress with recovery. The problem among a lot of elite athletes is that there is a high frequency of matches that are combined with the high frequency of training. When matches are played too close in succession, athletes are rushed from one performance peak to the next (Kellmann, 2002b). This also occurs in modern day sport where the period between the Off-Season and Competition phase is so short. This leads to short recovery phases, which ultimately leads to under-recovery (Gustafsson, Kenttä, & Hassmén, 2011; Kellmann, 2002b).

There are a various factors that could lead to under-recovery. Kellmann (2002b: 4) provides the following training errors as possible reasons:

> "(1) monotonous training programs; (2) more than three hours of training per day; (3) more than a 30% increase in training load each week; (4) ignoring the training principle of alternating hard and easy training days or by following two hard days with an easy day; (5) no training periodization

> and respective regeneration microcycles after two or three weeks of training; (6) no rest days."

However, overtraining does not only occur as a result of training errors, but can also occur as a result of a high frequency of competitions that does not allow for sufficient recovery before the next competition, and other stressors such as travel, occupation and inadequate sleep (Foster, 1998; Kellmann, 2002a).

Preventing overtraining is not always as simple as reducing the training load, instead each athlete's training loads should be individually determined in order to be able to reach their individual maximum performance (Kellmann, 2002b).

Smith and Norris (2002: 89) have made a few suggestions on how to prevent the overtraining syndrome:

> "Identify susceptible athletes; Minimize known causes, such as sudden increases in training or lack of adequate rest between seasons; Individualize training in recognition that athletes have different backgrounds and tolerances; Monitor athletes for early warning signs in known moderate-to-heavy training cycles; Minimize poor nutrition; Examine lifestyle and nontraining stressors."

The ultimate goal for monitoring training and recovery is to achieve optimal performance. This is done by managing optimal training and negative overtraining (Kenttä & Hassmén, 2002).

Several physiological adaptations occur in reponse to prolonged excercise. Although some of these adaptations have been used as markers for monitoring fatigue and overtraining, no single measure has been found that accurately assess the adaptations to an athlete's training programme (Borresen & Lambert, 2008). This is confirmed by Bosquet *et al.* (2008) who stated that for the interpretation of heart rate and heart rate variability fluctuations to be meaningul, it first needs to be compared to other signs and symptoms of overreaching.

C. MONITORING FATIGUE AND RECOVERY STATE

Kellmann (2010) suggested that because recovery is a process that is very much focused on the preferences of the individual, stress and recovery should be monitored continuously in order to determine which of the scales or processes the athlete is most sensitive to. Kellmann (2002a) suggests that both stress and recovery should be monitored continuously throughout the training season.

As a result, several monitoring tools have been developed to track changes and adaptations as a result of training. Most of these focus on measuring the overall wellbeing of the athlete. Examples are: the Borg RPE Scale, developed by Borg (1998), which quantifies how hard you perceived your training session was (Borg,

1998; Lambert & Borresen, 2006); the Recovery Scale (TQR), developed by Kenttä and Hassmén which allows the athlete to rate their recovery according to how they feel they have recovered, and according to what they have done to aid their recovery (Kenttä & Hassmén, 2002; Lambert & Borresen, 2006); and the Daily Analysis of Life Demands for Athletes (DALDA) questionnaire, a test developed by Rushall (1990) that is designed to monitor both the physiological stress associated with training, along with stress outside of training that contribute to total stress (Lambert & Borresen, 2006; Rushall, 1990). Testing the autonomic system and its responsiveness to the training stimulus may give a more direct method of assessment (Lamberts, Swart, Capostagno, Noakes, & Lambert, 2010).

It is regarded that the time it takes for post-exercise recovery to occur is associated with the training load of the previous session. It is thus considered that when using a standardised programme with a fixed intensity level and set duration, participants should, theoretically, have the same post-exercise recovery time. There are, however, a few factors that can affect the speed of the recovery process. Athletes with a higher fitness level or a higher training status will have a more rapid post-exercise recovery, for instance. Another factor affecting post-exercise recovery is the stress levels a person is experiencing. Someone with higher stress levels will have a slower recovery rate. Similarly, athletes that struggle to sleep will have a slower post-exercise recovery (Mann, Lamberts, & Lambert, 2014).

The advantage of using psychosocial tests instead of physiological tests for monitoring athletes lies in how quickly the information is available, compared to some

physiological tests that need to be put through several phases before the information is available Other advantages of psychosocial tests are that they are inexpensive and easy to administer (Kellmann, 2010).

Individuality is something coaches have to consider, especially when working with teams. No two players or athletes react to a training programme or to a training load in exactly the same way (Smith & Norris, 2002). Athletes and coaches should pay special attention to the recovery programme. It is not good enough to only recover partially before starting another hard training cycle. This could lead to overtraining. Coaches should also take special notice to players' individual needs as recovery is individual to each person. An activity that might help to relax one athlete, might not have the same effect on his/her teammate, it might cause him/her a greater level of discomfort and cause their stress levels to increase (Kellmann, 2002b).

D. HEART RATE RECOVERY

Heart rate recovery is described as the rate at which an athlete's heart rate decreases after moderate to heavy exercise, but can also be explained as the time it takes for the athlete's heart rate to return to normal after exercise (Borresen & Lambert, 2008). To specify an athlete's heart rate recovery is difficult because the rate of recovery varies according to the athlete's exercise level of experience (Pierpont & Voth, 2004). Heart rate recovery depends on the autonomic nervous system, and the relationship between the sympathetic withdrawal and

parasympathetic reactivation (Borresen & Lambert, 2008; Kaikkonen, Hynynen, Mann, Rusko, & Nummela, 2010; Lamberts, Swart, Capostagno, Noakes, & Lambert, 2010; Pierpont & Voth, 2004). The autonomic nervous system is interlinked with many physiological systems, which has a big effect on heart rate. The interaction between sympathetic withdrawal and parasympathetic reactivation has been investigated, with recent studies indicating that after stopping exercise, the parasympathetic reactivation occurs faster, and thus plays an important role in slowing down the heart rate after exercise. During high intensity exercises, the sympathetic system continues to dominate for some time after exercise has been stopped, which causes a slower heart rate recovery, even though the parasympathetic system has started. This indicates the importance of controlling the intensity of the exercise that is performed prior to testing heart rate recovery (Borresen & Lambert, 2008).

According to Lamberts, Lemmink, Durandt and Lambert (2004), a linear relationship between heart rate and exercise intensity occurs during periods of short duration and steady-state exercise. This indicates that heart rate tests should provide reasonable information regarding the athletes exercise intensity. Considering that as an athletes' aerobic fitness increases, a decrease in their heart rate will occur at controlled, submaximal conditions; an increase in heart rate during controlled, submaximal exercise, can suggest evidence of lack of conditioning and/or overtraining. To be able to ensure a controlled exercise intensity (especially from one test to the following), any factor that can influence the relationship between the heart rate and the exercise intensity needs to be neutralised. Examples of such factors are exercise duration,

environmental conditions and time of day. Heart rate recovery is also said to occur faster when aerobic fitness levels improve, which would indicate a higher percentage heart rate recovery (%hrr). Thus, by monitoring a person's %hrr, it is possible to assess their aerobic fitness, which can also help assessing the training programme and training adaptations (Lamberts *et al.*, 2004).

Fluctuations in an athletes' heart rate at fixed exercise intensities can be caused by overtraining or a lack of conditioning. By monitoring, and addressing, any changes one can prevent the onset or development of overtraining. People that are physically active have a faster heart rate recovery than sedentary individuals and heart rate recovery tends to decrease after an acute increase in exercise training load. Monitoring heart rate recovery to track the changes occurring due to training status can thus be useful (Lamberts & Lambert, 2009).

Lamberts and Lambert (2009) reported that to monitor changes in training load and recovery, and to ensure that it is accurate, the testing protocol should adhere to a few guidelines: the tests should be easily administered, non-invasive and sensitive to change. They concluded that when monitoring for changes in heart rate and heart rate recovery, the submaximal protocol should obtain a heart rate of 85 – 90% of the athletes' maximum heart rate. The reason for this is that there is less heart rate variability in this range.

When comparing the differences between heart rate variability and heart rate recovery, Lamberts *et al.* (2010) cited research by Buchheit *et al.* (2007) who

concluded that heart rate recovery may be a more sensitive indicator for recently applied training loads, while heart rate variability seems to be a better indicator of long-term training adaptations of the autonomic nervous system. Daneen, Lamberts, Kallen, Jin and Van Meeteren (2012) suggested in a review article that despite different methods, intensities and durations of exercise protocols used in various studies, (which makes comparison of the studies difficult) heart rate recovery was related to training status. They conclude by suggesting that heart rate recovery testing can be a valuable tool to monitor athletes.

Female athletes need special attention where monitoring is concerned, because in female athletes a higher percieved exertion, for example internal load, can lead to poorer recovery and, as a consequence, a lower level of self-efficacy (Di Fronso *et al.*, 2006). Kellmann (2010) reiterated that in order to avoid under recovery, physiological and psychological recovery plans should be used as part of a normal training programme.

An advantage of using a heart rate monitor is that these measures are non-invasive, can be applied to a large group of athletes simultaneously and the data will give the coaches the chance to evaluate the athletes' physiological adaptations to the training programme and whether the athlete is responding to the programme correctly (Benson & Connolly, 2011; Buchheit, 2014). This is indicated by information such as training zones and duration spent training in those zones; detection of early warning signs of overtraining; and recovery periods during interval training as well as between training sessions. An added advantage of the data received from monitoring heart

rate is that it is based solely on one person's heart capacity and not on that of somebody else. It also gives the opportunity to track the athlete during training to monitor if the training is too hard or too soft or whether the athlete is fully recovered from the previous training session (Benson & Connolly, 2011).

Tracking recovery by monitoring heart rate is possible due to a higher heart rate that the athlete will have when they are not fully recovered. When an athlete's muscles have not repaired all the microtears caused or replaced all the fuel sources lost during the previous training sessions, an increased metabolism rate will occur, which in turn will cause the athlete's heart rate to rise. Resting heart rate will also be elevated when athletes are tired, overtrained or ill. The body has to work harder, which is indicated by an increased heart rate (Benson & Connolly, 2011)

Coutts and Reaburn (2008) tested semi-professional rugby players with a six-week overloading training programme, the results from this study are consistent with the general suggestion that when an athlete's perceived fatigue levels increase, there should be an increase in the recovery related activities.

E. RESEARCH RELATED TO FIELD HOCKEY

A hockey team consists of a maximum of 16 players, 11 of which are on the field, the other five are the substitutes. Of the 11 players on the field, ten are field players, while one is a goal keeper ("Rules of Hockey," 2013).

Due to modern rule changes it is difficult to compare recent research with those of past decades (Bishop *et al.*, 2004; MacLeod, Bussell, & Sunderland, 2007). The modern rule changes have led to altered physiological demands in the players, and despite the rolling substitution rule there is still a significant drop in the average work rate of the players in the second half of the match (MacLeod *et al.*, 2007). The use of artificial turf has also led to a change of pace of the game, due to a reduction of the rolling resistance on the ball (Bishop *et al.*, 2004; Holmes, 2011). One of the biggest problems in understanding the physiology of hockey is the differences in methodology that researchers apply and specifically the differences in the movement classifications that are used (Bishop *et al.*, 2004; Gabbett, 2010; MacLeod *et al.*, 2007). The differences in classifying the different movements during the various studies on time-motion analysis have led to some researchers reporting matches with 78% low intensity activity, while others have reported 92.1% and even as much as 97% low intensity activity during a match (MacLeod *et al.*, 2007). Bishop *et al.* (2004) tested 14 men's hockey players and reported 95% low-intensity activity.

MacLeod *et al.* (2007), tested female hockey players during a match and found that there was a significant decrease in the players' average heart rate in the second half, compared to the first half. An interesting find from this study was that there were no positional differences found in the heart rate data. One reason they provided was that players are more versatile with regard to the position that they are able to play, which resulted in more players per position. Players are thus not limited to only one position and can easily be played in and rotated into any of the three key positions: forward,

link or halve. Bishop *et al.* (2004) reported that the intensity which the team played at decreased five minutes into each half of the game.

Gabbett (2010) tested 14 women hockey players with GPS-units and found that they ran an average of 6.6km during the match, with a range of 3.4 to 9.5km. Comparing the positions of the players, the midfielders spent more time and greater distances in high intensity running compared to strikers and defenders. In this study the players completed 97.3% of the match in low- and moderate-intensity activities (low intensity = <1m/s; moderate intensity = 1<x<5m/s; high intensity = >5m/s). The low-intensity activities were alternated by bouts of high-acceleration and high-velocity activity. The distances of this high-acceleration running were typically 20m, and were the same for the different positions.

Some situations, for example during tournaments, involve teams playing more than one match per week, or playing matches on consecutive days. When this happens, accumulative fatigue can affect the players' movement patterns during the subsequent matches. Spencer *et al.* (2005) tested 14 male hockey players during three matches that were played over four consecutive days and compared the changes. Results included increased time standing from game one to game three; decreased time spent jogging during matches; and increase in percentage time spent striding during games. The researchers of this study suggested that the increase in the amount of time spent striding may have resulted in players being out of position more often because the time standing around was increased along with a decreased time spent jogging. The number of repeated-sprints also decreased for the entire

team from game one to game two and three. To conclude, the researchers of this study suggested that when players compete in multiple matches per week, for example in this study: three matches in four days, that the players may experience residual fatigue. In addition, it seems that repeated-sprint activity is reduced when players compete in more than one game with less than 24hours or 48hours recovery.

F. CONTEXT OF THE CURRENT STUDY

The Western Province (WP) Hockey Grand Challenge league consists of 12 teams playing against each other at least once. After each team has played each opponent once, a log is drawn up with the top six teams with the highest points total forming a new group, with the bottom six teams forming a second group. In each newly formed group, each of those teams play each other again. This means that each team plays 16 WP league matches ("Western Province Hockey Union," 2012).

The University Sport South Africa (USSA) tournament is an annual competition where the top teams of each university in South Africa play one another. Eight women teams compete in the A section of the tournament. The eight teams are divided into two groups of four teams. In a group, all teams play each other once. After the group matches have been completed, two cross-group matches are played to determine the final position of each team, thus each team played 5 matches ("University of Johannesburg," 2012).

The u/21 Interprovincial Tournament (IPT) is based on the same concept as the USSA tournament. At the u/21 IPT there were 12 teams competing, which was divided into two groups of six teams, each team played 7 matches ("SA Hockey," 2012).

Players exposed to these different formats of competition were monitored the current study, throughout the season (Table 2.1).

Table 2.1 The players' schedule during each of the phases.

Phase	**Pre-Competition**	**1st Competition**	**USSA**	**Holiday**	**2nd Competition**
Week	**1 – 6**	**7 – 14**	**15 - 18**	**19 – 20**	**21 - 23**
Schedule	Stellenbosch hockey club (Maties) training WP u/21 training 3 WP u/21 matches 2 WP League matches	Maties training WP u/21 training SA u/21 training 7 Interprovincial Tournament matches 19 WP League matches	**Week 15 – 17** **Preparation** Field Training Vision training Fitness training Practice Matches **Week 18** **Tournament** 5 University Sport South Africa tournament Matches	Follow prescribed training programme	Maties training WP Senior Ladies training 6 WP League matches

CHAPTER THREE

METHODOLOGY

A. STUDY DESIGN

This study is descriptive in nature as it describes changes in the fatigue-recovery status of field hockey players during the different phases of a competitive season, and measures the correlation between the subjective and objective assessments of the variables. A heart rate recovery interval running test was used as an objective measure, while questionnaires were used to measure subjective perceptions. A sample of convenience was used for data collection.

B. PARTICIPANTS

1. Study population

Female hockey players (N = 25) from Stellenbosch University participated in this study. The first (Maties) and second (VICS) university hockey teams are the top two teams at the Maties hockey club and both compete in the Grand Challenge League of the Western Province Hockey league. The Grand Challenge league is the top club league in the Western Cape. During the first part of the season, the Maties played 11 matches, while the VICS played 10. Each of these teams trained three times a week. Each training session consisted of a 90 minute skills session and a 30 minute fitness session. Resistance training sessions also took place in the gymnasium, twice a week. The researcher had no control over any of the training or recovery sessions, nor the training outside of the programme.

Nine of the study participants also took part in the University Sport South Africa (USSA) competition which saw them playing five matches in six days, with the team finishing in the third position. In addition to the normal season, most of the players who participated in this study played at international and / or national level. They had separate training sessions for each of these teams. The researcher had no control over any of their training or recovery sessions.

Participants were included in the study if they were part of the Maties women's first (Maties) or second (VICS) hockey team squads at the start of the season. If players were ill or injured and could not partake in any physical activity, they were excluded for the time period during which they could not participate. Players were also excluded from the study if they did not complete eight or more Heart rate Interval Monitoring System (HIMS) tests.

Participants were included into one of two groups for statistical analysis: Maties or VICS. The players were included into the group which they played the majority of the matches for, for the duration of the study. Only two players played for both VICS as well as Maties, but they only started playing for Maties during the latter part of the season and therefore they were included in their original group, which was the VICS group.

2. Ethical Aspects

This study was approved by the Research Ethics Committee: Human Research (Humaniora) from Stellenbosch University, protocol number (HS514/2011A). Ms J Dix, Manager of Maties Hockey, consented to the study and allowed the researcher to approach the players to participate in the study. Players signed a consent form and were informed that they could withdraw from the study at any time (Appendix A). Participants were handed information sheets explaining each procedure after a verbal explanation was given. Players were also asked to complete a Personal Information questionnaire which was used to gather personal information as well as information about their playing positions and previous injuries. Before data collection started, players were familiarised with the tests and procedures to ensure they understood everything and knew what to expect.

C. PROCEDURES

Data was collected during the Pre-Competition, 1st Competition and 2nd Competition phases during the Grand Challenge league competitive season. USSA was added as a fourth phase in order to be able to compare the differences between a normal competition and a tournament. During USSA data was collected during the Preparation as well as the Competition cycle. Table 3.1 indicates the number of tests completed for each of the variables, during each of the phases.

Table 3.1 The number of tests completed during each of the phases during the season, for each of the variables.

	Pre-Competition	**1st Competition**	**USSA Preparation**	**USSA Competition**	**2nd Competition**
HIMS	n = 4	n = 8	n = 2	n = 0	n = 2
PF	n = 4	n = 8	n = 3	n = 0	n = 0
RESTQ-76	n = 0	n = 3	n = 3	n = 2	n = 2
Height	n = 0	n = 2	n = 2	n = 0	n = 2
Weight	n = 0	n = 2	n = 2	n = 0	n = 2

HIMS = Heart rate Interval Monitoring System test; PF = Perceptual Fatigue Questionnaire; RESTQ-76 = Recovery-Stress Questionnaire for athletes.

D. ANTRHOPOMETRICAL MEASUREMENTS

1. Height

Height was measured using a digital ultrasonic measuring rod stadiometer (SOENHLE 5003; Germany). Each player was instructed to remove her shoes and stand upright against a wall, feet together, and heels against the wall. Her head was placed in the Frankfort plane. She was instructed to take a deep breath. The digital rod was then placed on her head, with a clear line to the floor so that the ultrasonic signal would be accurate. Height was recorded to the nearest centimetre (cm).

2. Body weight

Body weight was measured using the SOENHLE Professional 7840 scale (Germany). The player was instructed to remove her shoes and wear only one layer of clothing. She was then instructed to get on to the scale, stand up straight, and look straight forward at a point on the wall. Body weight was recorded to the nearest 0.1 kilograms (kg).

E. TESTS AND MEASUREMENTS

1. Heart rate Interval Monitoring System test (HIMS)

The Heart rate Interval Monitoring System test (HIMS) is a submaximal heart rate recovery running test that monitors and predicts chronic fatigue in athletes (Sport Science Institute of South Africa, 2007, 2008).

Prior to the testing, the players were informed:

- That it was not a performance test.
- Not to consume any caffeine within two hours before the test.
- Not to do any training before the HIMS test.
- That they should stand completely still during the resting periods and were not allowed to talk, bend down to tie their shoe laces, or move in any way.
- To follow the pace as set by the auditory signal.

Before each test, each player was assigned a SUUNTO memory belt (Finland). These belts were worn under their clothes on their bare skin and were used to transmit the heart rate data of each player, in real time, to the computer of the researcher. Players included in the South African under-21 squad were allowed to wear their own SUUNTO heart rate equipment.

The HIMS test consisted of four two-minute running stages, interspersed with 1 minute resting periods. Each of the subsequent running stages has an increased

pace which is controlled by an auditory signal played from the laptop of the researcher. The pace of each of the stages was as follows: 1st stage: 8.4 km/h; 2nd stage: 9.6 km/h; 3rd stage: 10.8 km/h; 4th stage: 12.0 km/h. (Audio supplied by Prof M Lambert of UCT SSISA.) The inter-class correlation coefficient of the HIMS test ranges between R = 0.94 and 0.99 (Sport Science Institute of South Africa, 2008).

The running area was in an indoor hall with a synthetic surface. Players ran back and forth between two lines, 20m apart (Figure 3.1). At the start of the test, the players stood behind the first line. At the first signal, they started to run between the two lines, turning at each signal. At the end of each stage, the players stood still, upright, and with their arms next to their bodies.

At the end of the 4th stage, the players were instructed to stand completely still for 2 minutes.

While the players ran the test, a computer was used to monitor the heart rate of each player with the use of the SUUNTO memory belts, SUUNTO Team Manager, SUUNTO Monitor and SUUNTO Team Pod systems (Finland) (Figure 3.2). The information received from these systems was used to calculate the heart rate recovery percentage.

Figure 3.1 Participants running the HIMS test between two 20m lines. (Photo by LA de Villiers)

Figure 3.2 The SUUNTO system: SUUNTO Memory heart rate belt; computer with SUUNTO live Team Monitor; and SUUNTO Team Pod for live transmitting of information. (Photo: Internet; Available: http://www.sweatband.com/suunto-pro-team-pack.html)

The data from the HIMS tests were processed as follows:

On the heart rate graph, the 1st point of reference (S4) is the point at which the heart rate starts to decrease during the fourth stage. The 2nd point of reference (R4) is the heart rate 60 seconds after reference point one (Lambert, 2013; Lamberts, Maskell, Borresen, & Lambert, 2011). This is illustrated in Figure 3.3.

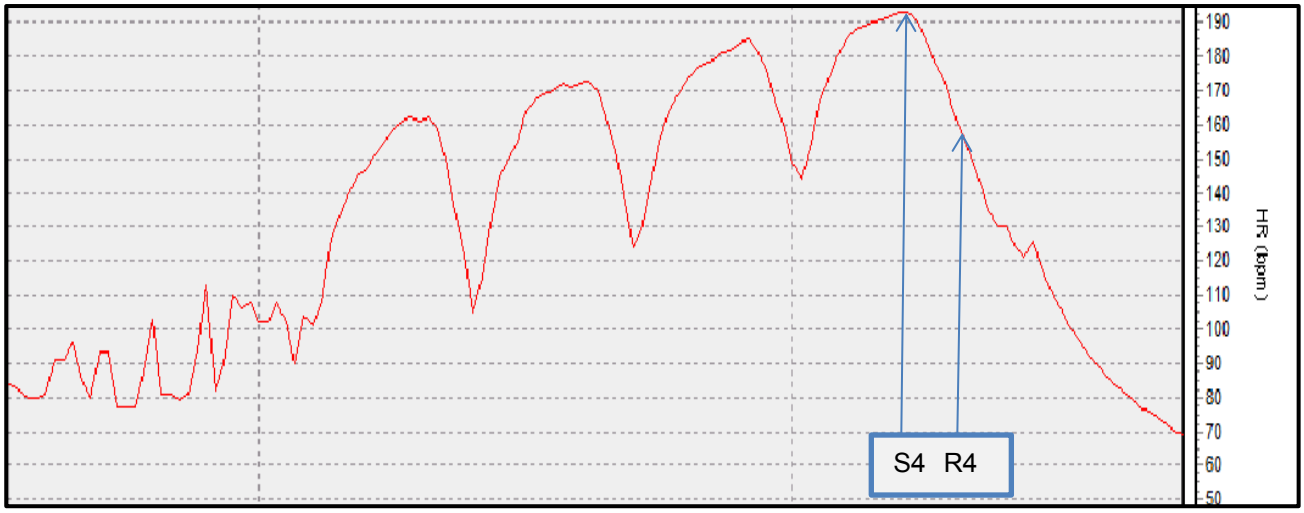


Figure 3.3 HIMS heart rate graph showing 1st point of reference (S4) and 2nd point of reference (R4). (Image: SUUNTO Team Manager software, Finland)

The following equation was used to calculate the percentage recovery: 100 – [(R4 / S4)100] (Sport Science Institute of South Africa, 2007).

Feedback of the HIMS results was communicated to the head coach and the head of conditioning of the Maties Hockey club on the same morning of the testing. The information was then used to manage the team and alter their training programme accordingly, when needed.

The following ratings of recovery are given to players with corresponding percentages:

- Very good: >23%
- Good: 19 – 22.9%
- Average: 17 – 18.9%
- Below Average: 14 – 16.9%
- Poor: <13.9%

During weeks 1 – 12 and weeks 19 – 20, testing took place on Monday mornings between 06h30 and 07h30 in the Sports Hall of the Department of Sport Science, Stellenbosch University. As suggested by Lamberts *et al.* (2004) an attempt was made to conduct the testing at the same time each day to avoid circadian changes in heart rate.

During the second Preparation phase (weeks 13 – 14), the players were training for the University Sport South Africa tournament (USSA). Players had a training camp and the HIMS test was conducted at 08h00. The times changed due to the late start of the training sessions of the training camp on those days. For week 13, the HIMS test was done on a Tuesday (instead of the usual Monday) owing to the fact that the training camp only started on the Tuesday.

A mean HIMS score (mean ± SD) was calculated for each group, for the combined phases. A mean HIMS score (mean ± SD) was also calculated for the total (combined) group, for each phase.

2. Perceptual Fatigue questionnaire

The perceptual fatigue questionnaire (Appendix B) assessed perceptual fatigue of the players on five subscales: Fatigue; Sleep Quality; General Muscle Soreness; Stress Levels; and Mood state (Mclean, Coutts, Kelly, Mcguigan, & Cormack, 2010). Players completed the questionnaire on a Monday, before the evening training session. The questionnaire was handed out during testing sessions on a Monday morning and was received back from players on the following Monday morning. The players were asked to complete the questionnaire before their afternoon training session in order to keep the completion of the questionnaire as close to the training as possible, and to make sure that everyone completed it at the same time.

The Perceptual Fatigue data was processed as follows:

The scores ranged from 1 – 5; 1 rated very bad and 5 rated very good. Each of these scales was used individually to determine the players' perceived fatigue from one week to the other.

For each of the subscales of the Perceptual Fatigue questionnaire, a mean score (mean ± SD) was calculated for each group, for the combined phases. For each of the subscales of the Perceptual Fatigue questionnaire, a mean score (mean ± SD) was calculated for the total (combined) group, for each of the phases.

3. The Recovery-Stress Questionnaire for Athletes (RESTQ-76 Sport)

The RESTQ-76 Sport questionnaire (Appendix B) measures the recovery-stress state of athletes (Kellmann & Kallus, 2001). It consists of 19 subscales, 12 of which are general stress and recovery scales, and seven consisting of sport-specific stress and recovery scales. With these scales the RESTQ-Sport assesses the potentially stressful and restful events and the consequences thereof during the past three days or nights. The items on the RESTQ-Sport questionnaire are all in the form of incomplete sentences and a Likert-type scale is used with values ranging from 0 (never) to 6 (always). This answer indicates how many times the participant participated in that activity during the past three days/nights. The 19 subscales of the RESTQ-Sport are the following: General stress; Emotional stress; Social stress; Conflicts/Pressures; Fatigue; Lack of energy; Physical Complaints; Success; Social recovery; Physical recovery; General well-being; Sleep Quality; Disturbed Breaks; Emotional exhaustion; Injury; Being in shape; Personal Accomplishment; Self-efficacy; Self-regulation (Kellmann & Kallus, 2001).

During the Pre-Competition phase the RESTQ-76 questionnaire completed was used as a familiarisation process, as is recommended, and therefore that data was not included for statistical analysis.

The three RESTQ-76 questionnaires completed during the 1st Competition phase were completed at the Welgevallen Hockey fields before the evening training started. During the Preparation phase for USSA, however, the questionnaires were completed during the morning, before the start of the HIMS test. The differences

between these two phases were due to time limitations experienced during the 1st Competition phase, which was not experienced during the USSA Preparation phase. Therefore, during the 1st Competition phase the questionnaire was completed in the afternoon when there was more time available.

During the USSA Competition phase, the players completed the first questionnaire before the start of the first match, and then again before the start of the last match. The two questionnaires completed during the 2nd Competition phase were completed on the morning, before the start of the HIMS test. Data for this questionnaire were processed to give the athlete a score of stress and recovery for each of the 19 scales.

Acceptable test-retest reliability over a 24-hour period ($r > 0.79$), internal consistency (Cronbach alphas > 0.70 for most subscales) and construct validity have been reported for the RESTQ-76 (Kellmann & Kallus, 2001).

For each of the subscales of the RESTQ-Sport 76 questionnaire, a mean score (mean ± SD) was calculated for each group, for the combined phases. For each of the subscales of the Perceptual Fatigue questionnaire, a mean score (mean ± SD) was calculated for the total (combined) group, for each of the phases.

F. STATISTICAL ANALYSIS

A mixed model repeated measures one-way analysis of variance (ANOVA) was used to compare phases and teams with the subjects treated as random effects, the team as the between subjects effect, and the phase as the within subject effect. Fisher least significant difference (LSD) tests were used for post-hoc testing.

For investigating the relationships between the different measured variables, Spearman correlations were calculated. A 5% significance level ($p<0.05$) was used as guideline for determining significant results. Correlations were interpreted according to the following values (Terblanche, 2010):

Pearson Correlation values	**Strength of correlation**
$r = 1$	Perfect Correlation
$0.75 \leq r \leq 1$	Strong Correlation
$0.50 \leq r \leq 0.74$	Moderate to good Correlation
$0.25 \leq r \leq 0.49$	Moderate Correlation
$0.00 \leq r \leq 0.24$	Weak Correlation
$r = 0$	No Correlation

CHAPTER FOUR

RESULTS

Players from the university's first and second women's teams were monitored over a period of 18 weeks to determine changes in their heart rate recovery and psychophysiological recovery as a result of participating in hockey over a season. The testing period was broken down into four different phases: Pre-Competition Preparation; 1st Competition; USSA Preparation and Competition; and 2nd Competition.

A. PARTICIPANTS

Of the 25 participants who started the study, 15 (age 20 ± 1.46 years) completed the study. The other 10 were excluded because they did not comply with the inclusion criteria. Table 4.1 shows that the Maties team weighed more and were taller than the VICS team.

Table 4.1 Age and Physical characteristics (mean ± SD) of the participants.

	Maties **n = 9**	**VICS** **n = 6**
Age (years)	**20 ± 1.50**	**20 ± 1.55**
Height (cm)	**166.0 ± 6.1**	**162.63 ± 4.22**
Weight (kg)	**64.32 ± 3.83**	**57.59 ± 5.46**

B. HIMS

The HIMS test was completed on a Monday morning, before any other exercise was performed. Table 4.2 shows the HIMS scores (mean ± SD). For the HIMS test, a higher score indicates a better level of physiological recovery.

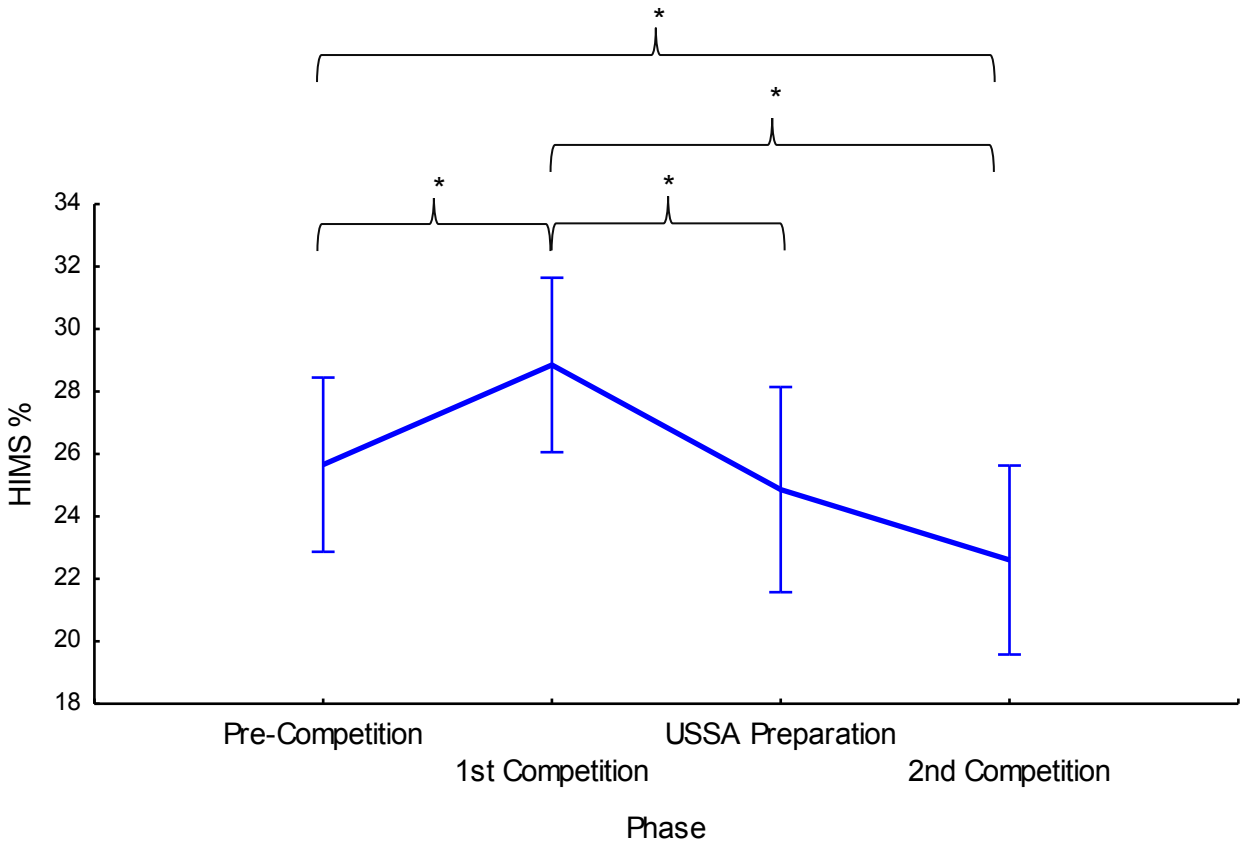
Table 4.2 HIMS scores (mean ± SD) for the total group for all the different phases

	Pre-Competition phase	1st Competition phase	USSA Preparation phase	2nd Competition phase
		Total Group		
HIMS score	25.66 ± 4.95*	28.85 ± 5.19*♦	24.96 ± 4.01♦	23.32 ± 7.14*♦

*** Significant differences between the Pre-Competition phase and 1st Competition and 2nd Competition phases (p < 0.05)**

♦ Significant differences between the 1st Competition phase and USSA Preparation and 2nd Competition phases (p < 0.05)

As can be seen in Figure 4.1 the physiological recovery of the players was significantly better during the Pre-Competition phase compared to the 1st Competition phase (25.66 ± 4.95 vs 28.85 ± 5.19; p = 0.003) and the 2nd Competition phase (25.66 ± 4.95 vs 23.32 ± 7.14; p = 0.01). When comparing the physiological recovery of the 1st Competition and USSA Preparation phases, the players were significantly better recovered during the 1st Competition phase (28.85 ± 5.19 vs 24.96 ± 4.01; p = 0.004). When the players' physiological recovery of the 1st Competition phase and the 2nd Competition phase was compared, they were significantly better recovered during the 1st Competition phase (28.85 ± 5.19 vs 23.32 ± 7.14; p = 0.000005).



*p < 0.05

Figure 4.1 Mean HIMS scores (mean ± SD) for all the different phases, for the total group.

A two-way analysis, with the teams and different phases as the two factors, was done and all interactions were insignificant. Because the two-way analysis was not significant, the two teams were compared without taking the phases into account. Table 4.3 shows that there was no significant difference (p = 0.55) between the two teams (Maties: 26.33 ± 6.71 vs VICS 25.62 ± 3.23; p = 0.55).

Table 4.3 HIMS scores (mean ± SD) for the two groups, over all the phases

	Maties	VICS	p-value
HIMS score	**26.33 ± 6.71**	**25.62 ± 3.23**	**0.55**

(p > 0.05)

C. PERCEPTUAL FATIGUE

The perceptual fatigue questionnaire was completed before every training session on a Monday afternoon. Significant differences were reported for the General Muscle Soreness and Stress Levels subscales ($p < 0.05$). Table 4.4 shows the Perceptual fatigue scores (mean ± SD) during the specific phases. For the Perceptual fatigue questionnaire a higher score on each of the subscales is desirable as it indicates less perceptual fatigue.

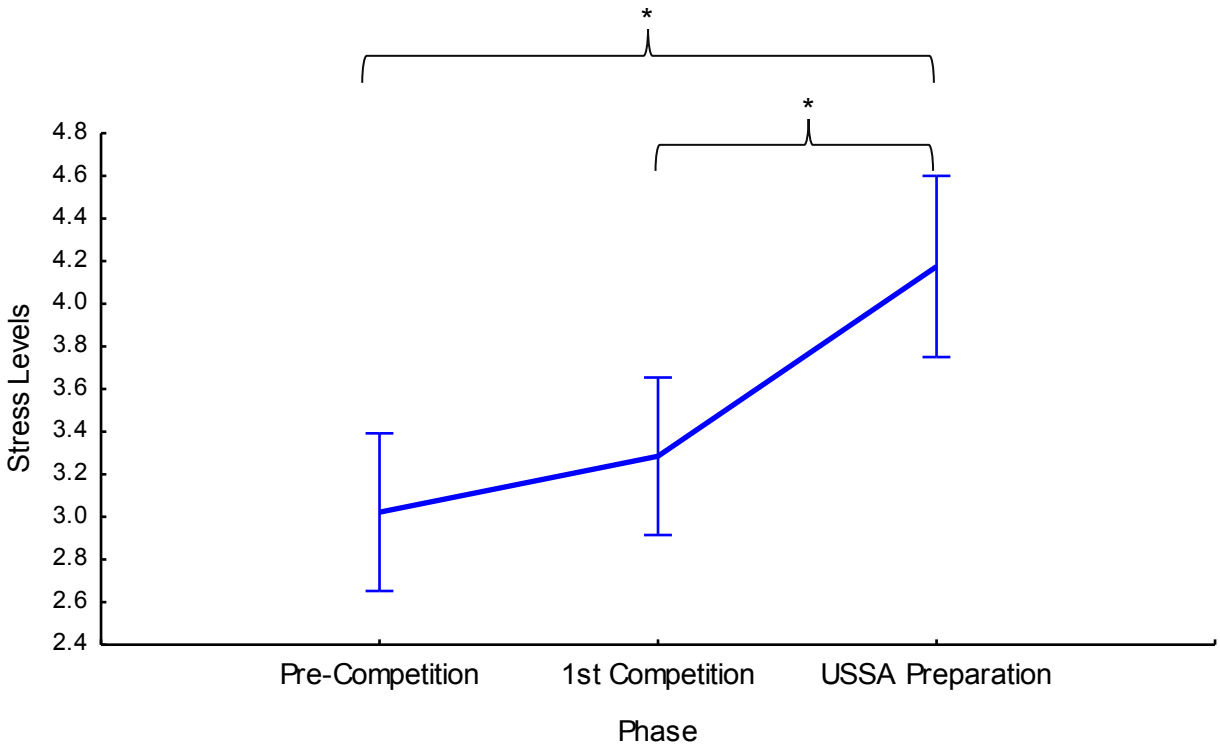
Table 4.4 Mean Perceptual fatigue scores (mean ± SD) for the total group over all the phases

Scales	Pre-Competition phase	1st Competition phase	USSA Preparation phase
	Total Group		
Fatigue	2.89 ± 0.54	3.06 ± 0.45	3.25 ± 0.38
Sleep Quality	3.41 ± 0.68	3.59 ± 0.44	3.54 ± 0.34
General Muscle Soreness	3.22 ± 0.75	3.17 ± 0.38♦	3.71 ± 0.82♦
Stress Levels	3.02 ± 0.75*	3.28 ± 0.59*	4.17 ± 0.78*
Mood Scale	3.92 ± 0.35	3.97 ± 0.38	4.17 ± 0.36

*** Significant difference between the USSA Preparation phase and Pre-Competition and 1st Competition phases for the Stress Levels Scale ($p < 0.05$)**

♦ Significant difference between the USSA Preparation and 1st Competition phase for General Muscle Soreness ($p < 0.05$)

During the USSA Preparation phase, the players reported higher scores for General Muscle Soreness when compared to the 1st Competition phase (3.71 ± 0.82 vs 3.17 ± 0.38; p = 0.04). The players also reported significantly higher scores for the Stress Level subscale during the USSA Preparation phase when compared to the Pre-Competition (4.17 ± 0.78 vs 3.02 ± 0.75; p = 0.000001) and 1st Competition phase (4.17 ± 0.78 vs 3.28 ± 0.59; p = 0.00002). This is indicated on Figure 4.2.



*p < 0.05

Figure 4.2 Mean scores (mean ± SD) for the Stress Level scale (mean ± SD) for all the different phases, for the total group.

A two-way analysis was done, with the teams and different phases as the two factors, and all interactions were insignificant. Because the two-way analysis was not significant, the two teams were compared without taking the phases into account.

Maties on average scored higher than the VICS on all subscales (Table 4.5), although none of these differences were statistically significant ($p > 0.05$).

Table 4.5 Mean Scores for the Perceptual Fatigue questionnaire (mean ± SD) for all the subscales for both teams for all the phases.

Subscales	Maties	VICS	p-value
Fatigue	**3.11 ± 0.44**	**2.79 ± 0.53**	**0.18**
Sleep Quality	**3.57 ± 0.67**	**3.40 ± 0.40**	**0.50**
General Muscle Soreness	**3.24 ± 0.65**	**3.13 ± 0.49**	**0.68**
Stress Levels	**3.35 ± 0.68**	**2.86 ± 0.57**	**0.14**
Mood Scale	**3.98 ± 0.33**	**3.90 ± 0.41**	**0.67**

D. RESTQ – 76 SPORT

The RESTQ – 76 Sport consists of 19 subscales – 12 of which are general stress and recovery related questions, while seven are sport stress and recovery related. Table 4.6 shows the scores (mean ± SD) for the total group, for each of the subscales over all of the phases.

A higher score on any of the stress subscales indicate the players feeling worse and experiencing higher levels of stress. A higher score on any of the recovery subscales, however, indicate the players feeling better and more recovered.

Table 4.6 The RESTQ – 76 Sport scores (mean ± SD) for the total group for all the phases.

	Scale	1st Competition phase	USSA Preparation phase	USSA 1st Match	USSA Last Match	2nd Competition phase
Stress	General Stress	1.43 ± 1.10*	0.86 ± 0.31	0.67 ± 0.44*	0.75 ± 0.47	1.20 ± 0.81
	Emotional Stress	1.61 ± 0.95†	1.00 ± 0.34†	1.25 ± 0.5	0.90 ± 0.49	1.43 ± 0.77
	Social Stress	1.48 ± 1.04	1.15 ± 0.53	0.79 ± 0.43	0.95 ± 0.80	1.52 ± 1.06
	Conflicts / Pressure	2.73 ± 1.25***	1.53 ± 1.13***♦	2.00 ± 0.57***	2.50 ± 0.77♦	2.37 ± 0.73***♦
	Fatigue	2.68 ± 1.11#	1.40 ± 0.68#	1.21 ± 0.81#+	2.00 ± 1.21	2.14 ± 0.73#+
	Lack of Energy	2.29 ± 0.81X	1.43 ± 0.59XΔ	1.29 ± 0.37XΔ	1.45 ± 0.45XΔ	1.99 ± 0.73Δ
	Physical Complaints	1.80 ± 0.83	1.25 ± 0.75	0.92 ± 0.38	1.80 ± 1.32	1.73 ± 0.78
	Disturbed Breaks	1.77 ± 1.53	1.16 ± 0.68	1.17 ± 0.75	1.35 ± 1.13	1.69 ± 0.80
	Emotional Exhaustion	1.54 ± 1.20	0.96 ± 0.82	0.92 ± 0.65	1.55 ± 0.74	1.27 ± 0.84
	Injury	2.28 ± 1.00	1.89 ± 1.08	1.46 ± 0.71	2.50 ± 1.50	2.28 ± 0.91
	Total Stress	2.03 ± 0.81°	1.44 ± 0.34°	1.43 ± 0.36°	1.64 ± 0.41	1.86 ± 0.49

	Scale	1st Competition phase	USSA Preparation phase	USSA 1st Match	USSA Last Match	2nd Competition phase
Recovery	Success	2.77 ± 0.75	2.41 ± 0.83	2.13 ± 0.65–	3.25 ± 1.36–	2.38 ± 1.16–
	Social Recovery	3.55 ± 1.24χ	4.15 ± 1.06χ	4.25 ± 0.79	4.65 ± 0.91χ	4.18 ± 1.21χ
	Physical Recovery	2.55 ± 0.73•	3.34 ± 0.93•♥	3.29 ± 0.62•♥	3.20 ± 0.51	2.55 ± 0.96♥
	General Well-being	3.69 ± 1.06♠	3.84 ± 0.77	4.29 ± 0.70♠	4.00 ± 0.40	3.68 ± 1.28
	Sleep Quality	2.95 ± 1.05◊	3.63 ± 0.91	4.08 ± 0.93◊	3.10 ± 0.72	3.30 ± 1.18
	Being in shape	2.87 ± 1.03	3.13 ± 0.73	3.41 ± 0.83	3.5 ± 1.13	2.70 ± 0.86
	Personal Accomplishment	2.95 ± 1.15	2.56 ± 1.14	2.46 ± 0.81	3.15 ± 1.46	2.93 ± 1.25
	Self-Efficacy	2.99 ± 0.83	2.81 ± 1.15	3.00 ± 1.18	3.70 ± 0.97	2.91 ± 0.95
	Self-Regulation	3.04 ± 0.89∞	2.93 ± 0.75∞	3.21 ± 0.77	4.05 ± 0.54∞	2.72 ± 0.97∞
	Total Recovery	3.04 ± 0.74∞	3.20 ± 0.67	3.35 ± 0.41	3.62 ± 0.55∞	3.04 ± 0.83∞

***** Significant difference between the 1st Competition phase and 1st USSA match for the General Stress scale ($p < 0.05$); **†** Significant difference between the 1st Competition and USSA Preparation phase for the Emotional Stress scale ($p < 0.05$); ******* Significant difference between the 1st Competition phase and USSA Preparation, 1st USSA match and the 2nd Competition phases for the Conflicts / Pressure Scale ($p < 0.05$); **♦** Significant difference between the USSA Preparation

phase and the last USSA match and the 2nd Competition phases for the Conflicts / Pressure Scale ($p < 0.05$); # Significant difference between the 1st Competition phase and the USSA Preparation phase, 1st USSA match and the 2nd Competition phase for the Fatigue Scale ($p < 0.05$); + Significant difference between the 2nd Competition phase and 1st USSA match Fatigue Scale ($p < 0.05$); X Significant difference between the 1st Competition phase and USSA Preparation phase, 1st USSA match and Last USSA match for the Lack of Energy Scale ($p < 0.05$); Δ Significant difference between the 2nd Competition phase and the USSA Preparation phase, 1st USSA match and Last USSA match for the Lack of Energy Scale ($p < 0.05$); ° Significant difference between the 1st Competition phase and USSA Preparation phase and 1st USSA match for the Total Stress Scale ($p < 0.05$).

_Significant difference between the Last USSA match and the 1st USSA match and 2nd Competition phase for the Success Scale ($p < 0.05$); χ Significant difference between the Last USSA match and the 1st Competition phase, the USSA Preparation phase and the 2nd Competition phase for the Social Recovery Scale ($p < 0.05$); • Significant difference between the USSA Preparation phase and the 1st Competition phase, 1st USSA match and the 2nd Competition phase for the Physical Recovery Scale ($p < 0.05$); ♥ Significant difference between the USSA Preparation, 1st USSA match and 2nd Competition phase for the Physical Recovery Scale ($p < 0.05$); ♠ Significant difference between the 1st USSA match and the 1st Competition phase for the General Well-being Scale ($p < 0.05$); ◊ Significant difference between the 1st USSA match and the 1st Competition phase for the Sleep Quality Scale ($p < 0.05$); ∝ Significant difference between the Last USSA match and the 1st Competition phase, the USSA Preparation phase and the 2nd Competition phase for the Self-Regulation Scale ($p < 0.05$); ∞ Significant difference between the Last USSA match and the 1st and 2nd Competition phases for the Total Recovery Scale ($p < 0.05$).

General Stress

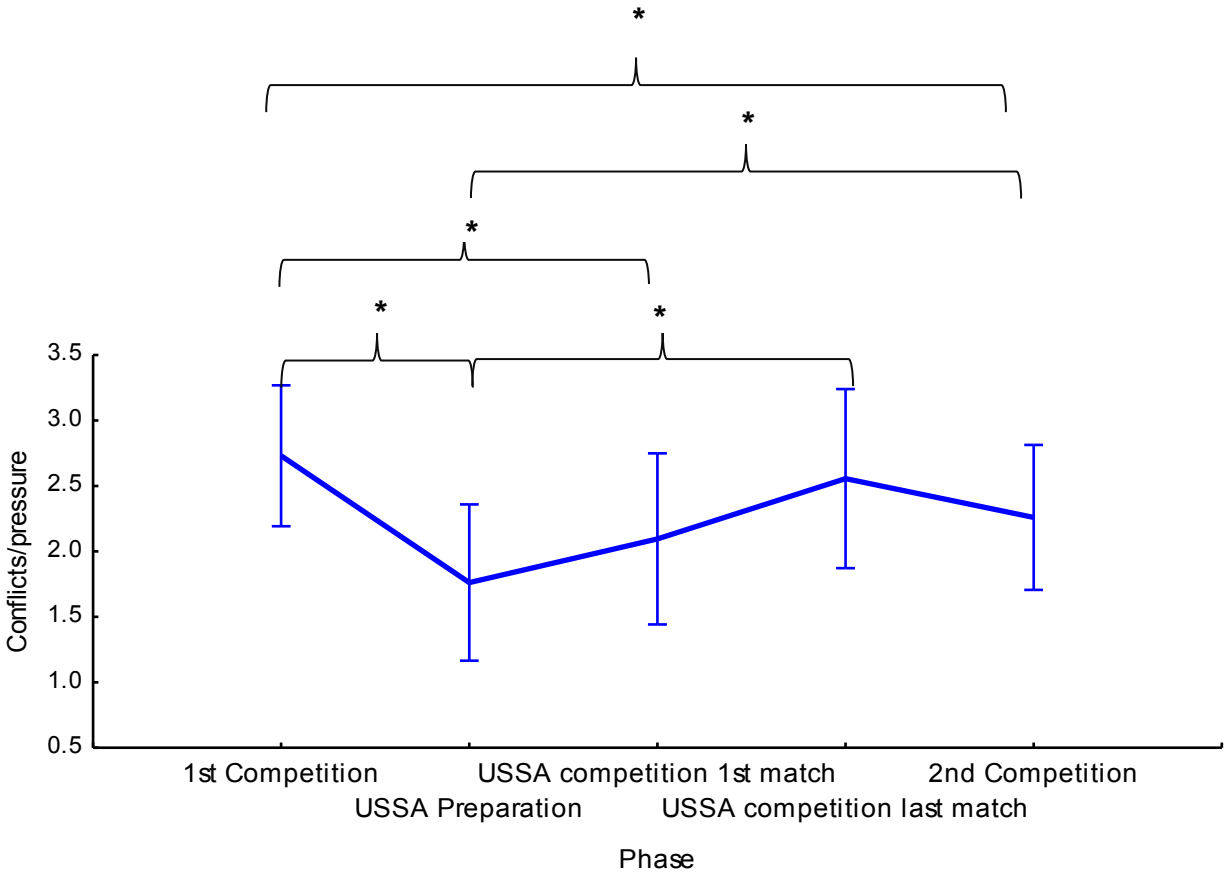
Players reported significantly higher scores for General Stress during the 1st Competition phase, compared to the 1st Match during the USSA tournament (1.43 ± 1.10 vs 0.67 ± 0.44; p = 0.04).

Emotional Stress

Scores for Emotional Stress were significantly higher during the 1st Competition phase, compared to the USSA Preparation phase (1.61 ± 0.95 vs 1.00 ± 0.34; p = 0.04).

Conflicts / Pressure

Figure 4.3 shows that the players reported the highest Conflicts / Pressure scores during the 1st Competition phase (2.73 ± 1.25) while the lowest scores were recorded during the USSA Preparation phase (1.53 ± 1.13). Scores for Conflicts / Pressure were significantly higher during the 1st Competition phase than the USSA Preparation phase (2.73 ± 1.25 vs 1.53 ± 1.13; p = 0.0001), the first USSA match (2.73 ± 1.25 vs 2.00 ± 0.57; p = 0.02), as well as the 2nd Competition phase (2.73 ± 1.25 vs 2.37 ± 0.73; p = 0.02). In addition, significantly higher scores were observed for the USSA Preparation phase compared to before the Last USSA match (1.53 ± 1.13 vs 2.50 ± 0.77; p = 0.01); and the 2nd Competition phase (1.53 ± 1.13 vs 2.37 ± 0.73; p = 0.04).

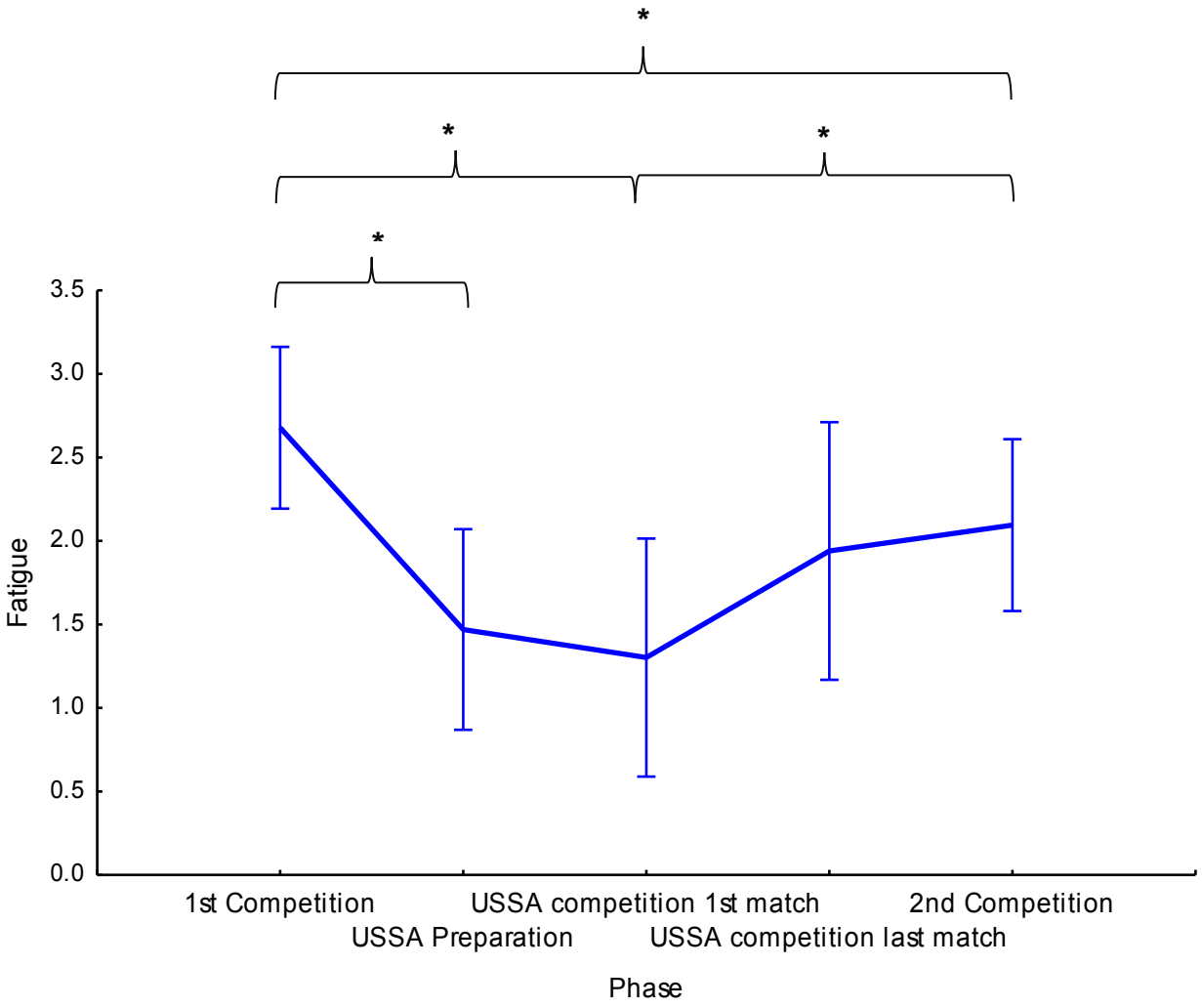


*p < 0.05

Figure 4.3 Mean scores (mean ± SD) for Conflicts/Pressures scale of the Perceptual Fatigue questionnaire for all the phases, for the total group.

Fatigue

Statistical significant differences were evident between several of the phases. During the 1st Competition phase, Fatigue scores were significantly higher than during the USSA Preparation phase (2.68 ± 1.11 vs 1.40 ± 0.68; p = 0.0007); the 1st USSA match (2.68 ± 1.11 vs 1.21 ± 0.81; p = 0.0008); and the 2nd Competition phase (2.68 ± 1.11 vs 2.14 ± 0.73; p = 0.05). The players reported higher Fatigue scores during the 2nd Competition phase compared to the 1st USSA Match (2.14 ± 0.73 vs 1.21 ± 0.81; p = 0.04). This is seen in Figure 4.4.



*p < 0.05

Figure 4.4 Mean scores (mean ± SD) for the Fatigue scale for all of the phases, for the total group.

Lack of Energy

Figure 4.5 illustrates the changes in the mean scores for the total group for Lack of Energy over all the phases. Statistical significant differences were found for several phases. Lack of Energy scores was significantly higher during the 1st Competition phase and the USSA Preparation phase (2.29 ± 0.81 vs 1.43 ± 0.59; p = 0.0006); the

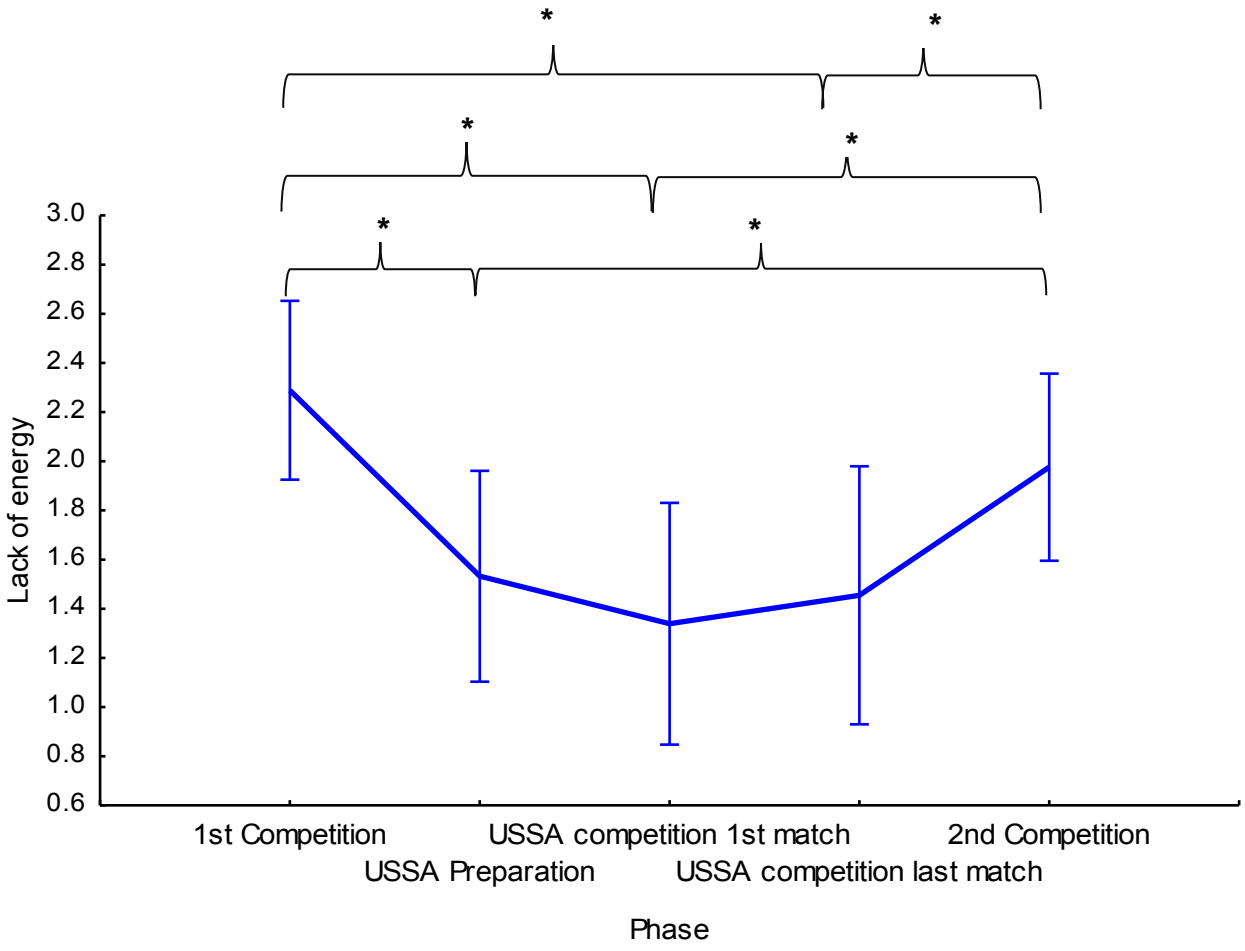
1st USSA Match (2.29 ± 0.81 vs 1.29 ± 0.37; p = 0.0003); and the Last USSA Match (2.29 ± 0.81 vs 1.45 ± 0.45; p = 0.002). In addition, the 2nd Competition phase yielded significantly higher scores than the USSA Preparation phase (1.99 ± 0.73 vs 1.43 ± 0.59; p = 0.04); USSA 1st Match (1.99 ± 0.73 vs 1.29 ± 0.37; p = 0.01); and USSA last match (1.99 ± 0.73 vs 1.45 ± 0.45; p = 0.05).

Total Stress

Scores reported for Total Stress was significantly higher during the 1st Competition phase than the USSA Preparation phase (2.03 ± 0.81 vs 1.44 ± 0.34; p = 0.01) and USSA 1st match (2.03 ± 0.81 vs 1.43 ± 0.36; p = 0.02).

Success

Significantly higher scores were reported before the Last Match of the USSA tournament than before the 1st USSA Match (3.25 ± 1.36 vs 2.13 ± 0.65; p = 0.01) and the 2nd Competition phase (3.25 ± 1.36 vs 2.38 ± 1.16; p = 0.009).

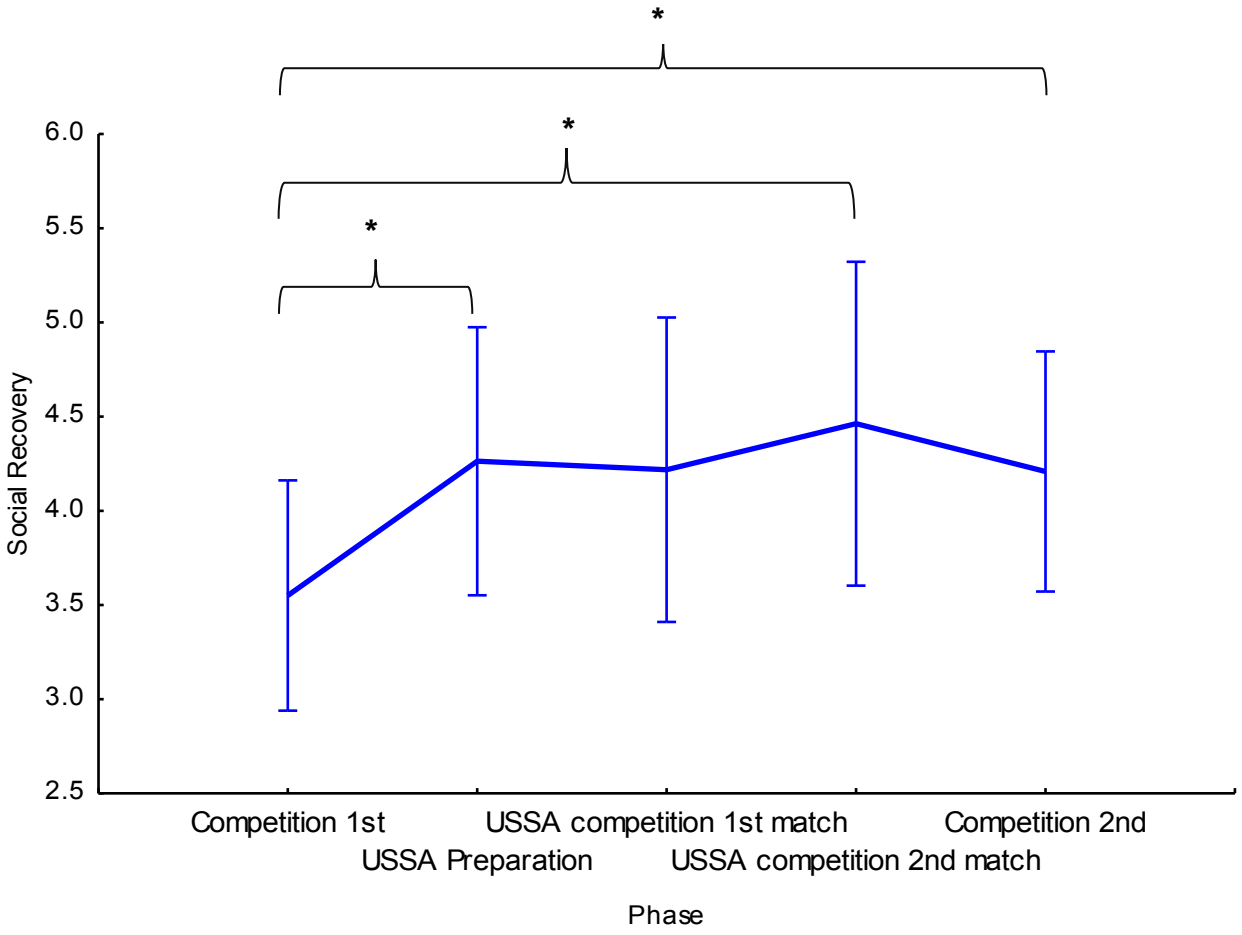


*p < 0.05

Figure 4.5 Mean scores (mean ± SD) for Lack of Energy for all the phases, for the total group.

Social Recovery

Mean scores for Social Recovery was significantly lower during the 1st Competition phase compared to the USSA Preparation phase (3.55 ± 1.24 vs 4.15 ± 1.06; p= 0.03); before the 2nd USSA match (3.55 ± 1.24 vs 4.65 ± 0.9; p = 0.03); and during the 2nd Competition phase (3.55 ± 1.24 vs 4.18 ± 1.21; p = 0.02) (Figure 4.6).



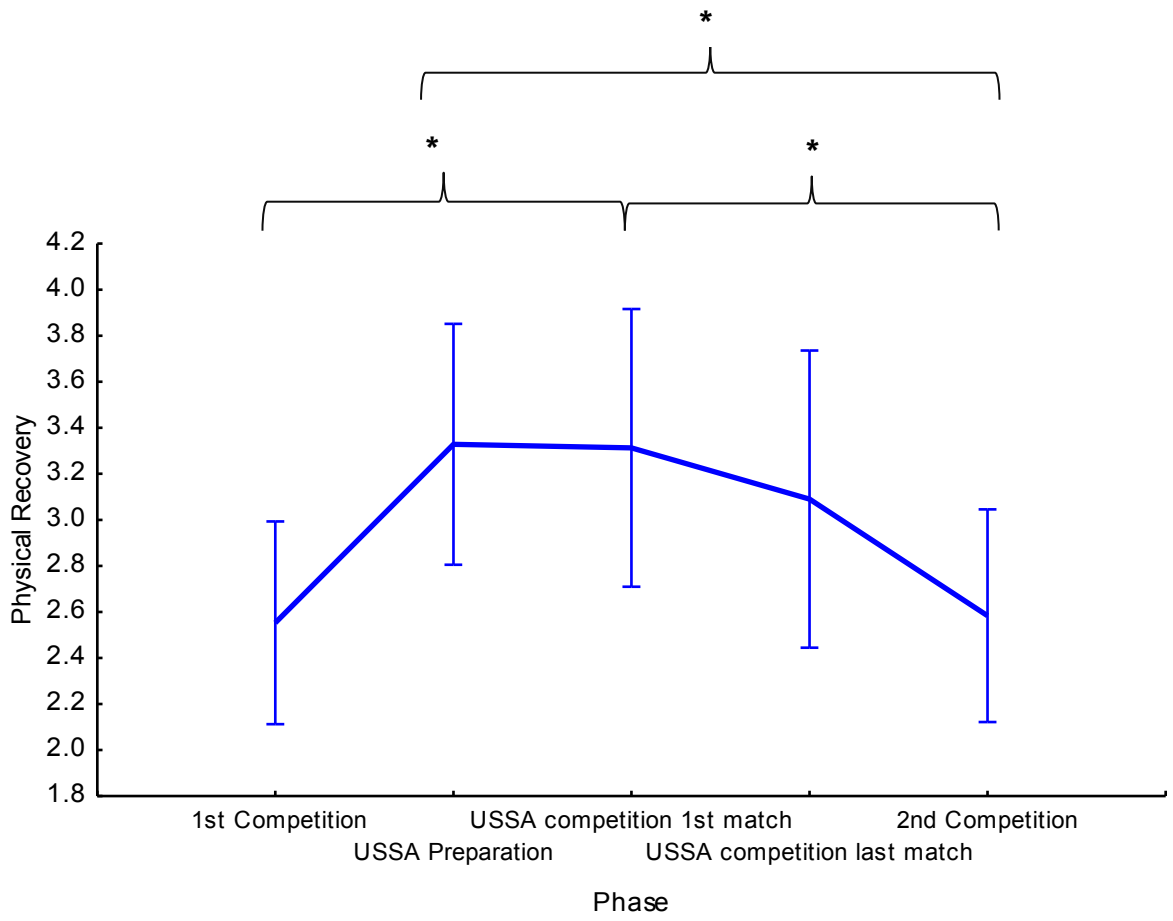
*p < 0.05

Figure 4.6 Mean scores (mean ± SD) for Social Recovery for all the phases, for the total group.

Physical Recovery

The mean scores for Physical Recovery are illustrated in Figure 4.7. Statistical significant differences were found between several of the phases. The scores for the 1st Competition phase were significantly lower than for the USSA Preparation phase (2.55 ± 0.73 vs 3.34 ± 0.93; p = 0.004); and the 1st USSA tournament match (2.55 ± 0.73 vs 3.29 ± 0.62; p = 0.01). Scores for the 2nd Competition phase were significantly lower than during the USSA Preparation phase (2.55 ± 0.96 vs 3.34 ±

0.93; p = 0.007); as well as the 1st Match at the USSA tournament (2.55 ± 0.96 vs 3.29 ± 0.62; p = 0.02).



*p < 0.05

Figure 4.7 Mean scores (mean ± SD) for Physical Recovery for all the phases, for the total group.

General Well-being

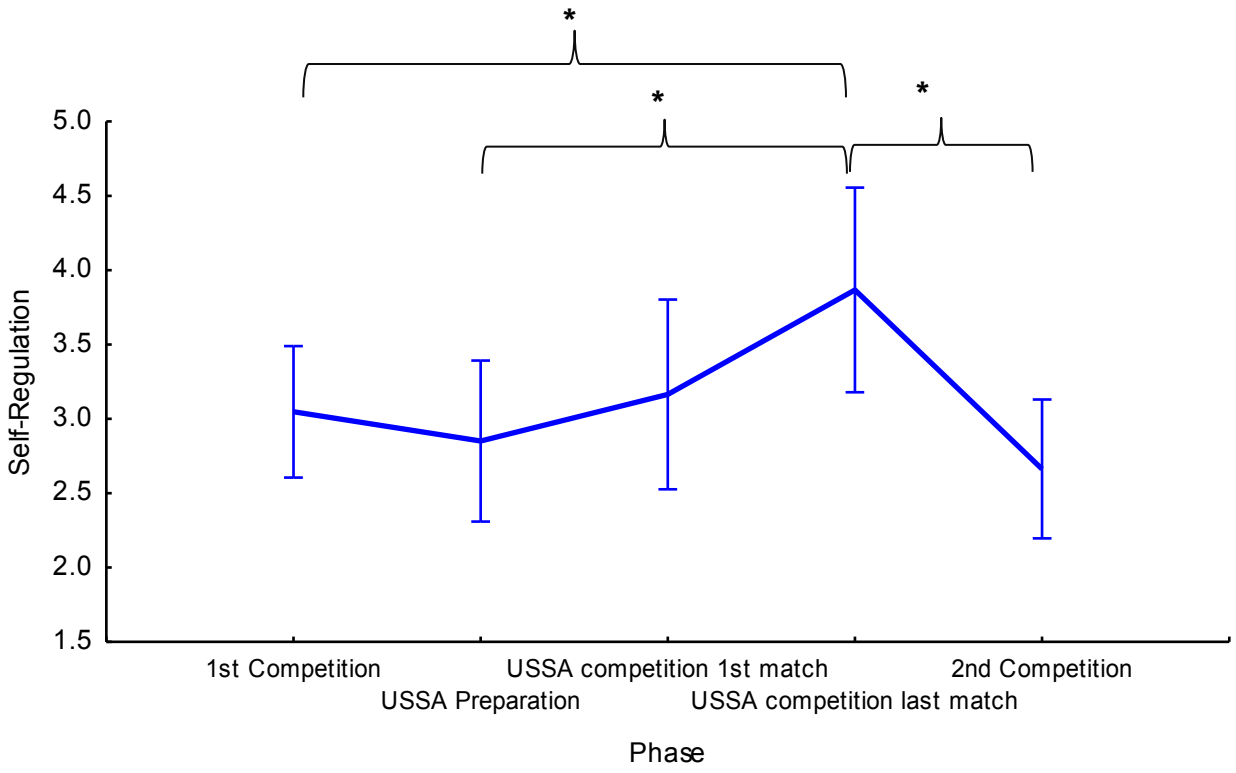
The General Well-being score was significantly higher before the 1st Match of the USSA tournament compared to during the 1st Competition phase (3.69 ± 1.06 vs 4.29 ± 0.70; p = 0.04).

Sleep Quality

For the Sleep Quality scale, the scores were significantly higher before the 1st Match of the USSA tournament compared to during the 1st Competition phase (4.08 ± 0.93 vs 2.95 ± 1.05; p = 0.007).

Self-Regulation

The last USSA match showed significantly higher scores for Self-Regulation than during the 1st Competition phase (4.05 ± 0.54 vs 3.04 ± 0.89; p = 0.02); USSA Preparation phase (4.05 ± 0.54 vs 2.93 ± 0.75; p = 0.009); and the 2nd Competition phase (4.05 ± 0.54 vs 2.72 ± 0.97; p = 0.002) (Figure 4.8).



*p < 0.05

Figure 4.8 Mean scores (mean ± SD) for Self-Regulation for all the phases, for the total group.

Total recovery

A two-way analysis was done, with the team and phase as the two factors, and all interactions for the RESTQ-76 Sport Questionnaire were insignificant. Because the two-way analysis was not significant, the two teams were compared without taking the phases into account. Table 4.7 shows the RESTQ scores (mean ± SD) for the two teams.

The players reported significantly higher scores before the last match of the USSA tournament, compared to during the 1st Competition phase (3.62 ± 0.55 vs 3.04 ± 0.74; $p = 0.03$) and during the 2nd Competition phase (3.62 ± 0.55 vs 3.04 ± 0.83; $p = 0.04$).

For the Stress-related subscales, the VICS team scored consistently higher than the Maties team. For the Recovery-related scales, the Maties team scored higher on all the subscales except the Self-Regulation scale in which the VICS scored higher.

Significant differences ($p<0.05$) were found for the following subscales: General stress, Emotional stress and Physical complaints, while trends towards significance ($p<0.10$) were found for the following Total Stress, Social recovery and General well-being subscales.

Table 4.7 Mean RESTQ-76 Sport scores (mean ± SD) for the two groups for all the phases.

	Scales	Maties	VICS	p-value
Stress	General Stress	0.92 ± 0.73	1.95 ± 0.98	0.02*
	Emotional Stress	1.17 ± 0.70	2.08 ± 0.82	0.03*
	Social Stress	1.17 ± 0.85	2.00 ± 1.12	0.12
	Conflicts / Pressure	2.29 ± 0.93	2.98 ± 1.11	0.32
	Fatigue	2.23 ± 0.99	2.73 ± 0.91	0.32
	Lack of Energy	1.98 ± 0.77	2.42 ± 0.73	0.31
	Physical Complaints	1.46 ± 0.66	2.25 ± 0.76	0.01*
	Disturbed Breaks	1.49 ± 1.13	2.11 ± 1.32	0.32
	Emotional Exhaustion	1.10 ± 0.87	1.90 ± 1.13	0.12
	Injury	2.07 ± 0.86	2.60 ± 1.01	0.30
	Total Stress	1.71 ± 0.59	2.33 ± 0.63	0.06***
Recovery	Success	2.80 ± 1.14	2.25 ± 0.47	0.23
	Social Recovery	4.22 ± 1.30	3.26 ± 0.94	0.09***
	Physical Recovery	2.80 ± 0.94	2.17 ± 0.42	0.13
	General Well-being	4.09 ± 1.2	3.06 ± 0.73	0.07***
	Sleep Quality	3.24 ± 1.04	2.91 ± 1.22	0.73
	Being in shape	3.00 ± 1.03	2.47 ± 0.72	0.25
	Personal Accomplishment	3.11 ± 1.37	2.68 ± 0.77	0.40
	Self-Efficacy	3.15 ± 0.96	2.64 ± 0.64	0.29
	Self-Regulation	2.88 ± 1.10	2.92 ± 0.62	0.93
	Total Recovery	3.25 ± 0.86	2.71 ± 0.44	0.16

***Significant difference was found between the Maties and VICS teams for the following scales: General Stress; Emotional Stress and Physical Complaints ($p < 0.05$).**

*****Trend toward significant difference between the Maties and VICS teams for the following scales: Total Stress; Social Recovery; General Well-being ($p < 0.10$).**

General Stress

A significant difference was found for the General Stress subscale where the VICS scored higher than the Maties team (1.95 ± 0.73 vs 0.92 ± 0.98; p = 0.02) for all the phases. The VICS also scored higher than the Maties during the 1st competition phase (2.17 ± 1.09 vs 0.93 ± 0.82; p = 0.02).

Emotional Stress

The VICS scored higher than the Maties team for all the phases (2.08 ± 0.82 vs 1.17 ± 0.70; p = 0.03); with the VICS scoring significantly higher during the 1st Competition phase (2.16 ± 0.85 vs 1.25 ± 0.87; p = 0.05).

Physical Complaints

For the Physical Complaints scores, the VICS players reported higher scores over all of the phases (2.25 ± 0.76 vs 1.46 ± 0.66; p = 0.01), with the VICS scoring significantly higher during the 2nd Competition phase (2.38 ± 0.68 vs 1.33 ± 0.55; p = 0.03).

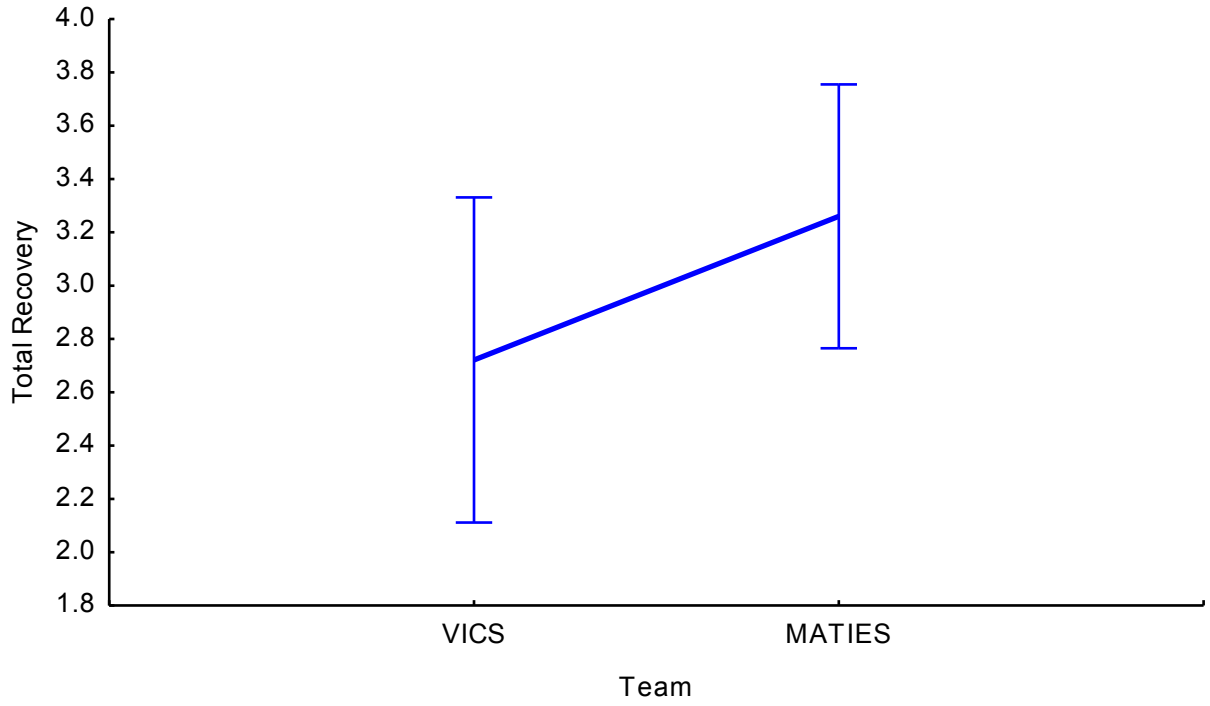
General Well-being

A trend toward statistical significant difference was seen for the General Well-being scale. The Maties team scored higher than the VICS (4.09 ± 1.2 vs 3.06 ± 0.73; p = 0.07) over all of the phases.

Social Recovery

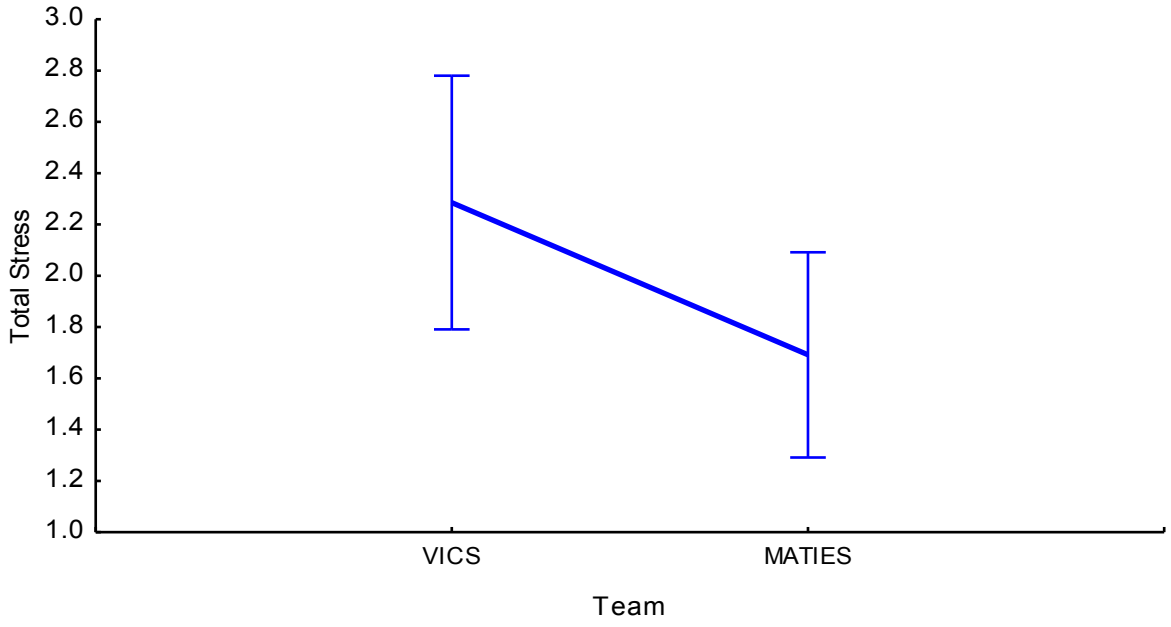
A trend toward statistical significant difference was seen for the Social Recovery scale. The Maties team scored higher than the VICS (4.22 ± 1.30 vs 3.26 ± 0.94; p = 0.09) over all of the phases.

For the Total Recovery scale the Maties team scored higher for all the phases (3.25 ± 0.86 vs 2.71 ± 0.44; p = 0.16), shown in Figure 4.9. The VICS scored higher over all the phases, with a trend towards a significant difference, for the Total Stress scale (1.7 ± 0.59 vs 2.33 ± 0.63; p = 0.06), shown in Figure 4.10.



p = 0.162

Figure 4.9 Mean scores (mean ± SD) for the Total Recovery scale for the two groups for all the phases.



p = 0.06

Figure 4.10 Mean scores (mean ± SD) for the Total Stress scale for the two groups for all of the phases.

E. CORRELATIONS

Spearman correlation tests were conducted between the objective (HIMS test) and subjective (questionnaires) measures of fatigue for each of the different phases (Appendix D). No significant correlations were recorded between the HIMS and the Perceptual fatigue questionnaire for all of the different phases tested. Significant correlations were found between the HIMS scores and several subscales of the RESTQ-76 Sport questionnaire. A moderate to good relationship was found between the HIMS and the Physical Recovery scale ($r = 0.54$; $p = 0.04$); and Being in Shape scale ($r = 0.67$; $p = 0.01$) during the 1st Competition phase. The Physical Complaints scale showed a moderate to good negative relationship ($r = -0.57$; $p = 0.03$) with the HIMS test.

Although not significant on a 95% level ($p < 0.05$), some scales did, however, show a trend toward a relationship on a $p < 0.10$ level. At a 90% level, the Fatigue scale showed a moderate negative relationship ($r = -0.44$; $p = 0.10$) and Total Recovery a moderate positive relationship ($r = 0.47$; $p = 0.08$) during the 1st Competition phase.

During the USSA Preparation phase the Personal Accomplishment scale showed a trend towards a positive relationship ($r = 0.71$; $p = 0.09$) with the HIMS test. During the 2nd Competition phase a trend towards a moderate correlation was found for General Well Being ($r = 0.57$; $p = 0.09$) and a trend toward a negative moderate correlation was found for Disturbed Breaks ($r = -0.55$; $p = 0.10$).

F. PLAYER PROFILES

	Player A	Player B
Highest playing level	South Africa u21	Club - VICS
Age	19	21
$\bar{x}$ weight ± SD	70.3 ± 1.28	59 ± 0.56
$\bar{x}$ height ± SD	172.8 ± 0.98	164 ± 1
Comments	Player A had SA u21 camps during holidays and extra training sessions over weekends, in comparison to the VICS player that only had the Maties training sessions. Player A also had extra matches and competed in the u21 Interprovincial Tournament (IPT) (Week 8). During this week Player B continued with normal training. Both player A and B competed in the USSA tournament. Player B had a different coach and a different fitness trainer for the majority of this study and only joined the Maties First team during the USSA Preparation phase. The following weeks correspond with the following phases: Week 1 – 6: Pre-Competition phase; Week 7 – 14: 1st Competition phase; Week 15 – 17: USSA Preparation phase; Week 22 – 23: 2nd Competition phase.	

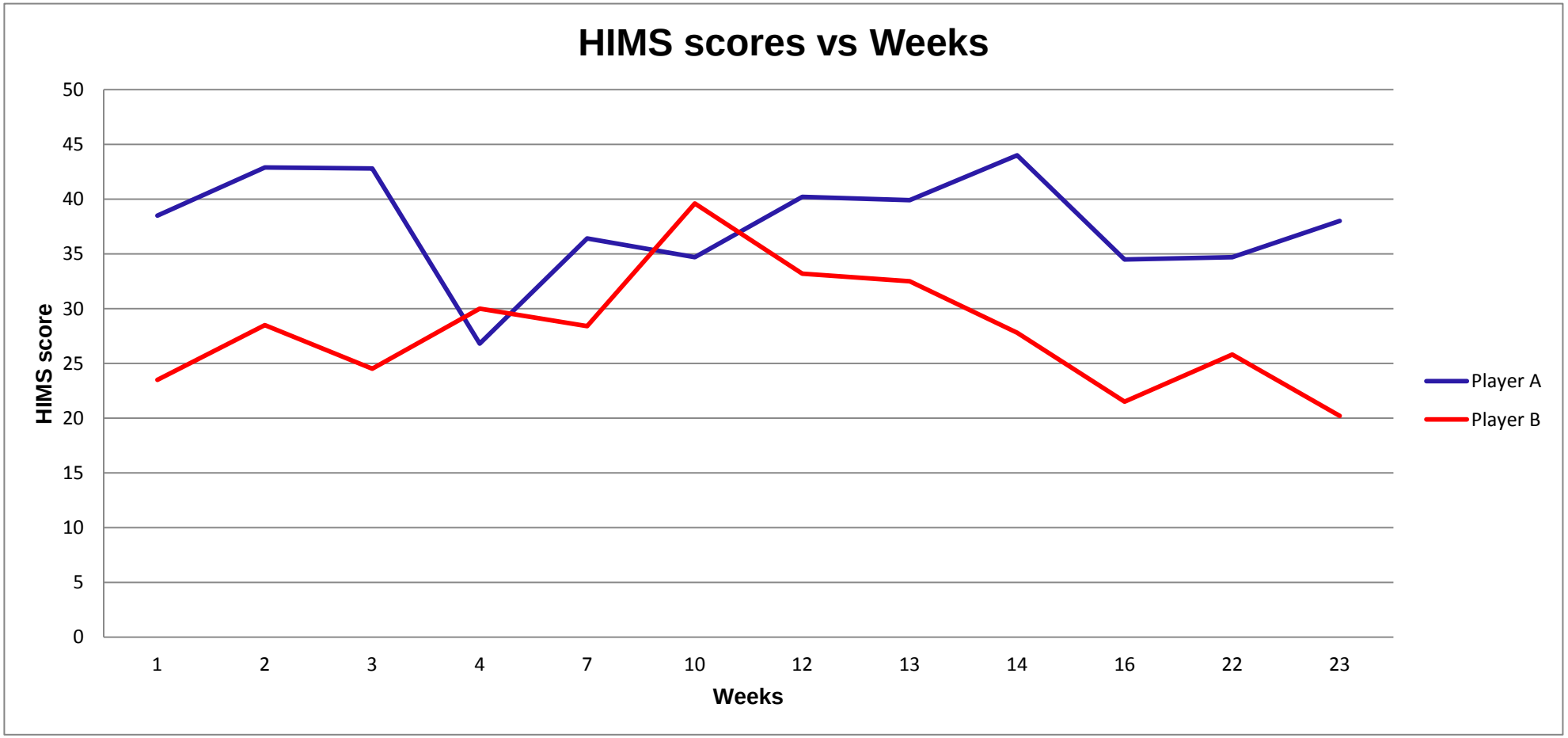


Figure 4.11 The comparison of HIMS score vs Weeks of two players during the different phases of a competitive season

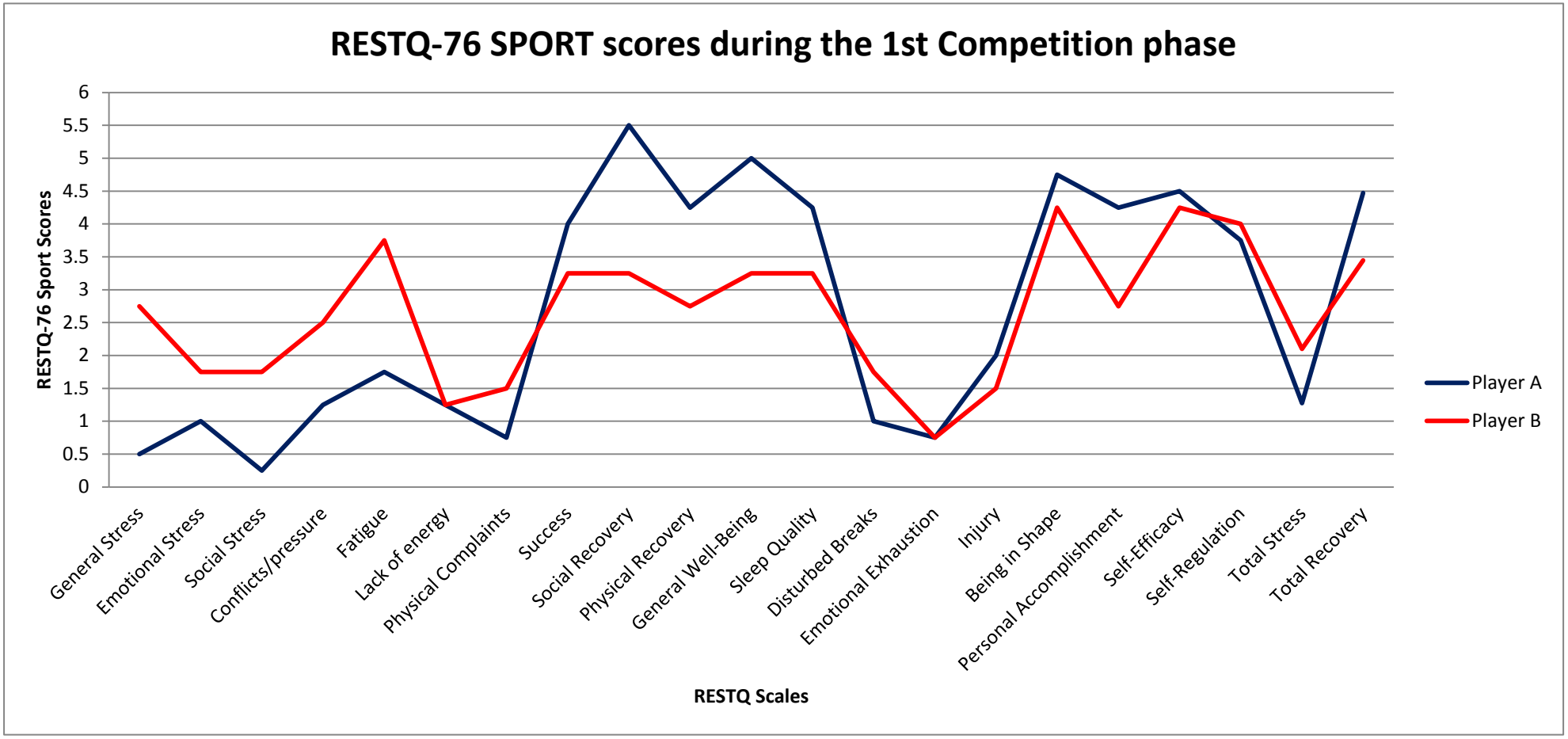


Figure 4.12 The comparison of RESTQ-76 Sport scores of two players during the 1st Competition phase

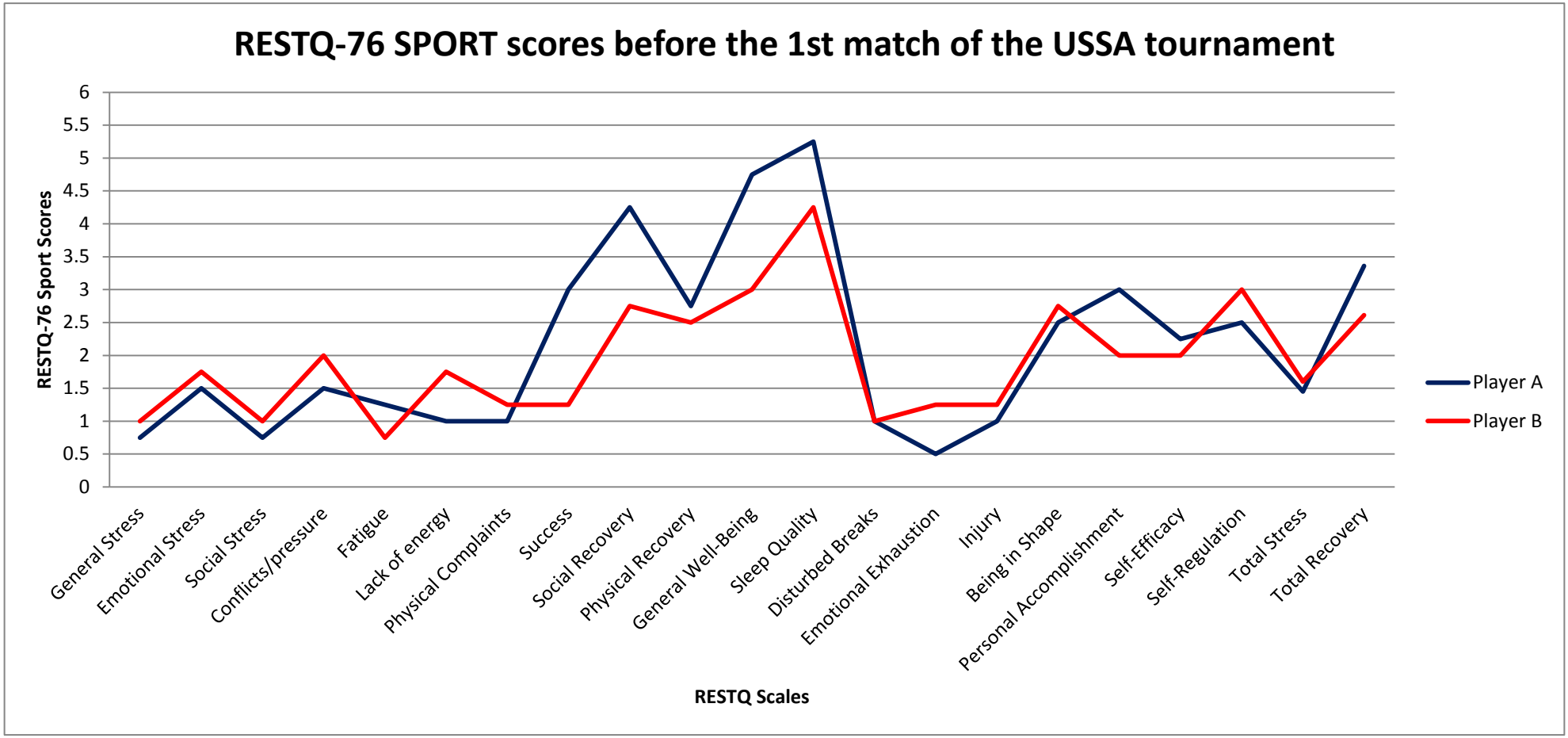


Figure 4.13 The comparison of RESTQ-76 Sport scores of two players before the 1st match of the USSA tournament

CHAPTER FIVE

DISCUSSION

A. INTRODUCTION

Elite hockey players (n = 15) were monitored by means of two questionnaires and the heart rate recovery tests (HIMS). The primary aim of the study was to monitor the accumulative fatigue and recovery status of elite field hockey players during different phases of a competitive season. The discussion will focus on the specific objectives of the study. Research objective five will be integrated into the other objectives.

B. RESEARCH OBJECTIVE ONE: To determine the changes in heart rate recovery of elite field hockey players during different phases of a competitive season.

Changes in heart rate recovery (HIMS) were evident throughout the season. Players showed the lowest physiological recovery state during the 2nd Competition phase. This could be due to accumulative fatigue, because the physiological recovery decreased from the 1st Competition to the 2nd Competition phase. Reilly and Ekblom (2005) also reported accumulative fatigue in soccer players, where top soccer teams in the world performed badly in international tournaments, due to accumulative fatigue. Although this argument has been countered by other teams that played the

same schedule, in the same tournament and performed better, it still indicates the need to monitor players closely.

A previous study on endurance-trained athletes found that post-exercise heart rate recovery increased significantly after an eight-week training programme (Borresen & Lambert, 2008). This increase in heart rate recovery could be similar to the change in the physiological recovery state between the Pre-Competition and 1st Competition phases that was seen in the current study. Borresen and Lambert (2008) also indicated that with endurance training a decrease will occur in the resting and submaximal heart rate. Since the HIMS test is a submaximal test, it can be assumed that by increasing the training intensity during the Pre-Competition phase, the resting and submaximal heart rate would also decrease. During the Pre-Competition phase the players were not as fit and a high intensity training programme was implemented to increase their fitness level.

According to Bosquet *et al.* (2008) after longterm interventions, a decrease was evident in heart rate at submaximal workloads. This can indicate that when players have a decreased heart rate at standardised submaximal workloads, that it could be indicative of long term fatigue.

As Gustafsson *et al.* (2011) suggested, non-training stressors should also be taken into consideration in order to avoid maladaptation. The sample for the study consisted of students, thus a plausible reason for the decrease between the 1st

Competition and the USSA Preparation phase could be that the examinations were taking place during the last part of the 1st Competition phase and continued until the first part of the USSA Preparation phase. During examinations, players tended to miss training sessions and matches were also played on Sundays, in order to accommodate those players that could not play a match because they had an exam to write. The increase in stress due to exams and a possible decrease in sleep, could have resulted in a decreased performance at the following training sessions as well as a decrease in recovery (Reilly & Ekblom, 2005). In addition to this, the high frequency of matches that were played during some of the weeks during the 1st Competition phase may also have been a contributing factor. Kellmann (2010) mentioned that it is not only training mistakes that can lead to overtraining, but a high frequency of matches, without sufficient time for recovery.

Borresen and Lambert (2008) also showed that, following an eight-week training programme which showed an increase in heart rate recovery, four weeks of detraining caused the heart rate recovery to return to its baseline level. This could be the reason for the decrease in heart rate recovery between the USSA Preparation and the 2nd Competition phase. Between these two phases, most players had at least a two week resting period, while others had a six to eight week resting period. This decrease in training load could have lead to a decrease in heart rate recovery. Similarly, the decrease in heart rate recovery during the 2nd Competition phase could be due to the sudden increase of training after a prolonged break. An increase in the heart rate at a submaximal intensity could indicate lack of conditioning (Lamberts *et al.*, 2004), and a sudden increase in training volume and intensity could lead to decreased recovery (Hartwig *et al.*, 2009).

Although the Maties team had a slightly higher heart rate recovery, no statistical differences were found between the two teams during any of the phases during the competitive season. Previous studies, like Hartwig *et al.* (2009), however, found that the players that coped better with the training, which in turn lead to better recovery profiles (lower stress, better recovery), appeared to be the more successful and fit players. These players, which are usually the first team players, also tended to have the highest training volume. Results from the current study differs from the study by Hartwig *et al.* (2009). The reason that no difference was seen between the two teams in the current study could be due to similarities in their training programmes and competition schedule.

C. RESEARCH OBJECTIVE TWO: To determine the changes in perceptual fatigue scores of elite field hockey players during different phases of a competitive season

Perceptual fatigue is categorised according to five different subscales. The lowest scores were reported for the following subscales during the Pre-Competition phase: Fatigue, Sleep Quality, Stress Levels and Mood State. According to Di Fronso, Nakamura, Bortoli, Robazza and Bertollo (2013) the Pre-Season phase consists of the majority of the physical training load. This is to prepare the athlete to be able to meet the requirements necessary during the Competitive phase. This is in accord with Bompa (1999) who stated that one of the objectives during the Preparatory phase is to acquire and improve general physical training. When starting the Pre-Competition phase players are detrained and the increase in the training load and intensity could be a possible reason for the bad scores during the Pre-Competition phase.

Fatigue Scale

The fatigue scale showed its lowest (worst) score during the Pre-Competition phase, with a slight, insignificant improvement during the 1st Competition phase. The scores improved again during the USSA Preparation phase. Di Fronso *et al.* (2013) explained that because of the higher physical load administered during the Preparatory phase, that this will lead to an increase (worse scores) in the fatigue scores. The greater the intensity of the training, the higher the fatigue level (Bompa, 1999). During the competition season, players spend more time on tactics and

physical training loads are changed with the next few matches in mind. This could mean that players get more time off, or that the intensity of some of the sessions are lower to accommodate the recovery process of the body. This could be a reason for the participants feeling less fatigued during the Competition phase. During the USSA Preparation phase, players are managed carefully, with a training schedule carefully planned out, and more time for recovery. During the USSA Preparation phase, players also do not have classes, and thus do not have any time pressure in their studies (Gustafsson *et al.*, 2011; Kellmann & Kallus, 2001) and in addtition spend a lot of time with their team mates, which could indicate that social support plays a role on the level of fatigue of a player.

Sleep Quality

The lowest (worst) score for the Sleep Quality scale was during the Pre-Competition Phase. The scores improved, insignificantly, during the 1st Competition phase, after which it worsened slightly (insignificantly) during the USSA Preparation phase. According to Kellmann and Kallus (2001) the slight improvement in the scores between the Pre-Competition phase and the 1st Competition phase could be due to an absence of struggling to fall asleep, as well as uninterrupted sleep.

The insignificant decrease in perceived sleep quality scores between the 1st Competition Phase and the USSA Preparation phase could be an indication of struggling to fall asleep and not getting enough sleep, as indicated by Kellmann and Kallus (2001).

General Muscle Soreness

The lowest (worst) general muscle soreness subscale score were reported during the 1st Competition phase. The worsening in perceived general muscle soreness from the pre-competition to the 1st Competition phase could be due to many factors. A study on perceived fatigue suggested that the recovery of perceived general muscle soreness is not limited to the type and the amount of training that follows that match, but can also be influenced by other factors such as adaptations to previous training (Mclean *et al.*, 2010). During the 1st Competition phase, the frequency of matches increased, as well did their other training and other responsibilities toward the provincial teams. During the 1st Competition phase the players not only had the club matches to play, but also had provincial and national matches and training sessions to attend. This increase in training load and intensity can lead to accumulative fatigue and increase in perceived general muscle soreness (Reilly & Ekblom, 2005).

Between the 1st Competition phase and the USSA Preparation phase the players' perceived general muscle soreness scores improved significantly, indicating a decreased level of perceived general muscle soreness. This decrease in muscle soreness could be due to the break (2 weeks) that most players had between the last league match and the USSA Preparation phase. Professional soccer clubs in Europe have opted to include a mid-season break to give the players' body a chance to adapt to the training and to give them time to rest. (Reilly & Ekblom, 2005).

Stress Levels

The worst score for the stress levels subscale was observed during the Pre-Competition phase with a significant increase during the USSA Preparation phase. A significant improved was also observed from the 1st Competition phase to the USSA Preparation phase. This indicates that the perceived levels of stress decreased as the season progressed. This could be owing to the fact that after the Pre-Competition phase the teams were chosen and the added stress of which team each player might make, had fallen away. It could also be due to a decrease in training load, due to the increase in competition frequency.

The change in stress levels between the 1st competition and USSA Preparation phase, could be due to exams being over, and having a break in training. Social support could also play a role in stress levels (Gustafsson *et al.*, 2011).

Mood State

The worst score for the mood state scale of the Perceptual Fatigue was during the Pre-Competition phase. From there, mood states were more positive (insignificantly) during the 1st Competition Phase, followed by a further, insignificant, increase in positive mood during the USSA Preparation phase. Coutts and Reaburn (2008) reported that previous research have indicated strong relationships between mood states with overreaching and overtraining.

The Maties players consistently had better subscale scores than the VICS players, albeit insignificantly so. This can be an indication of the difference in the players in the two teams. Hartwig *et al.* (2009), describes the players with better recovery profiles as the more successful, more talented and fitter players, and they were also the players with the highest training volume, which are usually the first team players. In this study the majority of the first team players also played for other teams, provincial and national, which gives an indication of their skill level.

D. RESEARCH OBJECTIVE THREE: To determine the relationship between recovery and stress during different phases of a competitive season.

For the possible explanations on the RESTQ, the scale as described by Kellmann and Kallus (2001) was used. See Appendix E.

Total Recovery

The group of players felt they had recovered worst during the 1st Competition phase and the 2nd Competition phase. A significant increase was found between the last match of the USSA tournament and the 1st Competition phases, as well as the last match of the USSA tournament and the 2nd Competition phases, indicating that the players felt most recovered right before the last match during the USSA tournament. A possible reason for this could be that during the 1st Competition phase the players had just come out of the Pre-Competition phase, where the majority of the training load is usually applied (Bompa & Haff, 2009; Di Fronso *et al.*, 2006) which could lead to the players still feeling fatigued from that phase. During the 2nd Competition phase some of the players had a lot of time off, and it might have felt like they have started with the Preparatory phase again.

Total Stress

The highest score for the Total Stress scale was seen during the 1st Competition phase, indicating that the players had the highest stress levels during the 1st Competition phase. From the 1st Competition phase, a significant decrease in stress was seen during the USSA Preparation phase. A significant decrease in stress levels was observed before the 1st Match during the USSA Tournament. Possible explanations for this could be that during the 1st Competition phase the players had examinations to write, which could add to the stress load (Gustafsson *et al.*, 2011). The decrease in stress during the USSA Preparation phase could be attributed to the fact that most of them were already on holiday, and that they had more time to spend with friends. The decrease in stress levels before the 1st match during the USSA tournament might be a result of the team psyching each other up and they are excited for the tournament that lies ahead.

When comparing the teams, the VICS scored consistenly higher than the Maties for all the Stress related scales, while the Maties scored higher for all but one of the Recovery scales. The one recovery scale that the VICS scored higher was the Self-Regulation scale.

VICS scored significantly higher than Maties for the General Stress, Emotional Stress and Physical Complaints subscales. The Maties players were the more experienced players, with the majority of them also playing for a provincial or national team. Despite these players having more training and matches than the other players, they knew how to handle it better (Hartwig *et al.*, 2009).

RECOVERY SCALES

Success

The lowest score for this scale was seen before the 1st Match of the USSA Tournament while the highest score was seen before the Last match of the USSA tournament. There was a significant increase in feeling of success from the 1st match of the USSA Tournament to the last match of the USSA Tournament. This increase can be owing to the results that the team have been getting at the tournament (finishing in the 3rd place) and enjoying what they are doing. They could have felt good about their chance on the day of the last match of the tournament (Kellmann & Kallus, 2001). There was a significant decrease in the feeling of success between the last match of the USSA tournament to the 2nd Competition phase.

Results from Jurimae *et al.* (2004) cited in Coutts and Reaburn (2008) found that there was a decrease in feelings of success following a six day training programme after training was doubled (Coutts & Reaburn, 2008). This could be an indication of the decrease in feelings of success during the 2nd Competition phase: the players started training very hard, along with the start of classes.

Coutts and Reaburn (2008) found similar results after they applied a progressive overload programme for six weeks. After the six weeks, the players experienced a decreased feeling of Success.

Social Recovery

The Social Recovery scores were at their lowest during the 1st Competition phase, afterwhich the scores increased during the USSA Preparation phase and then reaching its highest score before the last match of the USSA Tournament. A decrease was seen from the USSA tournament to the 2nd Competition phase. This indicates that the players felt most relaxed and had the most social interactions before the last match of the USSA Tournament. The increase in social interaction from the 1st Competition phase to the USSA Preparation phase, could be as a result of the eaxminations during the 1st Competition phase, as well as the players' other responsibilities, such as national and provincial teams, which took up most of their time. During the USSA Preparation phase and the USSA Tournament the players were around their friends and had more time to relax (Kellmann & Kallus, 2001).

Similar so the results found during Success, results from Jurimae *et al.* (2004) cited in Coutts and Reaburn (2008) found that there was a decrease in feelings of social relaxation following a six day training programme after training was doubled (Coutts & Reaburn, 2008).

Physical Recovery

The groups' Physical Recovery scores were at their lowest during the 1st and the 2nd Competition phases. From the 1st Competition phase there was a significant inprovement in the scores to the USSA Preparation phase. A significant improvement was also observed from the 1st Competition phase to before the 1st Match of the

USSA tournament. after which a significant decrease occurred to the 2nd Competition phase.

This means that the group felt least recovered during the 1st and 2nd Competition phases. This could be due to an increase training and increase in matches, which corresponds to what Coutts and Reaburn (2008) found after a six week overloading period.

A feeling of being fit and physically well will give a higher Physical Recovery score, which could be the reason for the increase in scores during the USSA Preparation and USSA Tournament phases (Kellmann & Kallus, 2001).

General Well-being

The players were in a better mood and were more content before the 1st match of the USSA tournament (highest score) than during the 1st Competition phase. This corresponds with research by Coutts and Reaburn (2008) who found a decrease in the General Well-Being scale after a progressive overloading training programme was followed for six weeks. In their study, the General Well-Being scale also decreased after six weeks of following a normal training programme.

During the 1st Competition phase the Maties and VICS players experienced an increase in training and matches, while during the USSA tournament, while a lot of

matches were played, no training was completed and special attention was given to recovery.

Sleep Quality

The lowest Sleep Quality scores were observed during the 1st Competition phase, while the highest score was recorded before the 1st Match of the USSA Tournament. There was a significant increase between the scores form the 1st Competition phase to the 1st match of the USSA tournament. The increase in the training loads, training volumes (matches) and non-training stressors (examinations) could be the reason for the bad Sleep Quality during the 1st Competition phase (Gustafsson *et al.*, 2011; Michael Kellmann & Kallus, 2001). In contrast to that, the good level of Sleep Quality during the USSA Tournament could be due to the fact that the team knew that they had an important match to play the next day, and focused on going to bed early (Kellmann & Kallus, 2001).

Being in shape

The lowest score for Being in shape was seen during the 2nd Competition phase, with the highest score before the last USSA match. This could be because the players felt most prepared and most fit during the USSA tournament, while they felt less fit after the holiday (Kellmann & Kallus, 2001).

Personal Accomplishment

The team possibly felt most connected and felt they enjoyed their sport the most before the last match of the USSA tournament (highest score), possibly due to the prospect of playing out for the 3rd position, while the team felt least integrated before the 1st match of the USSA tournament (lowest score) (Kellmann & Kallus, 2001).

Self-Efficacy

The group of players possibly felt most confident right before the last match of the USSA Tournament (highest score), possibly due to the prospect of finishing 3rd in the tournament, with the team and players feeling the least prepared and confident during the USSA Preparation phase, possibly because they had a lot of preparation still to do.

Self-Regulation

The worst scores for the Self-Regulation scale was seen during the 2nd Competition phase, with the highest score before the last match of the USSA Tournament. Significant increases were seen between the 1st Competition phase and the last match of the USSA Tournament, as well as between the 1st Competition phase and the USSA Preparation phase and the 2nd Competition phase. The athletes were most motivated and were prepared to push themselves in order to get their goals more before the last match of the USSA Tournament, than during any of the other phases (Kellmann & Kallus, 2001).

STRESS SCALES

General Stress

The General Stress scale scores were at their highest during the 1st Competition phase, with a significant decrease until the 1st match of the USSA Tournament (lowest scores). Coutts and Reaburn (2008) found an increase in the General Stress scale after an intensified overload six week training programme. This could be the reason for the high score during the 1st Competition phase, as they had an increase in matches and training load, which could lead to a higher stress level (Gustafsson *et al.*, 2011; Michael Kellmann & Kallus, 2001). The low stress scores before the 1st match of the USSA Tournament could be an indication that the players felt more relaxed. The increase in academic workload, specifically with regards to examination periods, may have lead to the high stress levels during the 1st Competition phase.

Emotional Stress

The Emotional Stress scale had its lowest scores during the last match of the USSA Tournament, with the highest score observed during the 1st Competition phase. A study by Di Fronso *et al* (2013) also showed higher frequency levels of emotional stress during the Competition phase than during Preseason, most likely because players have to deal with the stressful demands of crucial mathces during the Competitive season. This, coupled with non-training stressors can lead to higher Emotional Stress (Gustafsson *et al.*, 2011).

Social Stress

No significant difference was seen for Social Recovery over any of the phases. However, the lowest stress levels were observed before the 1st match of the USSA tournament, with the highest scores being observed during the 2nd Competition phase.

Social stress can be due to arguments and irritations concerning others – during the USSA preparation and the USSA tournament these players are together for relative long periods and it might just get to much for the players (Kellmann & Kallus, 2001). Although this does not explain why there was no significant difference, it may indicate why there was an insignificant increase in the score from the 1st match to the last match of the USSA tournament.

Conflicts / Pressure

The highest score for this scale was seen during the 1st Competition phase, with the lowest score seen during USSA Preparation phase. There was a significant decrease in the Pressure scale from the 1st Competition phase to the USSA Preparation phase, which could be an indication that during the 1st Competition phase the players were unsettled. It could also be due to the fact that the teams were still relatively new. During the USSA Preparation phase the scores decreased indicating a better environment between the players.

The increase in Conflicts / Pressure during the USSA Tournament (eventhough it was insignificant) could indicate that goals were not reached, as well as the possibility that the players being together for such a long period of time might be taking its toll (Kellmann & Kallus, 2001).

Fatigue

The Fatigue reached its peak value during the 1st Competition phase, while the lowest value was observed just before the 1st USSA match. Di Fronso *et al.* (2013) reported higher Fatigue scores during the Preseason due to the higher physical load the athletes have to train with in order to increase the physical, technical and tactical performance they will need later in the competition. Brink *et al.* (cited in Di Fronso *et al.* 2013) also stated that fatigue was one of the most sensitive subscales in assessing overreaching. This could also be the reason for the lower USSA Preparation phase scores, the players had more time to rest as they had dedicated training times and did not have the added stress of nontraining stressors such as studies/classes (Di Fronso *et al.*, 2013; Gustafsson *et al.*, 2011; Kellmann & Kallus, 2001).

Lack of Energy

One of the factors that could have contributed towards the Lack of Energy during the 1st part of the Competition phase, is the accumulative fatigue experienced during the preseason. With the increased physical demands of the preseason phase, which is required for physical adaptation, players may still be recovering from the high training

volumes and demands which may have affected their performance and physicality in the next phase (1st Competition phase).

This increase in training loads could lead to fatigue, which in turn could lead to the inability to concentrate. The decrease in scores during the USSA Preparation phase can indicate a willingness and eagerness to participate and learn. This is also reflected in the low scores prior to the 1st match at the USSA tournament. This might be indicative of an eagerness to participate and play. The significant difference between the USSA Preparation and Tournament scores compared to the 2nd Competition score could be owing to the fact that the 2nd Competition phase is rather close to the end of the year and the players may be tired and might not be as eager to participate and play hockey anymore (Kellmann & Kallus, 2001).

Physical Complaints; Injury; Emotional Exhaustion

No statistically significant changes was seen between any of the phases for these subscales. There was, however, a big difference between the lowest values – prior to the 1st match at the USSA Tournament – and the highest values– prior to the last match at the tournament. This could indicate the toll the competition takes on the players' body and mind when they play five matches in less than a 7. After the high volume of matches, the players may indicate a trend toward feeling burnt out and vulnerable, and after they have had some time to relax the scores come back down (Kellmann & Kallus, 2001). The increase in Emotional Exhaustion could be due to the increased workloads brought about by the high frequency of matches. The same

tendency was reported by Grobbelaar, Malan, Steyn and Ellis (2010) in a study on rugby players.

Disturbed Breaks

This subscale showed the highest score during the 1st Competition phase and the lowest score during the USSA Preparation phase. Although not significant, it could indicate the effect the absence of nontraining stressors have on the players (Gustafsson *et al.*, 2011).

E. RESEARCH OBJECTIVE FOUR: To determine the relationship between the objective and subjective measures of recovery and fatigue during different phases of a competitive season.

Correlation tests were conducted between the objective measures (HIMS test) and subjective measures of fatigue (Perceptual Fatigue questionnaire and RESTQ-76 Sport questionnaire for athletes). No correlations were found between the HIMS and the Perceptual fatigue questionnaire; however, several correlations were reported between the HIMS test and the RESTQ-76 Sport questionnaire. During the 1st Competition phase, positive correlations were seen between the HIMS and the Physical Recovery and Being in Shape subscales of the RESTQ-76 Sport. Although cause or effect wasn't established, it could be that players felt better about their physical recovery and about their fitness levels, therefore they performed better in the HIMS test. A negative correlation was seen between the HIMS test and the Physical Complaints scale. Those players who had more physical complaints showed poorer recovery on the HIMS test.

Furthermore, some scales did show a trend towards a significant correlation. During the 1st Competition phase the Total Recovery scale showed a positive relationship with the HIMS test, whereas Fatigue, showed a negative correlation. During the USSA Preparation phase, Personal Accomplishment and General Well Being showed a trend towards a positive correlation, while a trend towards a negative correlation was seen for Disturbed breaks.

The only other study that the researcher of this study is aware of that compared the HIMS and the RESTQ-76 Sport questionnaire results was conducted by Nel (2012). Nel (2012) also found a negative correlation between the HIMS test and the Physical Complaints scale, although, this correlation was found during the Development phase. In addition, Nel (2012) also found two other correlations between the HIMS and the RESTQ-76 Sport questionnaire: during the Development phase the HIMS showed a positive correlation with the Self-Efficacy scale, and a negative correlation with the Injury scale (during the Early Competition phase). Possible reasons for the differences in the findings between these two studies can be the differences in methodologies used in the respective studies: the number of participants and the duration of the studies differed greatly.

One can conclude that implementing one test might be sufficient, however, completing objective and subjective tests will allow for more specific data to be captured. If under certain constraints (equipment, space, time), only completing the RESTQ-76 questionnaire could be sufficient to collect information about your players at a specific time.

F. RESEARCH OBJECTIVE SIX: To compare the recovery stress profile of two players from the group to determine individuality within a group setting.

The player profiles on page 59 shows two players with two different skill levels who both participated in the current study. Player A is a SA u21 hockey player who also played for WP u21, while Player B only competed at club level. Due to Player A's extra responsibilities, she had extra training sessions as well as matches. For the majority of the season, Player A had a higher (better) HIMS score than Player B (Figure 4.11) indicating better recovery from her previous session, which most probably was on the day before the test (SA u21 squads trained on Sundays), whereas Player B has had more than 24 hours rest between her last training session and the HIMS test. Despite the extra training session that Player A had, she still trained as early as Player B on the day of HIMS testing.

Despite having more training sessions and matches, Player A, the more experienced player, handled the pressure and stressors better than Player B. This can be seen in Figure 4.12 and 4.13. During the 1st Competition phase Player A had a better Total Recovery score, as well as a better Total Stress score. Player B appears to be more stressed and less recovered than Player A. In Figure 4.13 the two players' scores become closer together. During the time that this RESTQ-SPORT questionnaire was taken, both the players were on the same team, as opposed to different club teams, and they have both been through a long preparation period. This might be the reason for the similar scores – the players suddenly have the same coach, go through the

same routine and are now part of the same team. Despite these similarities, the more experienced player, Player A, still seems to handle the training load better and had better recovery scores.

The coaches used the HIMS results as a guideline to make sure that players are in fact ready to train again. After receiving the HIMS results from the morning, the coach and conditioning coach may have decided to rather send the team for a contrast bath recovery session, as opposed to the usual training session followed by fitness on that evening.

G. CONCLUSION

The RESTQ-Sport and the HIMS were valuable tools to discriminate between players who had more stressors and were possibly under-recovered.

In all three measurement tools used; HIMS, RESTQ-Sport, and Perceptual Fatigue questionnaire, the Maties teams performed better than the VICS team, even though not all the differences were statistically significant. These monitoring tools can be used in a team environment. Each of the three monitoring tools uses each person as their own baseline. Even in a team environment, this gives one the opportunity to individualise training programmes and recovery methods.

Coaches need to remember that the start of the season is very tough on players, not only physically, but emotionally as well, and they should not only follow the guidelines with regard to different recovery modalities, they should apply it as well.

H. LIMITATIONS AND FUTURE RESEARCH

With a small sample size, as is the case in this study, the trends towards statistical significance might have been more significant if the population of the study was larger.

While every effort was made to ensure that the SUUNTO equipment was working and regularly serviced, the equipment sometimes did not work probably.

The reliability of participants showing up to tests and filling in the “take-home”-questionnaires when they are supposed to is not always in the researchers’ control and as a consequence some participants were excluded from the data analysis.

In a real training environment, adherence to club rules is very important. The population of the study was university students and adherence to the university term schedule was thus critical – this led to differences in the number of tests conducted during each phase. Some of the variables may not have shown any significant differences due to one or a combination of these limitations.

While this is a current limitation in this study, future studies can focus on completing all questionnaires before every HIMS test. This will allow the researcher additional information towards possible reasons for a low heart rate recovery. In addition, this

will help the coach manage the players better as this is a quick and easily administered questionnaire.

Future research can include a neuromuscular fatigue test, such as the jump test, to the current testing protocol, in order to test the difference between the heart rate recovery, and neuromuscular fatigue.

In addition, future research can also focus on the effect of recovery interventions, such as active recovery, passive recovery, ice baths or massage, with player monitoring over the same season.

Other future research can focus on comparing session training load with accumulative fatigue; and comparing weight fluctuations and accumulative fatigue during a competitive season.

The RESTQ-Sport questionnaire has not yet been validated in the South African context. Participants in this study were mostly English speaking, therefore the language was not a barrier but, future efforts should be made to validate the questionnaire for South African participants.

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APPENDIX A

STELLENBOSCH UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH

Monitoring accumulative fatigue and recovery status in elite field hockey players during different phases of a competitive season.

You are asked to participate in a research study conducted by Ms LA de Villiers (BHons Sport Science), from the Department of Sport Science at Stellenbosch University. The results of this study will contribute to my Masters thesis. You were selected as a possible participant in this study because you are a member of the Maties first and second women's hockey team.

1. PURPOSE OF THE STUDY

The primary aim of the study was to monitor accumulative fatigue and recovery state of elite field hockey players during different phases of the competitive season.

This is done through the use of SUUNTO heart rate monitors, the HIMS test and self-report measures such as the Perceptual fatigue questionnaire and the RESTQ-SPORT.

2. PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

Wear the SUUNTO memory belt (heart rate monitor) during all training sessions; complete the Perceptual fatigue questionnaire before every match and training session; participate in the HIMS (Heart rate Interval Monitoring System) test on a weekly basis; and complete the RESTQ-sport once a month. All participants act as their own control. The HIMS test will be completed at the Sports hall at Coetzenburg and the Perceptual fatigue and RESTQ-SPORT will be completed at the Maties Hockey Club at the Welgevallen Hockey fields. The HIMS test will take 15 minutes to complete.

SUUNTO memory belts (heart rate monitors)

The SUUNTO memory belt is a heart rate monitor that measures heart rate beat by beat and is stored on a data memory chip. It can record up to 24 hours of heart rate data. The belt is worn under your clothes and should fit snugly around your chest. It operates at 2.465GHz and weighs 61g.

HIMS

The Heart rate Interval Monitoring System test consists of 4 running stages of increasing intensity, alternated with 1minute recovery periods, and lasts a total of 12minutes. The pace of each of the 4 running stages is 8.4km/h, 9.6km/h, 10.8km/h and 12.0km/h respectively. By means of SUUNTO heart rate monitors, the heart rate is recorded and the auditory pace signals are pre-recorded onto a CD.

Perceptual fatigue questionnaire

The perceptual fatigue questionnaire is a psychological questionnaire which assesses their perceptual fatigue on 5 levels: Fatigue; Sleep quality; General muscle soreness; Stress levels; and Mood on a five-point scale. The five scores are added together to determine the overall well-being.

RESTQ-Sport

The Recovery-Stress Questionnaire for Athletes measures the recovery-stress state of athletes. It consists of a total of 19 scales, 12 of which are general stress and recovery scales, and 7 of which consist of sport-specific stress and recovery scales.

3. POTENTIAL RISKS AND DISCOMFORTS

There are no foreseeable risks or discomforts associated with this study.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Monitoring recovery status can enable the coaches to adapt the training load and prevent any injuries or illness. Overtraining can also be prevented when players are continuously monitored. With this study we will also increase our knowledge regarding both monitoring and hockey players, which can be useful for further research and service.

5. PAYMENT FOR PARTICIPATION

Participation in this study is voluntary and no remuneration will be offered to participants.

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. Confidentiality will be maintained by the researcher by safeguarding all information and data. Paper copies will be locked in a cupboard and electronic copies will be kept on a password protected personal computer. Any collected data can be shared with coaches if they would request that data. Statistical analysis will be done anonymously to ensure the participants confidentiality. Each player will be assigned to a certain number and code. In the event of publishing of data or results, the players will remain anonymous by continuing the use of codes and numbers. Findings will be reported to participants in a documented summary at the end of the year, with each participant only receiving their own document.

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. You may also refuse to answer any questions you don't want to answer and still remain in the

study. The investigator may withdraw you from this research if circumstances arise which warrant doing so. If the participant is not in the Maties first or second women's team for the entire duration of the study, the researcher can withdraw him from the study without any notice. If you volunteer to be in this study, you will be asked to complete a personal information sheet at the beginning of the study. This personal information sheet will be used as a means of getting sufficient information of each participant needed for the study such as hockey playing position, contact details, age. This document will then also be used to document/attach doctor's notes of any injuries or illnesses acquired during the study. This doctor's information is necessary to monitor the player during the period that they are not allowed to physically train.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

Jana (LA) de Villiers

14869799@sun.ac.za

084 548 5051

Dr. RE Venter

rev@sun.ac.za

(021) 808 4721

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to me by LA de Villiers in Afrikaans/English and I am in command of this language or it was satisfactorily translated to me. 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 this form.

_____

Name of Subject/Participant

_____ _____

Signature of Participant Date

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _____. She was 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 B

Perceptual Fatigue Questionnaire

	5	4	3	2	1	Record Score
Fatigue	Very fresh	Fresh	Normal	More tired than normal	Always tired	
Sleep Quality	Very restful	Good	Difficulty falling asleep	Restless sleep	Insomnia	
General Muscle Soreness	Feeling great	Feeling good	Normal	Increase in soreness/ tightness	Very sore	
Stress Levels	Very relaxed	Relaxed	Normal	Feeling stressed	Highly stressed	
Mood	Very positive mood	A generally good mood	Less interested in others &/or activities than usual	Snappiness at teammates, family and co-workers	Highly annoyed/ irritable/ down	

(Mclean *et al.*, 2010)

APPENDIX C

RESTQ-76 Sport Questionnaire

R E S T Q - 76 Sport

Single Code: _____ Group Code: _____

Name (Last): _____ **(First):** _____

Date: _____ Time: _____ Age: _____ Gender: _____

Sport/Event(s): _____

This questionnaire consists of a series of statements. These statements possibly describe your mental, emotional, or physical well-being or your activities during the past few days and nights.

Please select the answer that most accurately reflects your thoughts and activities. Indicate how often each statement was right in your case in the past days.

The statements related to performance should refer to performance during competition as well as during practice.

For each statement there are seven possible answers.

Please make your selection by marking the number corresponding to the appropriate answer.

Example:

In the past (3) days/nights

... I read a newspaper

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

In this example, the number 5 is marked. This means that you read a newspaper very often in the past three days.

Please do not leave any statements blank.

If you are unsure which answer to choose, select the one that most closely applies to you.

Please turn the page and respond to the statements in order without interruption.

In the past (3) days/nights

1) ... *I watched TV*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

2) ... *I did not get enough sleep*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

3) ... *I finished important tasks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

4) ... *I was unable to concentrate well*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

5) ... *everything bothered me*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

6) ... *I laughed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

7) ... *I felt physically bad*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

8) ... *I was in a bad mood*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

9) ... *I felt physically relaxed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

10) ... *I was in good spirits*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

11) ... *I had difficulties in concentrating*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

12) ... *I worried about unresolved problems*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

C.2 From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics.

In the past (3) days/nights

13) ... *I felt at ease*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

14) ... *I had a good time with friends*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

15) ... *I had a headache*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

16) ... *I was tired from work*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

17) ... *I was successful in what I did*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

18) ... *I couldn't switch my mind off*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

19) ... *I fell asleep satisfied and relaxed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

20) ... *I felt uncomfortable*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

21) ... *I was annoyed by others*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

22) ... *I felt down*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

23) ... *I visited some close friends*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

24) ... *I felt depressed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics.

In the past (3) days/nights

25) ... *I was dead tired after work*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

26) ... *other people got on my nerves*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

27) ... *I had a satisfying sleep*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

28) ... *I felt anxious or inhibited*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

29) ... *I felt physically fit*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

30) ... *I was fed up with everything*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

31) ... *I was lethargic*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

32) ... *I felt I had to perform well in front of others*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

33) ... *I had fun*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

34) ... *I was in a good mood*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

35) ... *I was overtired*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

36) ... *I slept restlessly*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

C.4 From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics.

In the past (3) days/nights

37) ... *I was annoyed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

38) ... *I felt as if I could get everything done*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

39) ... *I was upset*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

40) ... *I put off making decisions*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

41) ... *I made important decisions*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

42) ... *I felt physically exhausted*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

43) ... *I felt happy*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

44) ... *I felt under pressure*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

45) ... *everything was too much for me*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

46) ... *my sleep was interrupted easily*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	alwayss

47) ... *I felt content*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

48) ... *I was angry with someone*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

In the past (3) days/nights

49) ... *I had some good ideas*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

50) ... *parts of my body were aching*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

51) ... *I could not get rest during the breaks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

52) ... *I was convinced I could achieve my set goals during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

53) ... *I recovered well physically*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

54) ... *I felt burned out by my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

55) ... *I accomplished many worthwhile things in my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

56) ... *I prepared myself mentally for performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

57) ... *my muscles felt stiff or tense during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

58) ... *I had the impression there were too few breaks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

59) ... *I was convinced that I could achieve my performance at any time*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

60) ... *I dealt very effectively with my teammates' problems*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

C.6 From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics.

In the past (3) days/nights

61) ... *I was in a good condition physically*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

62) ... *I pushed myself during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

63) ... *I felt emotionally drained from performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

64) ... *I had muscle pain after performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

65) ... *I was convinced that I performed well*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

66) ... *too much was demanded of me during the breaks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

67) ... *I psyched myself up before performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

68) ... *I felt that I wanted to quit my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

69) ... *I felt very energetic*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

70) ... *I easily understood how my teammates felt about things*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

71) ... *I was convinced that I had trained well*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

72) ... *the breaks were not at the right times*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics. C.7

In the past (3) days/nights

73) ... *I felt vulnerable to injuries*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

74) ... *I set definite goals for myself during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

75) ... *my body felt strong*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

76) ... *I felt frustrated by my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

77) ... *I dealt with emotional problems in my sport very calmly*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

Thank you very much!

C.8 From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics.

APPENDIX D

Correlation table

	Variable 1	Variable 2	Spearman	Spearman p-val	# cases	Phase
	HIMS score	Fatigue	0.18	0.52	15	Pre-Competition
	HIMS score	Sleep Quality	0.40	0.14	15	Pre-Competition
Perceptual Fatigue	HIMS score	General Muscle Soreness	0.28	0.31	15	Pre-Competition
	HIMS score	Stress Levels	-0.03	0.92	15	Pre-Competition
	HIMS score	Mood	-0.01	0.97	15	Pre-Competition
	HIMS score	Fatigue	-0.08	0.78	15	Competition 1st
	HIMS score	Sleep Quality	0.26	0.35	15	Competition 1st
Perceptual Fatigue	HIMS score	General Muscle Soreness	0.07	0.82	15	Competition 1st
	HIMS score	Stress Levels	-0.29	0.30	15	Competition 1st
	HIMS score	Mood	-0.10	0.73	15	Competition 1st
	HIMS score	General Stress	-0.24	0.39	15	Competition 1st
	HIMS score	Emotional Stress	-0.23	0.41	15	Competition 1st
	HIMS score	Social Stress	-0.29	0.29	15	Competition 1st
	HIMS score	Conflicts/pressure	-0.38	0.17	15	Competition 1st
	HIMS score	**Fatigue**	**-0.44**	**0.10****	**15**	**Competition 1st**
	HIMS score	Lack of energy	-0.31	0.26	15	Competition 1st
	HIMS score	**Physical Complaints**	**-0.57**	**0.03***	**15**	**Competition 1st**
	HIMS score	Success	-0.03	0.90	15	Competition 1st
	HIMS score	Social Recovery	0.28	0.32	15	Competition 1st
	HIMS score	**Physical Recovery**	**0.54**	**0.04***	**15**	**Competition 1st**
RESTQ	HIMS score	General Well-Being	0.29	0.29	15	Competition 1st
	HIMS score	Sleep Quality	0.27	0.33	15	Competition 1st
	HIMS score	Disturbed Breaks	-0.17	0.55	15	Competition 1st
	HIMS score	Emotional Exhaustion	-0.22	0.43	15	Competition 1st
	HIMS score	Injury	-0.10	0.72	15	Competition 1st
	HIMS score	**Being in Shape**	**0.67**	**<0.01***	**15**	**Competition 1st**
	HIMS score	Personal Accomplishment	0.04	0.89	15	Competition 1st
	HIMS score	Self-Efficacy	0.34	0.22	15	Competition 1st
	HIMS score	Self-Regulation	0.24	0.39	15	Competition 1st
	HIMS score	Total Stress	-0.28	0.32	15	Competition 1st
	HIMS score	**Total Recovery**	**0.47**	**0.08****	**15**	**Competition 1st**
	HIMS score	Fatigue	0.21	0.69	6	USSA Preparation
	HIMS score	Sleep Quality	0.29	0.58	6	USSA Preparation
Perceptual Fatigue	HIMS score	General Muscle Soreness	0.00	1.00	6	USSA Preparation
	HIMS score	Stress Levels	-0.03	0.95	6	USSA Preparation

	HIMS score	Mood	-0.13	0.80	6	USSA Preparation
	HIMS score	General Stress	-0.14	0.76	7	USSA Preparation
	HIMS score	Emotional Stress	-0.57	0.20	7	USSA Preparation
	HIMS score	Social Stress	-0.07	0.91	7	USSA Preparation
	HIMS score	Conflicts/pressure	-0.04	0.96	7	USSA Preparation
	HIMS score	Fatigue	0.04	0.96	7	USSA Preparation
	HIMS score	Lack of energy	-0.07	0.91	7	USSA Preparation
	HIMS score	Physical Complaints	-0.11	0.84	7	USSA Preparation
	HIMS score	Success	0.39	0.40	7	USSA Preparation
	HIMS score	Social Recovery	0.32	0.50	7	USSA Preparation
	HIMS score	Physical Recovery	0.00	1.00	7	USSA Preparation
	HIMS score	General Well-Being	0.46	0.30	7	USSA Preparation
	HIMS score	Sleep Quality	0.46	0.30	7	USSA Preparation
	HIMS score	Disturbed Breaks	0.20	0.67	7	USSA Preparation
	HIMS score	Emotional Exhaustion	0.07	0.88	7	USSA Preparation
	HIMS score	Injury	-0.43	0.35	7	USSA Preparation
RESTQ	HIMS score	Being in Shape	0.04	0.96	7	USSA Preparation
	HIMS score	**Personal Accomplishment**	**0.71**	**0.09****	**7**	**USSA Preparation**
	HIMS score	Self-Efficacy	-0.04	0.96	7	USSA Preparation
	HIMS score	Self-Regulation	0.44	0.32	7	USSA Preparation
	HIMS score	Total Stress	-0.04	0.96	7	USSA Preparation
	HIMS score	Total Recovery	0.29	0.56	7	USSA Preparation
	HIMS score	General Stress	-0.41	0.24	10	Competition 2nd
	HIMS score	Emotional Stress	0.26	0.48	10	Competition 2nd
	HIMS score	Social Stress	-0.00	0.99	10	Competition 2nd
	HIMS score	Conflicts/pressure	-0.42	0.22	10	Competition 2nd
	HIMS score	Fatigue	-0.07	0.85	10	Competition 2nd
	HIMS score	Lack of energy	-0.12	0.74	10	Competition 2nd
	HIMS score	Physical Complaints	0.20	0.57	10	Competition 2nd
	HIMS score	Success	-0.02	0.96	10	Competition 2nd
	HIMS score	Social Recovery	0.37	0.29	10	Competition 2nd
RESTQ	HIMS score	Physical Recovery	0.19	0.60	10	Competition 2nd
	HIMS score	**General Well-Being**	**0.57**	**0.09****	**10**	**Competition 2nd**
	HIMS score	Sleep Quality	0.36	0.31	10	Competition 2nd
	HIMS score	**Disturbed Breaks**	**-0.55**	**0.10****	**10**	**Competition 2nd**
	HIMS score	Emotional Exhaustion	-0.34	0.33	10	Competition 2nd
	HIMS score	Injury	0.37	0.29	10	Competition 2nd
	HIMS score	Being in Shape	0.29	0.41	10	Competition 2nd
	HIMS score	Personal Accomplishment	0.26	0.48	10	Competition 2nd

	HIMS score	Self-Efficacy	0.05	0.89	10	Competition 2nd
	HIMS score	Self-Regulation	0.43	0.22	10	Competition 2nd
	HIMS score	Total Stress	-0.39	0.27	10	Competition 2nd
	HIMS score	Total Recovery	0.43	0.21	10	Competition 2nd

***p < 0.05; **p < 0.1**

APPENDIX E

Scales of the Recovery-Stress Questionnaire for Athletes

Scale	Scale Summary
1	**General Stress** Subjects with high values describe themselves as being frequently mentally stressed, depressed, unbalanced, and listless.
2	**Emotional Stress** Subjects with high values experience frequent irritation, aggression, anxiety, and inhibition.
3	**Social Stress** High values match subjects with frequent arguments, fights, irritation concerning others, general upset, and lack of humor.
4	**Conflicts/Pressure** High values are reached if in the preceding few days conflicts were unsettled, unpleasant things had to be done, goals could not be reached, and certain thoughts could not be dismissed.
5	**Fatigue** Time pressure in job, training, school, and life, being constantly disturbed during important work, overfatigue, and lack of sleep characterize this area of stress.
6	**Lack of Energy** This scale matches ineffective work behavior like inablity to concentrate and lack of energy and decision making.
7	**Physical Complaints** Physical indisposition and physical complaints related to the whole body are characterized by this scale.
8	**Success** Success, pleasure at work, and creativity during the past few days are assessed in this area.
9	**Social Recovery** High values are shown by athletes who have frequent pleasurable social contacts and change combined with relaxation and amusement.
10	**Physical Recovery** Physical recovery, physical well-being, and fitness are characterized in this area.
11	**General Well-Being** Besides frequent good moods and high well-being, general relaxation and contentment are also in this scale.
12	**Sleep Quality** Enough recovering sleep, an absence of sleeping disorders while falling asleep, and sleeping through the night characterize recovery sleep.

Scale	Scale Summary
13	**Disturbed Breaks** This scale deals with recovery deficits, interrupted recovery, and situational aspects that get in the way during periods of rest (e.g., teammates, coaches).
14	**Burnout/Emotional Exhaustion** High scores are shown by athletes who feel burned out and want to quit their sport.
15	**Fitness/Injury** High scores signal an acute injury or vulnerability to injuries.
16	**Fitness/Being in Shape** Athletes with high scores describe themselves as fit, physcially efficient, and vital.
17	**Burnout/Personal Accomplishment** High scores are reached by athletes who feel integrated in their team, communicate well with their teammates, and enjoy their sport.
18	**Self-Efficacy** This scale is characterized by how convinced the athlete is that he/she has trained well and is optimally prepared.
19	**Self-Regulation** The use of mental skills for athletes to prepare, push, motivate, and set goals for themselves are assessed by this scale.