Nutritional recovery practices of team sport athletes training at Nelson Mandela Metropolitan University, South Africa

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Thesis presented in partial fulfilment of the requirement for the degree of Masters of Nutrition at the University of Stellenbosch

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Declaration

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Date: 1 Augustus 2015

ABSTRACT

Aim: To determine nutritional recovery practices of team sport athletes training at Nelson Mandela Metropolitan University (NMMU), South Africa

Objectives: i) To determine timing and macronutrient composition of recovery meals ii) to determine factors driving recovery food choices, iii) to identify sources of recovery nutrition information iv) to compare data to current literature recommendations for optimal recovery, and v) to compare athletes in terms of gender and sport code.

Design: A cross-sectional study design with an analytical component.

Setting: NMMU, Eastern Cape, South Africa

Subjects: Qualifying students had to be 18 years of age or older, competent in English and part of a registered NMMU hockey (n=29), netball (n=26), or rugby (n=31) team.

Methods: A multiple choice questionnaire was used to identify sources of recovery nutrition information and factors influencing choices. 24-Hour diet recalls were analysed to establish timing and macronutrient composition of recovery meals.

Results: Eighty-six athletes including both females (53%, n=46) and males (47%, n=40); rugby (36%, n=31), netball (30%, n=26) and hockey (34%, n=29) voluntarily participated. Ninety-one percent (n=78) were between the ages of 19 and 24. Most athletes (86%, n=74) prepared their own recovery meals. Seventy-four athletes completed 24-hour diet recalls. Average daily macronutrient composition of all groups: fat (33 ± 8.7) percent of total energy, total protein (g/kg body weight (BW)/day) (1.49 ± 0.81); total carbohydrate (g/kg BW/day) (2.57 ±1.17). Eighty-eight percent (n=65) had a recovery meal after exercise. The average time lapse between exercise and the recovery meal was (40.5 ±28.27) minutes; with post-exercise carbohydrate intake (g/kg BW) (0.52 ±0.42) and post-exercise protein intake (g) (29.96 ±18.76). The most important factors driving recovery food choices were: *nutritional composition* (35%, n=30), *easy to prepare* (34%, n=29) and *it must fill them up* (13%, n=11). Sports nutrition advice came mainly from coaches (35%, n=30), family and friends (24%, n=21). Average daily carbohydrate intake (all groups) of 2.57g/kg/day (±1.17) was significantly below recommended literature values (5-7g/kg/day) (p=0.00). Daily protein intake (all groups) of 1.5g/kg/day (±0.81) met literature guidelines (1.2-1.7g/kg/day). The average fat intake (all groups) of 34% (±8.7) of total energy was within guidelines 20-35% of total energy. An average time delay of 40.5 minutes (±28.3) was significantly ($p=0.004$) above literature recommendation (< 30 minutes after exercise). All groups failed to meet recovery carbohydrate intake post-exercise 0.52g/kg BW (± 0.42; $p=0.00$), with rugby players (0.35g/kg BW ±0.33; $p=0.00$) and males (0.34g/kg BW ±0.32; $p=0.00$) having the least recovery carbohydrates. Protein needs post-exercise (20-25g) was met (all groups) 29.96g (±18.75). Daily protein intake for male athletes (1.95g/kg BW ± 0.85; $p=0.00$) and rugby players' (2.03g/kg BW ± 0.92; $p=0.00$) were significantly above literature recommendations (1.2-1.7g/kg BW), compared to female athletes (1.15 ±0.58; $p=0.61$) and netball players (1.00 ±0.58; $p=0.12$) where no statistical significance was found. Females had a significant time delay between exercise and the recovery meal of 50.12 minutes (± 31.02; $p=0.00$) compared to male athletes consuming recovery meal at 28.52 minutes (±18.9; $p=0.67$) after exercise. Netball players were found delaying recovery meal the most, with 59.64 minutes (±27.15; $p=0.00$) compared to hockey (33 minutes ± 30.01; $p=0.64$) and rugby players (29.88 minutes ±19.03; $p=0.97$) meeting recommendations.

Conclusion: All participating athletes significantly failed to meet recommended recovery and daily carbohydrate intake for team sport athletes, with emphasis on protein consumption; males consuming significantly more than recommendations. The significant time delay found between exercise and the recovery meal could negatively impact performance when recovery time is short. Lack of knowledge in the basics of recovery nutrition and general misconceptions in the field of nutrition as well as time constraints and tight budgets are the most likely factors influencing recovery food choices. Coaches, family, and friends as educators should be included as part of nutritional education programmes.

OPSOMMING

Doel: om voedings herstelpraktyke van spansport atlete by die Nelson Mandela Metroplitaanse Universiteit (NMMU) te bepaal.

Doelwitte: i) om die tydsberekening, sowel as die makronutrient samestelling van die herstelmaaltyd te bepaal ii) om faktore te identifiseer wat herstelvoeding keuses beïnvloed, iii) om bronne te identifiseer wat atlete gebruik as herstelvoedings riglyne, iv) om data te vergelyk met literatuur aanbevelings, en v) om verskille in geslag en sport modaliteite rakende die bogenoemde aspekte te indentifiseer.

Studie ontwerp: ‘n Dwarssnit studie met ‘n analitiese komponent.

Omgewing: NMMU, Oos-Kaap, Suid-Afrika.

Studiepopulasie: Alle atlete, Engelsvaardig, 18 jaar of ouer en deel van ‘n geregistreerde hokkie- (n=29), netball- (n=26), of rugbyspan (n=31), van NMMU is ingesluit.

Metode: ‘n Multikeuse-vraelys is gebruik om faktore te bepaal wat keuses van die herstelmaaltyd beïnvloed, sowel as bronne van sportvoedingsinligting te identifiseer. 24-uur-herroep-rekords is ontleed deur middel van FoodFinder III vir makronutrient samestelling, sowel as die tydeverloop tussen oefening en herstelmaaltyd.

Resultate: Ses-en-tagtig atlete, insluitend vroue (53%, n=46) en (47%, n=40) mans het vrywillig deelgeneem; rugby- (36%, n=31), netball- (30%, n=26) en hokkiespelers (34%, n=29). Meeste van hierdie atlete (86%, n=74) berei hul eie herstelmaaltye voor. Vier-en-sewentig atlete het 24-uur dieetrekords voltooi. Gemiddelde daaglikese makronutrient samestelling vir alle groepe was: vet (33 ± 8.7), totale proteïne (g/kg liggaamsmass (LM/dag) (1.49 ± 0.81) en koolhidraat (g/kg liggaamsmassa (LM/dag) (1.49 ± 0.81). Ag-en-tagtig persent (n=65) het ‘n herstelmaaltyd geneem na oefening. Die gemiddelde tydsverloop tussen oefening en die herstelmaaltyd was (40.5 ±28.27) minute; koolhidraat-inname na oefening was (g/kg LM) (0.52 ± 0.42 en protein-inname (g) (29.96 ± 18.76). Die belangrikste faktore wat die keuse van die herstelmaaltyd beïnvloed was: *nutrient samestelling* (35%, n=30); *maklik om voorteberei* (34%, n=29); en dit *moet hul versadig laat* (13%, n=11). Meeste sportvoedingsadvies kom van afrigters (35%, n=30), of familie en vriende (24%, n=21). Die gemiddelde daaglikse koolhidraat-inname vir alle groepe was: 2.57g/kg LM/dag (±1.17), en is beduidend minder as die literatuuraanbeveling (5-7g/kg/dag) (p=0.00). Daaglikse protein-

inname vir alle groepe was 1.5g/kg LM/dag (±0.81) en voldoen aan die literatuuraanveling (1.2-1.7g/kg/dag). Gemiddelde vet inname vir alle groepe was 34% (±8.7) van totale energie en was binne literatuuraanbeveling van (20-35% TE). Gemiddelde tydsverloop tussen oefening en herstelvoeding van 40.5 minute (±28.3) is beduidend (p=0.004) langer as literatuuraanbeveling (<30 minutes). Geen groep het daarin geslaag om voldoende koolhidraat na oefening inteneem nie. Die gemiddelde inname vir alle groepe was 0.52g/kg LM (± 0.42g/kg LM; p=0.00), met rugby spelers (0.35g/kg LM ±0.33; p=0.00) en mans atlete (0.34g/kg LM ±0.32g/kg LM; p=0.00) wat die minste koolhidraat inneem na oefening. Alle atlete het wel aan die proteinaanbeveling na oefening (20-25g) voldoen met 'n gemiddelde inname van 29.96g (±18.75) vir alle groepe. Mans atlete (1.95g/kg/ LM ± 0.85; p=0.00) en rugbyspelers (2.03g/kg LM ± 0.92; p=0.00) se daaglikse protein-inname was beduidend meer as literatuuraanbeveling (1.2-1.7g/kg LM) in vergelyke met vroue atlete (1.15g/kg LM ±0.58; p=0.61) en netbalspeelsters (1.00g/kg LM ±0.58; p=0.12) waar geen beduidende verskil gevind is tussen inname en literatuuraanbevelings nie. Vroue neem beduidend langer as literatuuraanbeveling voor hul 'n herstelmaaltyd neem na oefening, gemiddeld 50.12 minute (± 31.02; p=0.00) in vergelyke met mans atlete wat herstelmaaltyd neem gemiddeld 28.52 minute (±18.9; p=0.67) na oefening. Die langste vertraging na oefening voordat herstelmaaltyd geneem is, was onder die netbalspeelsters waar herstelmaaltyd eers na.64 minute (±27.15; p=0.00) geneem is in vergelyke met hokkie spelers (33 minutes ± 30.01; p=0.64) en rugby spelers (29.88 minute ±19.03; p=0.97) wat wel aan literatuur behoeftes voldoen.

Gevolgtrekking: Geen deelnemende atletes het daar in geslaag om voldoende herstel- sowel as daaglikse koolhidraate in te neem volgens literatuur aanbeveel word nie. Klem was gelê op proteïn inname, met mans wat beduidend meer per dag en as deel van die herstelmaaltyd inneem. Die lang tydsverloop na oefening voordat 'n herstelmaaltyd ingeeeem word kan spel negatief beïnvloed veral waar hersteltyd tussen oefening beperk is. 'n Tekort aan basiese inligting relevant tot herstelvoeding, sowel as tyd, en die koste van maaltye, was die mees algemeenste faktore wat die keuse van die herstelmaaltyd beïnvloed. Afrigters, familie, en vriende behoort ingesluit te word by herstelvoeding onderrigprogramme.

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Contributions by the principle researcher and fellow researchers

The principle researcher, M.A. Malherbe developed the idea and the protocol. The principle researcher planned the study, undertook all data collection, captured the data for analysis, analysed the data with the assistance of a statistician, Prof. D.G. Nel, interpreted the data and drafted the thesis. Dr. S. Potgieter and Dr. R.E. Venter provided input at all stages and revised the protocol and thesis.

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CHAPTER ONE

BACKGROUND AND MOTIVATION FOR THE STUDY

1.1 Introduction

The link between athletic performance and nutrition is well established in scientific literature and optimal nutrition is widely accepted as one of the means to enhance exercise performance and recovery from exhaustive exercise.[1,2] Refuelling and rehydration are fundamental goals of recovery between training sessions and competitive events and becomes even more important for the athlete competing in multiple workouts within a short period of time.[3] The following aspects will be covered in more detail through the literature review to provide more insight around the actual topic of exercise recovery.

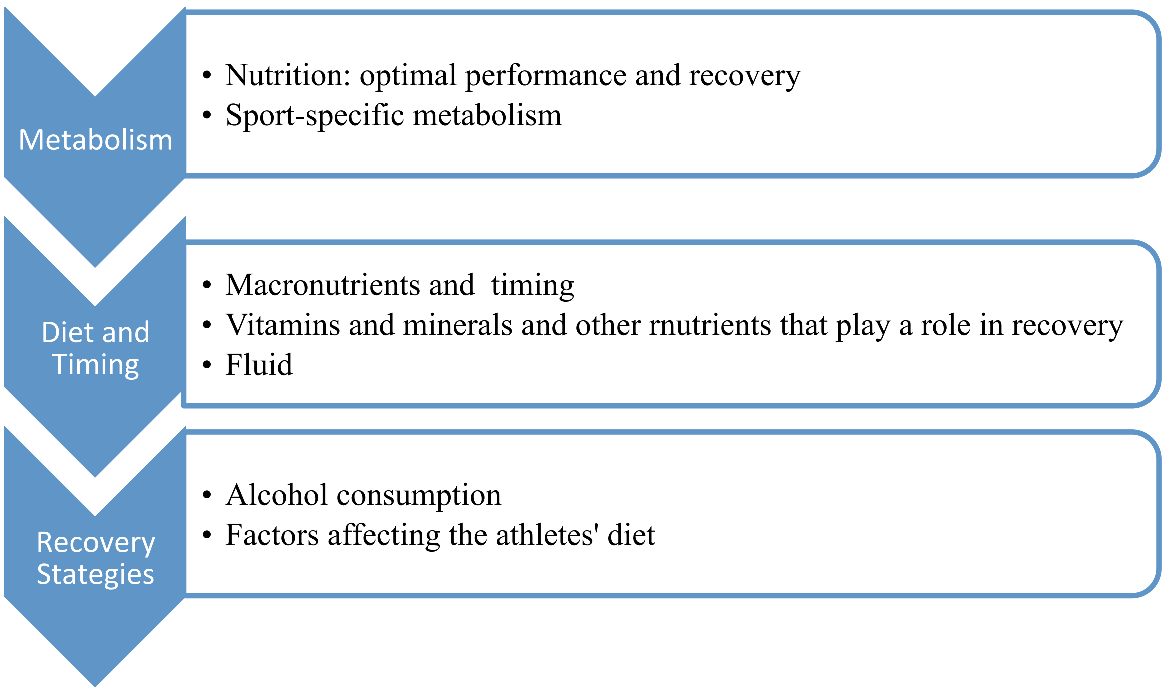

Figure 1: A flow diagram to illustrate aspects of recovery discussed in literature review

1.2 Motivation

As will be discussed in the theoretical background of this study below, the importance of nutrition as a functional element of athletic training is clear. Guidelines based on sound scientific evidence with regards to the quality, the structure and the timing of food intake are vital to ensure that athletes train more effectively, enhance their competitive performance, induce metabolic adaptations to training and reduce the risk of injury and illness.[4]

Previous research done at Stellenbosch University by Venter, Potgieter and Barnard, published in 2010, identified different recovery strategies used by elite South African team sport athletes to promote optimal recovery between steep training and competition schedules. Results from this study indicated that recovery modalities varied amongst the four sports codes (hockey, netball, rugby and soccer) that was investigated as well as between different levels of competition.[21] The purpose of the current study that took place at NMMU, was to review and assess the nutritional knowledge and practices of team sport athletes participating in similar team sports such as rugby, netball and hockey. The researcher wanted to identify what factors influence these university team sports athletes' recovery food choices, where they get their nutritional information from and how their practices compare with current literature recommendations, as a component of the athlete's complete recovery plan.

Hinton et al., 2004, published a study in which the authors examined the nutritional intake of college athletes from various sports and found that less than a third of the student athletes met the dietary requirement for athletes with regards to carbohydrate and protein intake. The researchers also found sixty-two percent of the female college athletes expressing concern with regards to weight and societal pressures, wanted to lose weight, which was associated with reduced energy and macronutrient intake.[5,6] Clarke and Reed (2003) studied the nutritional intake of a female group of college soccer players and found similar results of insufficient intake of carbohydrates as well as suboptimal intake of some micronutrients such as vitamin E, folate, copper and magnesium.[7] Gibson (2011) found similar results in Canada when a younger group of adolescent team sport athletes failed to meet daily energy and carbohydrate recommendations. He also identified decreased iron and vitamin D status and concluded that this suboptimal intake of macro-and micronutrients could negatively affect athletes' soccer performance, growth and development. College going athletes express a healthy attitude and interest in nutrition, however encounter numerous barriers possibly hindering optimal intake, not only limited to nutritional knowledge. Factors such as rigorous academic schedules, budget constraints, training and travelling schedules, peer pressures and limited skills with regards to the planning and cooking of meals all possibly affect the student athletes nutritional intake.[8] Further research was recommended to better understand the specific needs of college going athletes, leading to more sport specific and age appropriate nutritional intervention programmes.[8,9,10] A study done by Ruiz et al (2005) in a group of soccer players of various ages ranging from adolescent to adult players, also found suboptimal intake in total daily energy and carbohydrate intake, with intakes of these nutrients progressively worsening with age. Ruiz et al. stressed the importance of early intervention of nutritional education, to be continued throughout the athletes' careers, ensuring better performance outcomes as well as promoting healthy eating practices in general.[11]

The study population chosen for this study that took place at NMMU is a unique group. Being all university students this group would typically be young adults, under the influence of peers with regards to social interactions, the use of alcohol, fast foods and supplements use, appearances, time pressures and academic stress, and have typical tight student budgets. This study looked at factors affecting and influencing these unique student athletes' recovery food choices, and the factors driving their choices.[12] Athletes access various sources to obtain sports nutrition advice including coaches, massage therapists, physiotherapists, sport scientists, medical doctors, dietitians as well as via tertiary education programmes, books, magazines, social media and the internet. With this study, the researcher also strived to identify the most common sources where athletes seek sports nutrition advice from to ultimately improve the quality of information available through these channels of communication.[13]

Results from this study will assist coaches, sports manager and health care professionals working with student team sport athletes, to identify focus areas in nutrition. Dietary advice to student athletes can then be tailored to facilitate faster recovery times, better physiological adaptation to exercise and better health in general.[14]

The study was cross-sectional with an analytical component. It reports on the knowledge and application of nutritional recovery strategies, used by field based team sport rugby, netball and hockey athletes training at Nelson Mandela Metropolitan University, July-November 2014 as well as the factors that influenced their choices.

1.3 Aims of the investigation

The primary aim of this study was to determine the nutritional recovery strategies used by field based team sport athletes participating in hockey, netball and rugby training at the Nelson Mandela Metropolitan University, South Africa during July-November 2014, as well as the factors that drive their recovery nutrition choices and where they source their recovery nutrition information from. The secondary aim of this study was to compare dietary intake of macronutrients and the timing of the recovery meal with current literature on recovery nutrition for team sports.

1.4 Objectives

The objectives of the study were to:

1. Determine the timing, energy and macronutrient composition of the current nutritional recovery strategies used by team sport athletes at NMMU by means of 24-hour recalls.
2. Determine factors influencing recovery strategies used by this group.
3. Assess where these athletes get nutritional information from.
4. Statistically compare the timing and macronutrient intake of the recovery meal applied by these athletes to current literature recommendations for optimal nutritional recovery.
5. Compare athletes in terms of gender differences, as well as according to sport code with regard to the above mentioned aspects.

1.5 Outline of the thesis

Current literature relating to recovery nutrition will be presented in chapter two. The research methodology used in the study will be described in chapter three. Chapter four is a draft manuscript that will be submitted for possible publication in the International Journal of Sport Nutrition and Exercise Metabolism and summarizes the results found by the researcher. Final conclusions and recommendations are made in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 The role of nutrition in optimal performance and recovery

Low health literacy is associated with poor health outcomes.[15] Good nutrition assist the athlete in the ability to train and compete intensely, adopting an active lifestyle of adequate nutrition, sufficient rest, and achieving performance results whilst avoiding injury.[16] Team sport athletes are ofthen required to partake in moderate to high intensity training or competition sessions within 8-24 hours recovery time between sessions.[17]

Recovery nutrition involve the restoration of muscle and liver glycogen stores, resynthesis, repair and adaptation of muscle tissue post-exercise and the replacement of fluid and electrolytes that may improve endurance capacity and performance during subsequent exercise sessions.[17] A well balanced diet and exercise programme, proper timing of nutrient intake, sufficient rest and recovery as part of the athletes' programme are vital to these processes.[18,19,20] Adequate carbohydrates, protein, fat and micronutrients should be derived from a wide variety of available foods and without a nutritional recovery plan which will help the athletes to plan ahead, they might find this difficult, especially when they are tired and pushed for time.[4]

Previously published research by Lambert and Borreson (2006), stated that inadequate recovery "is a training error" and will prevent athletes from reaching their peak performance.[21,22] Contemporary training programmes for power sports involves diverse routines, placing a wide array of physiological demands on these athletes.[23] Competition schedules are extremely demanding with little recovery time for professional athletes participating in club and provincial games. Frequent high intensity training sessions are common for the elite power sport athlete most of the seasons and nutritional intake should be adequate to support both recovery and adaptation. Habitual food intake to recovery over a period of time proved to no longer be adequate with the physical demands placed on professional athletes.[18,23,24] Low muscle glycogen levels pre-exercise reduces high intensity performance and strategies to ensure optimal intake of recovery nutrients such as carbohydrate and protein post-exercise is vital. Stellingwerff and Maughan (2011) suggest that the timing, type and amount of protein post-exercise strongly influence recovery and adaptation, especially when a) athletes are training more than once a day, (b) when athletes train in the evening and typically again early the next morning, and (c) when athletes are unable to consume a high carbohydrate diet over the twenty-four hours following a high intensity workout.[23,25] This requires a multi-faceted, often aggressive, nutritional recovery strategy plan to support both the health and general training needs of the athletes, tailored according to specific training phases as well as meeting the acute demands of skill and cognitive alertness during times of competition.[23,26,27,28]

Athletes often look for quick fixes to support their busy training and competition schedules which could potentially lead to an over reliance on non-scientifically supported performance enhancing supplements with very few supplements matching the extravagant health and performance claims often made.[19,28,29] Supplement use cannot compensate for poor food choices and an inadequate diet. Although some athletes may derive great benefit from certain supplements, such as creatine monohydrate, the risk of a positive doping test versus the essence of a balanced diet and strategically planned meals and snacks to support recovery and performance, far outweighs the risk of supplement use in the competitive athlete.[19,29] Education with regards to the efficacy and safety of sports supplements should form part of any nutritional advisory programme.

2.2 Sport-specific metabolism

Team sports, classified as either field- (rugby and soccer) or court sport (netball), can be described as intermittent, high intensity exercise.[1,26]

There are many different components to power sport athletes' training programmes, for example skills training, endurance training and resistance-training. Together these components ensure efficient metabolic adaptation to exercise and athletes maintaining the best power to weight ratio for their sport.[16]

2.2.1 Metabolic adaptations to exercise

Regular aerobic and resistance exercise result in physiological changes in the cardiovascular, respiratory, endocrine and immune systems in the body and significant metabolic adaptations in skeletal muscle. Myoglobin, the oxygen binding protein, increases with regular exercise, increasing oxygen availability in muscle fibres. An increase in capillaries increases the blood flow to and from muscle, increasing the oxidative capacity of trained muscles. Both the number and the size of mitochondria are increased, along with an increase in the oxidative enzymes, making energy needed for working muscle more efficient. The capacity to store glycogen is also greatly increased in the endurance trained athlete. Muscle protein lipoprotein lipase activity is increased and as a result the ability of trained muscles to use fat as an energy source is also improved. The endurance trained athlete's muscles thus have an enhanced ability to utilize triglycerides as fuel source for local lipolysis in the capillary bed of the working muscle. These metabolic changes assist the trained athlete to perform at higher rates of work than the untrained individual. The level to which these changes occur is individualized and may be due to genetic factors and the initial level of fitness.[77,78,34]

2.2.2 Energy Systems

Maughan (2003) highlighted, that most team sports e.g. hockey, netball and rugby, require a certain level of skill to be maintained throughout a match. Fatigue in these athletes will hinder optimal performance by limiting well executed movements, increase the likelihood of mistakes made by the players and also putting them at greater risk of sports injuries towards the end of their game.[30,31] The availability of carbohydrates to working muscles is critical for optimal muscle contraction.[32]

Adenosine triphosphate (ATP) is the high energy compound found in cells and used as fuel. The body has limited capacity for storage of ATP, so it must be generated quickly during exercise, especially during high intensity exercise. Only a limited amount of energy can be produced quickly without the need for oxygen. The average amount of glycogen stored in the body's muscles is 300-400g, with exceptions for untrained individuals where the volume of glycogen storage could possibly be less and in the highly trained individual, possibly more.[30] These carbohydrate stores of the body can be depleted during a single exercise session.[32]

Literature reviewed by Barker et al (2010) suggests that almost all sports derive energy from both the non-oxygen dependent as well as the oxygen dependent energy systems. Each energy system is designed to provide optimal energy for a specific type of exercise.[33] When exercise intensity is low and at steady pace, ATP can be adequately produced aerobically from the oxidation of fat and carbohydrates.[30] This aerobic metabolic process thus has the ability to provide energy more slowly over long durations, provided there is sufficient substrate or fuel and also sufficient oxygen delivery to the cells.[34]

As exercise intensity increases, athletes will end up needing a level of ATP that cannot be supplied sufficiently through the aerobic oxidation of fat and carbohydrates alone.[30] In very high intensity activities where the intensity exceeds the capacity to supply sufficient oxygen to meet energy demands, the non-oxygen dependent glycolysis system becomes the major pathway for ATP production.[23] Carbohydrate is the main fuel source for exercise intensities above 75% VO_2 max. Sports that require a high level of power as well as speed over short distances have a high anaerobic component. The non-oxygen dependent metabolic pathways is almost entirely dependent on phosphocreatine and glycogen as fuels.[32,34]

Failure in considering the type of activity the athlete partakes in will most certainly lead to suboptimal performance of the individual. The random fluctuation in team sport exercise intensities leads to a unique pattern of energy substrate utilization in sports such as rugby, hockey and netball, and is characterized by continuous changes in intensity, maintaining skill and cognitive alertness for an extended period of time and is relying greatly on the body's fuel stores.[27,28]

Team sports are characterized by bursts of high intensity exercise, followed by periods of rest or lower intensity, typically 'stop-start' activities with no two games alike. This pattern requires energy derived from both the oxygen-dependent energy system as well as the non-oxygen-dependent energy system.[26] Athletes participating in team sports have highly developed metabolic pathways utilizing different combinations of phosphagen, carbohydrate and fat as fuel derived from both oxygen-dependent as well as non-oxygen-dependent metabolic pathways.[23] The non-oxygen-dependent processes are solely reliant on already existing ATP stores, phosphocreatine and muscle glycogen, but the oxygen-dependent processes derive the energy from muscle glycogen, blood glucose, fat and to a lesser extent protein, highlighting carbohydrates as a priority fuel source used in both the oxygen-dependent and non-oxygen-dependent energy systems.[26,34] Protein will be used when other fuel sources are not available but normally accounts for as little as five percent of the total energy needed in exercise lasting two to three hours but plays a vital role inducing adaptations to exercise and is very necessary for muscle hypertrophy post-exercise. The intensity and the duration of the exercise determine to a large extent how much energy is contributed by carbohydrates and how much energy from fat. The greater the intensity of the exercise, the greater the reliance on carbohydrates as fuel source during activity.[30]

Team sports athletes rely heavily on muscle glycogen for the majority of energy during team sport activity, with nearly equal reliance on fat and blood glucose for most of the remaining energy source. Fat, most of the time, is not in short supply. However, the amount of glucose in the blood is small and therefore needs constant awareness by the athlete to ensure a continuous source of glucose is available for the duration of exercise. Dehydration and carbohydrate depletion are the most likely contributors of fatigue in exercise events lasting thirty minutes or longer.[28,35]

Because of the high carbohydrate requirements for these team sport athletes and limited endogenous carbohydrate reserves, it becomes vital that athletes seek to maximize carbohydrate availability to maintain and replenish glycogen stores.[24,26] Findings from a systematic review by Russell and Kingsley (2015) on the nutritional interventions in soccer players, supports the intake of carbohydrate during a game, to resist a loss in skills experienced by soccer players due to fatigue.[31] Aragon and Shoenfeld (2013) reported that protein losses in glycogen depleted athletes are more or less double which would be counterproductive to the team sport power athlete aiming to preserve muscle mass.[36] Ensuring replenishment of glycogen stores after exercise becomes vital in the preparation for the next game as well as muscle repair and inducing adaptations to training such as skeletal muscle hypertrophy.

2.3 Dietary composition: macronutrients

The nutritional requirements of the team sport athlete depends on various factors such as: the number of players, the rules of each sport, the number of substitutions allowed during a game, the duration, intensity and frequency of games, physical requirements, position specific tasks and the level of competition.[19,20,26]

Strenuous physical activities may increase the rate of energy utilization by as much as twenty to hundred times above the expended energy rate at rest and therefore athletes require more energy and macronutrients per kilogram body weight compared to sedentary individuals. When macronutrient intake is sufficient, total energy requirements of the athlete will usually be met.[4,34]

Team sport athletes such as rugby, hockey and netball players require a combination of both power and muscle endurance to sustain optimal performance for the duration of the game. To maintain power and performance, these athletes require rapid and repeated breakdown of glycogen stores to supply the necessary energy. Reductions in glycogen stores have been associated with impaired performance of team sport athletes.[16] Optimizing carbohydrate storage as part of their recovery before the next exercise session is critical for the team sport athlete in achieving and maintaining his or her performance. No gender difference was found by Hausswirth et al (2011) in these athletes' capacity to replenish glycogen stores. The main focus post-exercise remains a combination of carbohydrates and protein intake.[37]

2.3.1 Carbohydrates

Different types of carbohydrates are treated differently by the body. Some mediate an immediate high glycaemic index (GI) response such as glucose, whilst others mediate a slower insulin response. Circulating blood glucose is derived mostly from dietary carbohydrates. The amount of carbohydrate consumed by the athlete is the most important nutrient that affects muscle glycogen storage.[18] Daily carbohydrate intake is essential in any athlete's diet and should be timed and tailored according to training sessions and individual preferences in order to ensure optimal pre-workout nutrition as well as supporting fast and effective recovery post-exercise.[4,20,23]

Glycogen depletion activates glycogen synthase, an enzyme involved in converting glucose to glycogen and the highest rates of muscle glycogen storage occurs within the first hour after exercise. As a result of exercise, muscle cells become more sensitive to insulin with an increased permeability to glucose. Glycogen storage is influenced by the presence of insulin as well as the rapid supply of glucose. Immediate intake of moderate to high glycaemic index carbohydrates (1g/kg BW) immediately after exercise and continued every hour thereafter, aids the rapid resynthesis of muscle glycogen stores over the first four hours of recovery.[18,22,23,38] Early consumption of carbohydrates immediately after exercise could become an important tool for athletes to use where recovery time in between events are limited. Failure to consume carbohydrates immediately after exercise results in very low rates of glycogen replenishment until feeding occurs and is extremely important when the athletes partake in multiple training sessions within an eight to twelve hour period.[18] Under circumstance where athletes train only once a day, carbohydrate rich meals and snacks could be planned in a comfortable and practical way for the athlete.

Low pre-exercise muscle glycogen stores reduces high intensity exercise performed by team sport athlets.[23] Considering the limited storage capacity for carbohydrates in the human body the understanding of how to keep glucose from becoming depleted, should be the focus of any athlete's nutrition practices.[34]

Constantly training in an energy and carbohydrate depleted state may compromise immune function and lead to training staleness and burnout.[23]

The human body can store approximately 350g of carbohydrates in the form of glycogen, an additional 90-100g in the liver and a small amount of glucose circulating consisting of approximately 5g.[34,39] Muscle glycogen and blood glucose are the most important substrates for the contracting muscle. Fatigue during prolonged exercise (>60 minutes) is often associated with muscle glycogen depletion and a reduction in blood glucose concentration.[16,35] Pre-exercise muscle and liver glycogen concentrations and habitual carbohydrate intake is essential and should be timed according to the athletes training sessions to ensure optimal nutrition.[4,35]

The body has systems to maintain circulating blood glucose within a relatively narrow range by using insulin and glucagon hormones produced by the pancreas as modulators working synergistically. Insulin is secreted by beta-cells in the pancreas and glucagon by alpha-cells also of the pancreas. The stimulus for insulin secretion will be high blood glucose. The higher the blood glucose, the higher the amount of insulin secreted. A small amount of insulin however, is constantly secreted, even as blood glucose levels are normal so that a constant flow of glucose is provided to the cells of the brain and muscles.[34] Insulin affects the cell membranes of muscle and fat cells, allowing glucose to enter the cell, providing much needed sources of energy.

With low blood glucose levels between meals or when that occurs during training, the release of glucagon is increased. The lower the blood glucose the greater the release of glucagon production.[34] Glucagon causes catabolism, the breakdown of liver glycogen stores, releasing glucose molecules into the blood circulation. Glucagon might also stimulate gluconeogenesis where glucose are manufactured from non-glucose substances, e.g. more or less 60% of glucose released to sustain blood glucose is derived from liver glycogen stores and the rest synthesized from lactate, pyruvate, glycerol and amino acids.[34,40]

Besides insulin and glucagon there are two more hormones influencing the athlete's blood glucose levels. The first is adrenaline (epinephrine), a stress hormone that initiates extremely rapid breakdown of liver glycogen to quickly increase blood glucose. The second hormone is, cortisol, which is secreted from the adrenal gland, also a stress hormone promoting protein catabolism, making certain amino acids are available for gluconeogenesis. Both these hormones are released as a result of exercise related stress. Controlling adrenaline/epinephrine production helps to preserve liver glycogen and controlling cortisol levels, helps preserve the breakdown of muscle protein.[34]

Carbohydrates provide the majority of fuel for exercise intensities above 75% of VO_2 max, the maximum optimum rate at which the heart, lungs, and muscles can effectively use oxygen during exercise. Carbohydrate stores in the liver and in muscles are limited.[23,38,39] When these stores are depleted and blood sugar levels are low, the central nervous system activity is depressed. This lower central nervous system activity results in lower levels of concentration and increase irritability. Low blood sugar levels may thus be related to mental fatigue in the athlete, which again is related to muscle fatigue. Because of the fact that liver muscle glycogen stores are so easily depleted during exercise, the intake of carbohydrate before, during and after exercise is critical in maintaining performance of both mental and muscle function.[34]

Carbohydrates is a critical fuel source for athletes as the human body can more efficiently produce energy per unit of oxygen from carbohydrate, than from any other fuel. The availability of carbohydrates as substrate for muscles and the central nervous system becomes a limiting factor in performance during prolonged intermittent high intensity exercise sessions (>90 minutes)[38,34]

Unique to team sports is that no two games are the same. Carbohydrate intake during games might be helpful to maintain adequate glucose to fuel the brain for attention and decision-making during these prolonged games.[26]

It is therefore critical for any athlete participating specifically in high intensity activities like our team sport athletes, often performing short burst of sprints, to ensure optimum recovery of glycogen stores before the next event in order to maintain peak performance.

Total daily energy requirements must be met to maintain normal growth and maintenance of tissue, tissue repair and supply of energy for the activity performed by the athlete, after which attention should be given to the macronutrient distribution of the athlete’s diet.

Studies indicated an increase in glycogen storage with increasing carbohydrate intake with a glycogen storage threshold at a daily carbohydrate intake of 7-10g/kg body mass with passive recovery.[18]

Ingestion of carbohydrates after exercise is recommended as soon as practically possible.[24,36] The highest rates of muscle glycogen synthesis occur during the first hour after exercise. This is due to the activation of glycogen synthase as a result of glycogen depletion, as well as the increased permeability of the muscle cell membrane to glucose, together with an as increased insulin sensitivity induced by exercise. Post-exercise carbohydrate intake of 1-1.5g/kg BW, ingested within thirty minutes after exercise will lead to higher glycogen storage levels. When recovery periods between exercise sessions are long, e.g. twenty-four hours or more, the recovery nutrition focus shifts in ensuring the athletes consumes adequate energy and carbohydrate during the following twenty-four hours post-exercise. Under these circumstances, the type of carbohydrates and the timing of the carbohydrate becomes less important and can be chosen according to what is practical and enjoyable for the athlete.[3,4]

Carbohydrate intake becomes more significant when the time between exercise sessions is less than eight hours. An example of this would be when matches are played consecutively or games are played every day during a tournament for a few days in a row. It is then recommended that athletes consume carbohydrates as soon as practical after their workout to effectively maximize recovery time between exercise sessions, ideally within 30 minutes after exercise.[3,4]

Failure to consume carbohydrates in the immediate phase post-exercise, leads to a slow rate of glycogen repletion until feeding occurs. This early intake of carbohydrates becomes even more important when there are only 4-8 hours of recovery in between exercise sessions.[18,24,32]

The food schedule of the athlete needs to be practical and comfortable. Often it is not practical to consume large amounts of carbohydrates (1-1.5g/kg/hr) in a short period of time when recovery times between exercises sessions are short.[32] The combination of carbohydrate and protein during the early recovery phases post-exercise has shown positive results on recovery of muscle glycogen, muscle protein regeneration and subsequent exercise performance. This could be of great importance to athletes who are involved in multiple training or competition schedules, training or competing on consecutive days.[4,23,36,41] The combination of protein (0.2-0.4g/kg/hr) with carbohydrate (0.8g/kg/hr-1g/kg/hr) stimulates endogenous insulin release and promotes muscle glycogen repletion at the same rate as if carbohydrate was ingested 1.2g/kg/hr.[32,41] The added protein of more or less 20-25g protein or 9g essential amino acids combined with 30-40g high glycaemic index carbohydrates immediately after exercise will stimulate muscle protein synthesis and inhibit protein breakdown. This will allow for muscle accretion. Ingestion of such small amounts of protein 5-6 times daily might also further support maximal protein synthesis throughout the rest of the day.[4,41,42,43]

Inadequate carbohydrate intake over repeated days will lead to a gradual depletion of the glycogen stores with subsequent impairment of athletic performance and endurance. Team sport athletes are encouraged to maintain a moderate daily carbohydrate intake as set out below and should be individualized where possible. The lower range is suggested where daily training does not heavily deplete muscle glycogen stores:[3,4,16,19,20,23,26,32,44,45,46,47,48]

- 1-1.5g/kg/hr. within the first 30 minutes after exercise and repeated every 2 hours for the first 4-6 hours after exercise or 0.8-1g/kg/hr +20g protein (0.2-0.4g/kg/hr) within 30 minutes after exercise, repeated every 2 hours for the next 4-6 hours

- 5-7g/kg/day with a moderate exercise program (e.g. 1-2 hours/day)

- 7-10g/kg/day with moderate to heavy endurance training (e.g. 2-3 hours/day)

It is also suggested that the intake of smaller snacks may reduce gastric discomfort rather than one big meal, still providing the benefits of glycogen storage during the early phases of recovery.[18,38]

There appears to be minimal difference between males and females in their capacity to replenish glycogen stores or the timing of post-exercise carbohydrate intake to ensure optimal glycogen repletion.[37,38]

Both liquids and solids appear to be equally efficient in providing glucose for muscle glycogen synthesis and should be determined by the practical and personal choice of the athlete. Liquids might be more practical and appealing for a fatigued athlete with a loss of appetite.[18,24,38,42,45]

Intakes of glucose and sucrose have shown similar results whereas the same amount of fructose promotes a much lower rate of glycogen synthesis.[14,42,49] It is therefore recommended that foods with a moderate to high glycaemic index should take priority in the post-exercise nutritional recovery strategies of athletes and should start immediately after exercise.[38,49] Ideally co-ingestion with protein after exercise has been shown to accelerate protein synthesis.[24,26] It can be difficult for athletes to take in sufficient energy and carbohydrates after exercise unless there is a well-established plan to do so. Training by itself without a sound nutrition plan to support training, will be self-limiting.[34]

2.3.2 Protein

Besides the replenishment of glycogen stores after exercise, repair to damaged muscles and muscle reconditioning are important components of post-exercise recovery.

Metabolic adaptation for the team sport athlete post-exercise means not only muscle accretion but more efficient energy delivery by improved cardiovascular efficiency. Improved cardiovascular efficiency is facilitated by the increased capillary density, increased myoglobin and oxygen carrying capacity of blood. The increase in the size and the number of intracellular mitochondria, assist in increased protein synthesis. Together these metabolic adaptations result in more efficient energy systems, ultimately increasing performance.

Many athletes believe that taking extra protein will enhance performance in some or other way which often leads to the under consumption of other equally important nutrients. There is however strong evidence to suggest that the timing, type and amount of protein intake influence post-exercise recovery and adaptation with the main objective post exercise to be replenishment of glycogen stores, muscle repair and muscle synthesis. Endurance exercise increases leucine oxidation. Power sport athletes have increased protein requirements compared to sedentary individuals to facilitate muscle protein repair and muscle synthesis.[4,23,32]

For muscle repair to take place after exercise, a positive protein balance is needed to facilitate this process of repair and protein synthesis and allow exercise induced muscle adaptation to take place. At rest in a fasting state, the breakdown of protein is faster than muscle protein synthesis, creating a negative protein balance. Exercise stimulates both protein breakdown, as well as protein synthesis in the time immediately after exercise. Carbohydrate- and protein intake after exercise is very important to obtain this positive protein balance to facilitate muscle damage repair and skeletal muscle reconditioning. Carbohydrate intake post-exercise lessens the effect of a negative protein balance after exercise by inhibiting protein breakdown attributed to elevated insulin blood levels therefore stimulating protein accretion post-exercise. Beelen et al (2010) found that taking 20 grams protein (0.2-0.5g/kg BW) or 9 grams (6-20g EAA) of essential amino acids post-exercise increases muscle protein synthesis for the first two hours after exercise with whey protein, which is high in leucine, leading to faster intestinal absorption rates compared to soya- and casein protein. Both whey and soy protein however stimulates muscle protein synthesis more than that of un-hydrolysed casein. Casein contains less leucine, delays gastric emptying with a subsequent delay in the release of available circulating amino acids and thus slower protein resynthesis rates. A combination blend of both whey or soy and casein protein after exercise potentially prolongs protein synthesis during the recovery hours where whey protein provides the necessary leucine trigger for protein synthesis and casein continues to provide slow releasing amino acids.[4,41,50] Provided sufficient amounts of protein is ingested post-exercise, additional consumption of carbohydrates after exercise does not seem to increase the rate of protein synthesis. Co-ingestion with 30-40grams high glycaemic index carbohydrates immediately after exercise however results in increased glycogen resynthesis.[4,41]

Some amino acids can be synthesized from other amino acids, referring to non-essential amino acids and others cannot be synthesized in the body and needs to be obtained from foods we eat, referring to essential amino acids, both equally important. Certain amino acids can also be converted to glucose and metabolized to provide ATP energy and as Lemon (2000) has highlighted, becomes more important when energy and carbohydrate intake are restricted.[32] The need for protein as energy source during physical activity rises as glycogen stores depletes. Due to the elevated daily energy requirements most athletes do not struggle to meet daily protein requirements, but those that might be at risk of insufficient protein intake are; vegetarians, young athletes that are still growing, athletes on weight loss diets or those restricting food intake due to religious or cultural reasons.[4,32] During times that athletes restrict energy intake to promote fat loss, protein consumption can be as high as 1.8-2g/kg/day.[20,43]

Most athletes have a higher protein requirement than the average individual. These requirements are in most circumstances easily met via the diet. The recommended protein intake for team sport athletes are 1.2-1.7g/kg/day, consumed as 3-4 protein rich meals a day, which will maximize muscle protein synthesis.[4,16,19,23,39,43] Team sport athletes trying to increase lean mass and decrease fat mass to improve their power to weight ratio should aim for their daily protein intake towards the upper range of recommendations and possibly decreasing carbohydrates intake as low as 3-4g/kg/day still optimizing carbohydrate intake during critical times e.g. immediately post-exercise.[4,16,43]. Recommended amounts of protein may vary depending on the athletes training status. Experienced athletes would require less protein, whilst protein requirements are higher during periods of frequent high intensity training. According to guidelines adopted by the International Olympic Committee (IOC), protein intake above these guidelines does not have any additional benefit or performance enhancing effect and can promote amino-acid catabolism, increased calcium excretion and increased protein oxidation as well as detracting the athlete from other key nutrients such as carbohydrates, with well-proven benefits.[4,19] The upper-limit for daily protein intake has been set at 2g/kg/day with only one or two exception when athletes train in extreme conditions.[32]

As discussed above, there is increasing evidence to consume small amounts of protein e.g. 0.2-0.5g/kg (20-25g protein) within thirty minutes after exercise to aid muscle recovery by increasing the rate of protein synthesis and enhanced adaptation to exercise, provided sufficient carbohydrates is still consumed to replenish glycogen stores. The optimal carbohydrate: protein ratio for muscle repair seems to be: 3-4:1. Additional recovery protein consumption does not promote higher rates of muscle protein synthesis and simply promotes increased amino acid catabolism and protein oxidation.[4,16,19,20,23,32,41,43,45,46]

Protein consumed in a liquid form combined with carbohydrates after exercise might be easier to consume, for example, flavoured bovine milk, that is high in leucine (BCAA), with added carbohydrate is a cost efficient, safe and an effective recovery sports drink. This might be vital for athletes with limited time between exercise sessions, a reduced appetite, or if they are struggling to manage the volume of carbohydrates recommended to promote fast recovery between consecutive exercise sessions.[4,43]

2.3.3 Fat

Fat requirements of athletes are similar to that of sedentary individuals. It is essential to consume adequate amounts of fat in the diet to ensure optimal health, maintain an energy balance and promote the intake of essential fatty acids, fat soluble vitamins A, D, E and K and restore intramuscular triacylglycerol used as a fuel source during aerobic activities.[4,51]

Fat in the diet adds taste and creates the feeling of being full due to the longer gastric emptying time. Should fat intake be reduced, sufficient energy from other macronutrients, mainly carbohydrates should make up total energy.[34,39]

For most athletes, achieving a low body fat with an increased power to weight ratio can lead to significant performance increases. Different power sports will dictate different optimum body composition and body mass requirements. Excess fat intake might come at the expense of carbohydrate intake which might have a negative effect on training and performance during competition.[4,23,52]

A moderate fat intake of more or less 30% of total daily energy intake is recommended for the team sport athlete.[4] Athletes having difficulty in sustaining weight because of very high energy expenditure might need slightly higher fat intakes than the normally recommended 20-35% of total energy but are advised not to follow a diet containing less fat than 15-20% of total daily energy intake.[20] Should an athlete need to change his or her body composition it is important that the athlete understands that these modification might take time as diets found to be very low in fat potentially increase junk food intake. It is therefore recommended that body composition changes is best done out of season. Menu plans that are very low in fat has also been found to increase junk food intake.[26]

When we consume excess energy, fat is stored in the body in the form of triacylglycerol in adipose tissue and muscle cells, to be used for energy at a later stage as needed under proper conditions of oxygen availability. Maximal fat oxidation normally occurs at 60-65% of VO_2 max. Triacylglycerol consist of three fatty acids and a glycerol molecule. When fat is burned as a source of energy, each molecule is cleaved into fatty acids and the glycerol molecule. Glycerol is a unique fat and is burned more like carbohydrates in the working muscle. Free fatty acids are transported to working muscles where they are oxidized for energy. This process is referred to as the beta-oxidative metabolic pathway as for this process to take place, requires both carbohydrates. The lower the intensity of exercise the greater the proportion of fat burned to meet energy needs. As intensity increases, less fat is burned for energy and more carbohydrates are used to meet the growing energy demand.[34]

Some researchers found that training on a diet high in fat is associated with an increased ability to oxidize fat during exercise.

The technique 'fat adaptation' refers to the intervention where well trained athletes consume a high fat , low Carbohydrate diet for up to two weeks, during which time they will continue their normal exercise regimes. This two week high fat low carbohydrate period is then immediately followed by a high carbohydrate diet and the tapering of their exercise programme for 1-3 days before competition. This 'dietary periodization' protocol has been found to increase the rate of whole body and muscle fat oxidation, subsequently making the athlete less reliant on glycogen as fuel as it can now burn fat as an additional fuel source during exercise, preserving glycogen stores for longer.[79]

However, there are some indications that relying on fat as fuel source, can inhibit the necessary physiological adaptations associated with exercise which normally makes the athlete more efficient in utilizing glycogen, leading to a better sustained performance during high intensity exercise. Some athletes are also seen as 'responders' and others as 'non-responders' which pose some practical issues in identifying 'responders' and then optimizing regimes and dietary periodization strategies that will be beneficial to them.[79]

Another 'fat adaption' technique used is training on low glycogen stores or low blood glucose levels and then competing when glycogen stores are optimally replaced. This is a popular trend amongst competitive athletes these days. Training low is suggested to be defined as training with about 50% of resting muscle glycogen for about half of the athlete training sessions. In theory training low stimulates the body to signal different energy metabolism pathways. Training in a glycogen-depleted state can promote the body to be potentially more efficient at utilizing fat and potentially spare glycogen during endurance-type exercise and therefore this 'training low, competing high' strategy is used to potentially develop a more efficient engine for endurance-type exercise.

The placement of training sessions rather than dietary manipulations might be a better approach to achieve low glycogen levels for specific workouts. Training after an overnight fast, consuming water during prolonged workouts or withholding carbohydrates in the hours immediately after training as well as restricting carbohydrates below the optimal fuel requirements suggested for the volume of training are all experimental techniques used in training the body to become better at oxidizing fat as fuel source during exercise.[3]

Still, a lot of question marks are hanging over the 'training low, competing high' concept and whether it always is beneficial to the athlete. Maintaining high intensity workouts become a challenge without having the necessary fuel/carbohydrates available for the body to use to maintain performance. Ideally athletes would want to maintain the same intensity during practice games as what will be required during matches. Completing workouts with the adequate fuel available to muscles will lead to a more positive training effect, allowing the athlete to train at a higher intensity for a longer duration of time. Changes in the diet from training to match day might also potentially cause some unwanted gastro intestinal upset or discomfort on the day of the competition as the athlete's digestive tract might not be used to the volume or type of fuel consumed on the day. Constant 'training low regimes' might also interfere with the athletes ability to consume optimum daily carbohydrate necessary for recovery and muscle synthesis and can possibly lead to fatigue, increased injury risk and potentially negatively effects on the athlete's immune system, compromising recovery.[3,4]

Fat ingested before or in conjunction with a carbohydrate- and protein-rich meal, slows down gastric-emptying, leading to a delayed rise in glucose and insulin levels.[53] It is therefore recommended that fat should be limited during the recovery period immediately after exercise to favour the intake of carbohydrate and protein creating a fast uptake of carbohydrates necessary for glycogen synthesis as well receiving the leucine trigger from protein, stimulating protein synthesis.[37] However, in the general scope of the diet, fat should be maintained at an adequate level of more or less 30% of total energy intake.[37,38]

Fat as effective fuel source for the athlete are thus still under review and need further research before recommendations to follow a high fat diet to enhance performance can be concluded and translate to dietary guidelines.[3,4]

2.4 Fluid requirements

Water and sodium which is primarily responsible for intracellular fluid, replacement needs can usually be done by normal eating and drinking practices if there is no urgency to recovery within a short period of time.[54] Yet, athletes often start practice sessions in a slightly hypo-hydrated state.[26] Should the recovery time be limited and severe hypo-hydration occurred (>5% of body weight), aggressive fluid and electrolyte intake should be encouraged to facilitate recovery before the next exercise sessions.[54] Fluid replacement after exercise should be an immediate priority. It is recommended that athletes' bodyweight is measured before and after exercise to determine accurate fluid losses. Other techniques such as the use of simple urine colour charts can be helpful and are often more practical for the athletes to self-monitor hydration states, bearing in mind that urine colour can be influenced by vitamin supplementation.[26]

Sweat losses can be high when athletes train or compete in hot climates such as areas within South Africa. Athletes also tend to follow slightly different drinking practices associated with stress during competition times, either over or under hydrating themselves [40] Authors' guidelines via American College of Sports Medicine, recommend 1.5 litre of fluid per kilogram BW lost during exercise where rapid recovery is required. Added sodium should stimulate thirst and promote fluid retention and should be added when sweat losses are high.[4,54] Reductions of body weight of 1-2% generally does not seem to influence athletic performance provided the duration of training is less than 90 minutes in a moderate temperate (20-21˚C). However the athletes' subjective sensation of effort is increased during exercise if hypo-hydration is allowed to develop further (>3-4%), it is likely to lead to a decrease in performance.[54] Team sport athletes in South Africa often train in temperatures greater than 20 ˚C, and should be taught to hydrate well when training sessions prolonged and practicing in extreme heat. Utilize opportunities during games as well as during half time breaks and having drinking bottles ready and available will assist the teams sport athlete to consuming small amounts of fluid (150-200ml) every 15-20 minutes.[4,20,26]

2.5 Alcohol

Team sport athletes have a known tendency to socialize and consume alcohol after events whether it is seen as a reward for hard work they put into their training or as an integral part of team sport club culture and bonding with other athletes.[17.55,56] Some athletes and coaches have the misconception that alcohol intake after exercise will help athletes relax, sleep better and numb the pain associated with exercise induced sports injuries after games. Scientist found that low to moderate intake of alcohol do not positively influence performance, but rather decrease endurance performance of athletes and negatively affects sleep.[56]

Many university students see drinking alcohol as an integral part of their higher education experience. However, surveys done in the United States amongst college-going athletes indicated a higher incidence of alcohol use and binge drinking opportunities amongst student athletes than their sedentary friends. This puts them at greater risk for alcohol-related harm.[56]

A dietary survey with elite Australian football players revealed a large consumption of alcohol after games.[55,57] In the United States, the National Institute on Alcoholism and Abuse (NIH) has found that 80% of all university-going students consume alcohol and about 50% of the students reported binge drinking within the previous two weeks at the time the survey was done in America.[25]

Most students would have had some experience with alcohol before arriving at their university campus, but some aspects of the new university life can exacerbate problems such as: unstructured time, easy access to alcohol, inconsistent enforcement of drunk driving and alcohol abuse, limited interaction with parents and other adults, and peer pressure.[58]

Although the majority of the students do not appeared to have consumed alcohol during the recording days of this particular study, a NCAA survey including a broad spectrum of male and female sports teams, reported alcohol use by 80.5% of the respondents and there seems to be some evidence that team sport athletes consume large amounts of alcohol in the post-exercise period.[1,18]

The effect alcohol has on recovery depends on various factors; such as the timing of alcohol consumption after exercise, the volume of alcohol consumed, the level of injury after exercise, as well as the recovery time the athlete has before the next training session; thus whether the athlete will be able to return to their pre-exercise state before the next exercise session.[56]

Dehydration has been shown to impair performance and it is vital for athletes to consume adequate fluids and electrolytes after exercise to restore fluid balance before their next training event. Alcohol in large quantities has a negative effect on the restoration of fluid balance via its diuretic effect, however in small quantities less than 0.49 g/kg bodyweight should pose a minimal threat to fluid balance restoration after exercise.[34,39,56] Evidentially athletes are more likely to drink sodium-rich beverages after exercise. Fluid balance after exercise can be restored when athletes consume sodium-rich beverages, containing 25 mmol/L sodium, in amounts greater than what was lost during exercise as sweat.[59] Previous research has found low alcohol beer or low alcohol beverages containing 1-2% alcohol and non-alcoholic beer or beverages have similar rehydration potential, however an increased alcohol content of 4% or more appears to delay recovery and increase urinary losses. It is therefore recommended that should athletes consume alcohol beverages after exercise, emphasis should be on low-alcohol beers and beverages.[59]

During the ‘celebration’ period after exercise, athletes forget about their nutritional recovery strategies. Previous research found impaired glycogen recovery when alcohol was consumed in large amounts after exercise as alcohol does not provide substrate for glycogen formation, displacing valuable carbohydrate sources from the athletes’ typical diet. Alcohol thus interferes with glycogen resynthesis and musculoskeletal glycogen uptake after exercise mostly due to a disinterest from the athletes to follow the necessary nutritional recovery strategies, consuming adequate carbohydrate and protein post-exercise necessary for glycogen restoration and protein synthesis and adaptation. Protein synthesis and adaptation was inhibited even when post-exercise nutritional status was optimised, possibly by inhibiting insulin-like growth factor and insulin levels.[18,57,56]

Normally trauma to soft tissue triggers a complex immune response in the body, ensuring the inflammatory stimulus is dealt with effectively. Alcohol however affects this fine balance in the body negatively by shifting it to a net anti-inflammatory response by altering cytokine activity. Alcohol down-regulates the production of tumour necrosis factor which results in decreased endothelial cell activation leading to a decrease of neutrophil endothelial cell adhesion necessary for cell repair. The lack of tumour necrosis factor in the blood further inhibit the endothelium to produce several vital pro-inflammatory molecules necessary for recovery whilst it simultaneously increase the number of anti-inflammatory molecules, overall lessening the effectiveness of the body's immune response.[56]

Alcohol is known to have a vasodilatory effect which can increase bleeding time and swelling after exercise due to the increased blood flow to the site of injury. The increased oedema is likely to increase the severity of the injury, negatively affecting the rate of recovery and healing of soft tissue injuries.[39,56]

Alcohol abuse can lead to serious academic problems, injury, assault, death, sexual abuse, practising unsafe sex, alcohol dependence, drunk driving, vandalism as well as other health problems which can limit the athletes' reaching their optimal performance.[58] In general alcohol reduces reaction time, accuracy, hand-eye coordination, strength, power, and endurance. It also impairs balance and body temperature regulation.[39]
Safe levels of alcohol consumption as set out by the World Health Organization, is four standard drinks per day for males, and two standard drinks per day for females. A standard drink is classified as an average beverage containing eight grams of alcohol. Educating team sport athletes to understand the effects of alcohol consumption on their sporting performance, as well as the recovery from exercise and general health, should form part of nutritional recovery education strategies for athletes and should include dosage of no more than 0.5 g/kg bodyweight alcohol during the period immediately after exercise provided there are no serious soft tissue damage.[56]

2.6 Other nutrients commonly used in recovery

Athletes should be encourage on an ongoing basis to seek advice from professionals in the field of sports nutrition to assist them in making educated and scientifically sound choices, specifically in their choice to use 'other nutrients' to enhance performance.[16] Based on nutritional guidelines set out by the IOC and the ISSN, a few of these nutrients used specifically during recovery will be briefly discussed here.

2.6.1 Glutamine

Glutamine is a non-essential amino acid abundant in human muscle and plasma and is an important fuel source for some cells of the immune system such as lymphocytes and macrophage. It also acts as a fuel source to the intestinal wall needing a continuous supply, giving preference to available amino acids above skeletal muscle tissue.[47,60] It forms an integral component of protein, transporting nitrogen across tissues and it has a further role to play in acid-base regulation, gluconeogenesis and being a precursor for nucleotide bases and the anti-oxidant glutathione. Glutamine is synthesised mostly in skeletal muscle with its release into circulation having an immune-stimulatory and anabolic effect.[61] It is speculated that supplementing glutamine will supply the gut with the necessary glutamine fuel to sustain intestinal integrity and spare muscular glutamine for recovery of muscle tissue via stimulating protein synthesis. Evidence of the direct influence of glutamine supplementation on muscle protein synthesis after exercise however it is limited.[47]

Heavy training regimes and prolonged training are associated with a decrease in plasma glutamine concentrations below 600µmol/L. A low plasma glutamine concentration is associated with immune impairment possibly leaving athletes more susceptible to infections. This drop in plasma glutamine levels is most likely due to an increased in liver intake of glutamine for gluconeogenesis and the synthesis of acute phase proteins to buffer acidosis. The effects of exercise on the plasma concentration are largely dependent on the intensity and the duration of the exercise. Gleeson (2008) found that even though glutamine is essential to the proliferation of lymphocytes, the drop in plasma glutamine levels after exercise is not sufficient to compromise lymphocyte proliferation. Recovery nutrition guidelines still supports adequate protein and carbohydrates after exercise and standard supplementation with glutamine is unlikely to have any additional benefit.[69] Researchers suggest further study to investigate glutamine's role in promoting glycogen synthesis as a recovery supplement to athletes when adequate carbohydrates are met in the recovery meal.[60]

2.6.2 Creatine monohydrate

Creatine use is popular amongst power sport athletes and it is suggested that creatine may increase muscle phosphocreatine levels leading to a more rapid regeneration of ATP during high intensity workouts.[26] Humans have a requirement of 2-3g/day of this naturally occurring compound creatine, consumed mostly from protein sources in the diet such as meat and fish, whilst the rest will be synthesized from amino acids glycine, arginine and methionine.[47]

Creatine supplementation was found to enhance muscle skeletal hypertrophy, facilitating faster muscle repair as well as improving strength and power in power sports. This is especially evident in sporting events demanding repeated bouts of high intensity exercise by inhibiting protein breakdown and enhancing protein synthesis. An increase resynthesis of ATP potentially also improve performance by increasing the athletes' training capacity and quality of exercise sessions, further stimulating muscle protein synthesis.[4,16,47]

Supplementation with creatine usually starts with a loading phase where the athletes will take 20g of creatine spread over the day in 4-5 boluses for 2-5 days after which the dosage is reduced to 2-5g of creatine per day for three days during the maintenance phase.[47] In order to optimise adaptation facilitated by regular resistance training sessions and increasing fat free mass, recovery nutrition guidelines from the International Society of Sport Nutrition recommends a small amount of creatine (0.1g/kg BW) to be added to the recovery carbohydrate and protein snack after exercise.[4] Athletes should understand that not all individuals will respond to creatine supplementation in the same way, and some might not respond at all. This can possibly be due to do each individual's genetic muscle fibre profile as well as habitual food intake.[47] These guidelines on creatine supplementation should be reviewed in the South African context where product safety and purity is questionable and the potential risk versus possible beneficial effects should be individualized.[26] The sport supplement market is non-regulated, posing a huge health risk to athletes consuming not only supplements containing impurities, but possibly also contaminated supplements that could lead to a positive doping test and as a result, be banned from competitive sport especially when the same results can be achieved by consuming adequate carbohydrates and protein within thirty minutes after exercise.[4]

2.6.3 Branched chain amino acids (BCAA)

Protein sport supplements are some of the most marketed products to athletes to promote muscle synthesis and decrease protein breakdown during and after exercise.[60] It has been speculated that supplements with an amino acids mix in comparison with intact protein will stimulate a greater insulin and growth hormone release, with subsequent anabolic effects on protein synthesis, assisting in muscle repair after exercise.[47]

BCAA's are seen as an endogenous vasodilator that might enhance blood flow and improve endurance capacity of athletes.[60] Branched chain amino acids, leucine, isoleucine and valine can be metabolized by muscle as an additional source of energy and has been studied for its effects on lowering the ratings of perceived exertion during exercise as well as improving cognitive performance after exercise. This could potentially be important for student athletes that have other academic commitments after sports practices.[60] Leucine specifically, is often included in nutritional recovery supplements and potentially helps to avoid muscle protein breakdown and is seen as a trigger for protein synthesis. Resistance exercise usually form part of the team sport athlete's training regime. Williams (2005) suggested adding 'ample' (0.1 g/kg BW) essential amino acids during the first three hours after training will assist muscle protein synthesis and recovery from heavy resistance exercise.[4,60] A research review done in 2006 by Ohtani et al found that the long term effect of an amino acid mixture containing 30% BCAA and administrated at 7.2g per day (half in the morning and half in the evening taken after meals) to a group of rugby players over three months, during intensive training, may increase red blood cell production, enhancing the oxygen carrying capacity of the blood, improving athletic performance. Their review conclusion was that recovery from muscle fatigue after exercise is enhanced by the intake of an amino acid mixture containing a combination of essential branched chain amino acids, by reducing muscle damage during strenuous activity and having a protein sparing effect during recovery.[47,60]

2.6.4 Caffeine

With the ingestion of both caffeine and carbohydrates after exercise, blood glucose and blood insulin levels were found to be elevated, possibly assisting glucose transport into the muscle, leading to 60% higher glycogen storages in the four hours after exercise than what has been reported when only carbohydrates were consumed. High caffeine dosages should only be administrated with caution as it can lead to jitteriness, insomnia and gastro-intestinal upset. Some evidence suggests an enhanced muscular strength with acute caffeine intake and improved endurance and reaction times.[4,16]

2.6.5 Arginine

Arginine administrated intravenously stimulates insulin secretion. Tsai et al (2009) found a significant increase in serum insulin levels thirty minutes after exercise with the ingestion of 0.1g/kg BW arginine during the recovery period. The suggestion is that an additional arginine supplement creates an anabolic environment by increasing glucose concentration and stimulates insulin secretion, potentially increasing muscle glucose update and carbohydrate oxidation whilst suppressing fat oxidation.[62] Arginine is also seen as an endogenous vasodilator that might enhance blood flow and improve endurance capacity of athletes. Further research is however necessary to substantiate routine supplementation to enhance endurance performance.[60]

2.6.6 Micronutrients: vitamins and minerals

Micronutrients are essential to health and athletes should consume sufficient amounts from their diet provided they consume a wide variety of foods and meet daily recommendations for energy and macronutrients. Athletes that might benefit from an additional multi-vitamin and mineral supplement are those that are pregnant, ill, vegetarian, recovering from injury, or following an energy restrictive diet.[4,20]

Vitamins C and E are both strong antioxidants and have been found to possibly decrease oxidative damage and inflammation caused by free radicals, reducing muscle soreness caused by heavy training schedules, and assist in maintaining a healthy immune system to those not consuming a healthy balanced diet containing antioxidants. There is however is no evidence stating that exercise induced oxidative stress affects performance negatively. The International Olympic Committee is not in favour of additional antioxidant supplementation, especially a high dose single nutrient supplementation, as toxic levels may impair muscle functioning and reduce training adaptations. Athletes should rather focus on eating a well-balanced diet that meets the total daily energy requirements.[4,63]

Some mineral deficiencies cause a threat to the athletes' health such as calcium deficiency leading to premature osteoporosis, iron deficiency and sodium phosphate deficiency restricting maximal oxygen update, anaerobic threshold and endurance capacity. Sodium chloride plays an important role in the maintenance of fluid and electrolyte balance and zinc, possibly decreasing exercise induced changes to the immune function.[4]

Vitamin and mineral supplements are commonly used by team sport athletes. Clark et al. (2003) reviewed the nutritional intake of 145 female soccer athletes from twenty-two university teams and found that more than fifty percent of these athletes used a vitamin and mineral supplement, mostly a general multivitamin, as well as calcium and iron.[1] Some scientists recommend athletes to use anti-oxidants in conjunction with their possibly non optimal diet in order to decrease reactive oxygen species that forms during endurance exercise. Free radicals have been found to promote muscle fatigue possibly resulting in a decrease in performance. However, there is no evidence to support that oxidative stress caused by exercise is detrimental to the athlete's health or performance.

Vitamin D might have a performance-enhancing effect in athletes with insufficient intake or exposure to sunlight and possibly also reduce the incidence of stress fracture formation when combined with calcium supplementation. However considering South Africa's climate, and most team sport activities happening outside, this should not pose a problem to South African team sport athletes. Limited evidence to support Vitamin D supplementation, as well as the risk to build up toxic levels of this nutrient posing side effect to the athlete, warn against regular Vitamin D supplementation.[4]

It is recommended that athletes should consult with a registered sports dietitian to alter eating habits ensuring optimal intake from daily food intake and avoid supplements especially single nutrient high dose anti-oxidants.[4]

2.7 Factors affecting nutritional needs

Previous research has identified a number of factors influencing athletes diets of which probably the most common were: lack of time to cook, financial limitations, inadequate cooking skills and difficult living arrangements.[6]

It is well documented that early introduction of carbohydrates after exercise is vital in starting glycogen resynthesis especially where recovery time is limited between exercise sessions.[1,24,41] Recovery nutrition is often delayed because of transportation, weather, drug testing and press conferences and snacking might become an important component of the nutritional recovery process. These should be taken into account when an appropriate nutrition recovery strategy is being formulated by a registered sports dietitian in collaboration with an interdisciplinary team.[26,46] Many athletes report a diminished appetite during the first two to three hours immediately after strenuous exercise sessions. Holway et al (2011) has also found that team sport athletes ate less on competition days due to stress levels and travel schedules or prefer to sleep more on these exercise days.[26] Inadequate intakes of carbohydrates leads to some degree of ketosis associated with nausea and a loss of appetite often further reducing intake. This becomes especially important on consecutive days of competition as during a tournament. Glycogen depletion will hamper performance and aggressive strategies to replace glycogen stores after exercise is needed.[24,26] Certain micronutrient deficiencies in itself, like thiamine for example, is also associated with reduced appetite and sub optimal recovery intake.[34]

Availability and convenience to the student athlete are important when choosing a recovery meal.[1] Previous research has found that menus very low in fat encouraged the 'smuggling' of junk foods and that the athletes preferred more repetitive familiar foods as part of their recovery meal as oppose to lots of choices.[26] This should be taken into consideration in the planning recovery schedules with practical guidance on the inclusion of healthy fast food choices

Other reasons for inadequate intake of carbohydrates post-exercise could include the use of certain drugs or an illness which may alter taste and cause appetite loss.[34] In these cases it would be important for the athlete to strategically consume carbohydrate rich meals and snacks around important exercise sessions ensuring energy needs are met for exercise commitments as well as promoting high carbohydrate availability to enhance performance and support speedy recovery.[3]

Athletes often express concern over pressures from society and coaches regarding their weight and might purposefully restrict food intake after exercise to manage their weight, especially female athlete often ingesting sub-optimal energy and carbohydrate levels in general, including that of the recovery meal.[3,6,23,52] Some of these athletes might be at risk of micronutrient-depletion and the use of a vitamin and mineral supplement not exceeding the recommended daily intake, may be consumed as a preventive measure. Performance will not improve with the use of a vitamin and mineral supplement if individuals already consume nutritionally adequate diets.[64]

Frequent travel and exposure to altitude and cold may disrupt athlete's digestion, bowel movements, and eating patterns, leading to discomfort and insufficient recovery nutrients which will compromise health and performance.[46]

Team sport athletes undertake a diverse training programme and therefore nutritional recovery strategies should be individualized with the primary focus on recovery of muscle glycogen stores and the synthesis of new proteins.[23] Overtraining, associated with lack of sleep, constant fatigue, mood swings and an increased risk of infections will decrease appetite and lead to weight loss due to sub optimal nutrient intake.[34]

During team sport events, refuelling time during competitions are often limited. As the duration of training events can often be two hours, these athletes can benefit from carbohydrates and fluids during exercise and refuelling strategies should be planned and timed correctly.[23]

Athletes should therefore implement a variety of recovery modes as part of an effective recovery and regeneration strategy of which nutrition and rehydration form an integral part and address any questions and concerns about the quality of his or her diet to a registered dietitian who is experienced in sports nutrition.[2,21,64,65] According to authors Hawley and Burke (1997),[24] the manipulation of eating schedules might play an important role in achieving specific nutritional goals both during training and times of competition to ensure optimal recovery and performance.

Limited published research exist to describe dietary habits and lifestyle demands placed on field-and court based teams sport athletes especially that of women.[1] A small dietary survey conducted in the past by Clark et al. (2003) on 13 college going female NCAA (National Collegiate Athletic Association) soccer athletes in the United States, assessed pre and post season dietary intake, body composition and performance indices.[1] Findings from this study indicated a marginal intake (<75% of DRI) of several micronutrients, e.g. calcium, chromium, iron, magnesium, selenium, zinc, vitamins E, D, C, B6 and pantothenic acid, also including insufficient energy and carbohydrate intake, vital to optimal recovery. The authors debated possible reasons for poor micronutrient intake in these athletes as (a) a low intake of nutrient-dense foods, such as fruit, vegetables, whole grains and (b) an overreliance on fast convenience and processed type of foods including fizzy and sports drinks.[1,66]

Nutrition education and recovery strategies can be implemented at several levels, including individual counselling of athletes, team talks, fact sheets, supermarket and shopping educational tours, as well as the sports dietitian being present at meal venues and interacting with athletes providing information. Knowledge of the cultural environment associated with the sport must accompany decision making with regards to the athletes' recovery regime.[26]

CHAPTER THREE

METHODOLOGY

3.1 Aims of the investigation

The primary aim of this study was to determine the nutritional recovery strategies used by field based team sport athletes participating in rugby, hockey and netball training at the Nelson Mandela Metropolitan University, in South Africa during July-November 2014. The secondary aim was to compare the dietary intake of macronutrients of the above mentioned athletes with recommendations from current literature on recovery nutrition.

3.2 Objectives:

1. To determine the timing, energy and macronutrient composition of the current nutritional recovery strategies used by team sport athletes at NMMU by means of 24 hour recalls.
2. To assess where these athletes get recovery nutritional information from.
3. To determine factors influencing nutritional recovery strategies used by this group.
4. To statistically compare timing, energy, and macronutrient intake for optimal recovery to current literature recommendations.
5. Compare athletes in terms of gender differences, as well as according to sport code with regard to the above mentioned aspects.

3.3 Research question

What are the factors influencing university-going team sport athletes' recovery nutrition knowledge and the application of current sport specific literature recommendations?

3.4 Hypothesis

Null-hypothesis (H_0)

There is no difference in the timing and macronutrient composition of the recovery meal and the macro nutrient composition of the diet of team sport athletes training at NMMU compared to current literature recommendations of power sports athletes with regards to the total daily energy intake, macronutrient composition of their diet and the timing of the post exercise meal.

3.5 Study Design

This study is a cross-sectional with an analytical component.

3.6 Study population

Players from rugby, netball, and hockey teams registered with the Nelson Mandela Metropolitan University' Sports Bureau qualified for inclusion in this study. All players meeting the inclusion criteria and willing to complete the study questionnaire were included.

All players included in the study were registered members of a rugby, hockey or netball team of the Nelson Mandela Metropolitan University during the 2014 season. A total of 36 teams took part in the study, consisting of: 15 rugby teams with a total of 225 athletes, 11 netball teams with a total of 77 athletes and 10 hockey teams (5 female teams) with a total of 110 athletes. There was no control group.

3.7 Inclusion criteria:

1. Players training at Nelson Mandela Metropolitan University during the time of data collection, assuming all students studying at NMMU were competent in English.
2. Players had to form part of a registered rugby, netball or hockey team at NMMU.
3. Players had to provide informed consent to participate.
4. Both male and female players, 18 years of age and older were included in the study.

3.8 Exclusion criteria:

1. Athletes who were not registered as NMMU students.
2. Athletes who were registered NMMU students, but not part of rugby, netball or hockey team registered with the NMMU sports bureau.
3. Athletes younger than 18 years of age.
4. Athletes that didn't give written informed consent.

The director of the Nelson Mandela Metropolitan Sports Bureau was contacted via email and a list of all registered netball; hockey and rugby teams were obtained. This was used to calculate the total study population as well as a minimum number of participants necessary for statistical significance purposes.

All players meeting the inclusion criteria and willing to complete the study questionnaire were included in the study.

Data was collected during July-November 2014.

3.9 Methods of data collection

3.9.1 Questionnaire development and validation

Ethical clearance from the University of Stellenbosch was received on the 21st of July 2014 (S14/05/112) after which the questionnaire specifically designed for this study, was sent to two content experts for review. Main suggestions on improving content validity are summarized below:

1. Keep questions focused on recovery nutrition after exercise as indicated in title of the study
2. Do not limit answers with the multiple choice questionnaire, but leave some questions open-ended by including an option for ‘other’, for example.
3. Split the feedback on recovery nutrition in two: (a) recovery nutrition after general aerobic fitness training and (b) recovery nutrition after resistance training, e.g. request answering two different questions.

A pilot study was conducted on the 12th of August 2014 at the Crusaders Rugby Club, in Port Elizabeth to test face validity. The purpose of the study was explained to the pilot study group and all athletes willing to participate were asked to complete the questionnaire. All fifteen players that participated in the study completed and signed a consent form and each athlete received a copy of the consent for their own record. Students were asked to comment whether the questions were well understood and easily interpreted to ensure the questionnaire communicates what the researcher intended to measure. Nine participants completed the questionnaire successfully in twenty minutes including the briefing time.

The section following below describes problems that were identified during execution of the pilot study, and how the researcher resolve these issues to improve the overall face validity of the questionnaire.

1. Problem: Six questionnaires were incomplete where athletes failed to answer every question. All of the questions that were 'missed' were single word answers where athletes were requested to answer in their own words rather than choosing from a multiple choice list like the rest of the questionnaire.

   Changes made: All questions asked in the questionnaire were changed to a uniform format of multiple choice questions. Options available for selection included an open-ended answer option e.g. "other" where athletes could write their answer in if it was not available in the multiple choice list.
2. Problem: Some athletes signed the consent form in the wrong place.

   Change made: Consent forms were marked with red dots to indicate where the athlete had to sign. The researcher also made use of an assistant, checking that consent forms were signed as they were handed back.
3. Problem: Two athletes asked what was meant with 'chronic fatigue' and three students asked the definition of "resistance training'.

   Changes made: The wording in the questionnaire was changed from, 'Chronic fatigue', to 'feeling tired all the time' and 'resistance training' was changed to 'weight training'. Both descriptions were tested and well understood by the athletes.
4. Problem: Athletes pointed out a typing error in question 29, referring back to question 25 instead of question 28.

   Changes made: error was corrected on the questionnaire question.
5. Problem: Athletes found questions leading onto the next question confusing

   Change made: multiple questionnaire answer option was adapted to also include an option for example, "I don't use a supplement" to make answering easier and athlete doesn't have to page back. Each question on the questionnaire in other words had to be answered.
6. Problem: Some of the clip boards that were used during the pilot study got lost.

   Changes made: Inventory was kept and all material and equipment were counted and checked after each data collection session.
7. Problem: The informal environment of the sports field was found to be quite noisy where players were very talkative. The researcher found it to be very different from a more controlled classroom environment, thus made the communication more difficult than what was anticipated.

Changes made: The researcher utilized the coach in creating order, focusing athletes on the task of completing the questionnaire. The researcher also made use of a research assistant.

3.9.2 Subject recruitment

Data collection for main study consisted of two components, namely a descriptive component as well as an analytical component.

The various sports managers from NMMU were contacted prior to data collection to arrange appropriate times for data collection to take place prior to training sessions. All data was collected during the competition phase of the three sport codes. All athletes present at the training sessions, willing to part take and meeting the inclusion criteria were included in the study.

3.9.3 Ethical aspects

All athletes participated voluntarily. Written consent was given before completion of the questionnaire. No names were recorded on the questionnaire in order to maintain anonymity. Confidentiality was protected by destroying telephone details after data collection was completed.

3.9.4 Data collection

All data collection and data capturing was done by the researcher self. This provided consistency and quality control with regards to research practices followed, meeting the high academic and ethical requirements set by the University of Stellenbosch, that all research conducted will be transparent and honest and data captured correctly for data analysis, using Microsoft Excel 2010.

A detailed background to the study as well as an explanation regarding the two components of the study (questionnaire as well as 24hour recalls) was given to each group prior to consent.

3.9.4.1 Questionnaire

The adapted 36 point multiple-choice questionnaire (Addenda A) was used to gain information relating to the descriptive component of the main study looking at: age, the level of competition, the intensity of training practices, as well as the volume of training. The questionnaire further identified whether the athletes have had nutrition education before and by whom, the importance of nutrition, their food choices and also the factors that are influencing their food choices.

Completion of the questionnaires was done prior to exercise sessions with the exception of five rugby players who willingly completed the questionnaire in a relaxed atmosphere after their practice sessions under similar circumstances as those completing the questionnaire before there training.

Athletes were asked to complete the 36 question multiple choice questionnaire (Addenda A) that took them approximately 15 minutes. Questionnaires were all in English, assuming all students registered with Nelson Mandela Metropolitan University were competent in English as all lectures and examination papers at this tertiary institution are presented in English. Pens were provided to the athletes.

3.9.4.2 Diet recalls

To gain information with regards to daily intake of macro-nutrients as well as recovery nutrition practices, a telephonic diet recall was chosen based on the logistics and time constraints as not all the athletes were based on campus. For quality control purposes, two 24 hour diet recalls for each consenting athlete was done telephonically on random days which included both week and weekend days, done by the same researcher. The researcher was adequately trained in taking diet recalls with 15 years dietetic experience as a registered dietitian, and well familiar with the FoodFinder software programme that was used to analyse the diet recalls.

3.10 Data analysis

Data from all eighty six completed questionnaires were entered on a spreadsheet in Microsoft Excel 2010 and statistically analysed with the help from a statistician from Stellenbosch University, using Statistica computer software.

The two day 24-hour diet recalls were analysed by the researcher using a computer software programme, called FoodFinder III.

FoodFinder III is a software programme developed by the Medical Research Council of South Africa to analyse food intake of individuals or groups for macro and micronutrient composition. The first food comparison tables of the Nutritional Intervention Research Unit of the Medical Research Council of South Africa was published in 1981 and have become the standard reference to be used by dietitians and other health care professionals involved in nutrition research in South Africa. These nutrition composition tables were later updated into an electronic software programme by WAMTechnology CC and the MRC, developing FoodFinder III into the high quality software programme that it is today. (MRC Research Information System Division, www.mrc.ac.za; foodfinder3@mrc.ac.za; telephone: +27 21 9380895)

Where specific food items such as meal replacement shakes, protein shakes or energy bars could not be found in the current FoodFinder database, the macronutrient composition of the food items were taken from the specific item's food label and added to the database for analysis. Portion sizes were entered as household measurements or diameter measurements as it was recorded by the researcher during the 24-hour diet recalls using visual cues to ensure accurate portion control. Diet recalls were specifically analysed for total energy intake, total carbohydrate, protein and fat intake. The timing of recovery meals post-exercise was documented in terms of minutes after exercise, before a recovery meal was consumed. Macronutrient composition of the diet as well as the timing and the macronutrient composition of the recovery were then compared to current literature recommendation with the help of a statistician.

Literature suggests the following:[3,4,16,19,20,23,26,35,46,47,67]

Moderate exercise training (1-2 hours/day) for power sports athletes:

- Total daily carbohydrate: 5-7g/kg/day with a moderate exercise program (e.g. 1-2 hrs/day)
- Total daily protein: 1.2-2g/kg/day
- Total daily fat: 20-35% of total daily energy intake

Post-exercise recovery guidelines:

- Carbohydrate: 1-1.5g/kg BW. within the first 30 minutes after exercise
- Protein: 20-25g taken with carbohydrate within 30 minutes after exercise

Athletes were classified under 'moderate training' as most athletes (92%, n=79) that participated in this study reported exercise sessions greater than an hour, with 47% (n=30) of the athletes training 3-4 times per week and 43% (N=37) training 5-6 times per week Exercise intensity was rated moderate to high with 71% of the athletes indicating level of intensity during exercise sessions as 7-8 out of 10, where 10 equals maximum intensity.

3.11 Statistical analysis

For statistical purposes, the study population size was estimated with the help of a statistician, Dr Harvey from Stellenbosch University based on the assumption that most of the athletes will follow quantity guidelines for macronutrients as suggested in the literature. One of the primary variables of interest, namely the total daily carbohydrates, was used to base the sample size on. (literature recommendation is 5-7g/kg/day). A mean carbohydrate value of 6g/kg/day was chosen. A 95% confidence interval with a three unit standard deviation (3g/kg/day) was used to estimate study population size for each sport modality, assuming a precision of how close the measured values will be to one another, of one unit (1g/kg/day). The estimated population size was then indicated as: 27 hockey players, 25 netball players and 31 rugby players. No NMMU soccer teams were made available to participate in the study and were therefore excluded as a whole.

A total of 36 teams were then invited to participate in the study, consisting of: 10 hockey teams (110 players), 11 netball teams (77 players) and 15 rugby teams (225 players),

Eighty six athletes voluntarily participated in the study. These athletes included: 29 hockey players, 26 netball players and 31 rugby players, meeting the population size criteria for statistical purposes.

Statistical analysis was done by Prof. D.G. Nel from Stellenbosch University. Descriptive data from the questionnaire were reported in the form of a mean value and a standard deviation for nominal data for each of the sports codes (hockey, netball, and rugby), for gender and for the population as a whole. Percentages of the total population were calculated to determine the general tendency amongst gender and the different sports modalities.

T-tests were performed to test mean values against a reference constant taken from literature recommendations (reference constants used: daily carbohydrate = 5g/kg/day; daily protein = 1.5g/kg/day, recovery carbohydrate = 1g/kg/day; recovery protein = 20g; time between exercise and recovery meal = 30 minutes). P-values less than 0.05 indicated statistically significant results.[68]

In the first part of the study, the 36 point questionnaire were used to identify and describe the study population participating in team sports at the NMMU with regards to age, race, gender, level of competition and training, number of years participating in their sport, as well as identifying the factors influencing the athletes' recovery food choices and preferred sources for recovery nutrition information.[10,14,66,70]

The second part of the study was the analytical component of the study. The 24 hour dietary recalls were analysed via FoodFinder III by the researcher self for macronutrient composition. This was then compared to current literature recommendations to optimize recovery, specific to the power sport athlete. Each recovery meal was timed as to how many minutes after exercise the meal was consumed, and then analysed for macronutrient composition. This too was compared to current literature recommendations for timing and macronutrient composition of the recovery meal as well as total daily macronutrient consumption of the athletes.

CHAPTER 4

DRAFT MANUSCRIPT

Draft manuscript for submission of article to the *International Journal of Sport Nutrition and Exercise Metabolism (IJSNEM).* Author guidelines set out in Addenda C, pg.88 of thesis. Note that the following changes will be made before submission to journal: double spacing of text, page numbers will be moved to the upper right corner of each page.

Title Page

International Journal of Sport Nutrition and Exercise Metabolism

Inadequate nutritional recovery strategies of team sport players at the Nelson Mandela Metropolitan University, South Africa

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International Journal of Sport Nutrition and Exercise Metabolism

Inadequate nutritional recovery strategies of team sport players at the Nelson Mandela Metropolitan University, South Africa

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It is widely accepted that optimal nutrition assists in enhancing performance and speeding up recovery time after exercise.

The study assessed nutritional practices of university team sport athletes from Nelson Mandela Metropolitan University (NMMU), South Africa, determining timing and macronutrient composition of meals and recovery meals and comparing it to literature recommendations, also identifying factors driving recovery food choices and sources of nutrition information. Data comparisons were done for gender and participating sports codes. Eighty-six English speaking female (n=46) and males (n=40), aged 18 years or older participated as part of a registered hockey (n=29), netball (n=26) or rugby (n=31) NMMU team. Seventy-four athletes completed two 24-hour diet recalls. Average (all groups) daily carbohydrate intake was 2.57g/kg/day (±1.17), significantly below recommended literature values (5-7g/kg/day) (p=0.00). Daily protein intake was 1.5g/kg/day (±0.81), meeting literature guidelines (1.2-1.7g/kg/day), with males (1.95 ± 0.85; p=0.00) and rugby players' (2.03 ± 0.92; p=0.00) daily protein intake significantly above recommendation (1.2-1.7g/kg BW) compared to females (1.15 ±0.58; p=0.61) and netball players (1.00 ±0.58; p=0.12) where no statistically significant difference was found. Average fat intake was 34% (±8.7) of total energy, within 20-35% of total energy guideline. Average time delay (all groups) 40.5 minutes (±28.3) was significantly (p=0.004) above recommendation (< 30 minutes after exercise). All groups failed meeting recovery carbohydrate 0.52g/kg BW (± 0.42; p=0.00) with rugby players (0.35g ±0.33; p=0.00) and males (0.34g ±0.32; p=0.00) having the least carbohydrates after exercise. Protein post exercise (20-25g) was met by all groups in recovery meal 29.96g (±18.75). Females demonstrated a significant time delay between exercise and recovery meal 50.12 minutes (± 31.02; p=0.00) compared to males consuming recovery meal at 28.52 minutes (±18.9; p=0.67) after exercise. Netball players delayed recovery meal most with 59.64 minutes (±27.15; p=0.00) compared to hockey (33 minutes ± 30.01; p=0.64) and rugby players (29.88 minutes ±19.03; p=0.97) meeting recommendations. Protein was the rated most important nutrient after exercise (48%, n =41). The factors driving recovery food choices were: *nutritional composition* (35%, n=30), *easy to prepare* (34%, n=29) and, *it must fill them up* (13%, n=11). The most important sources of recovery nutrition were: coaches (35%, n=30); family and friends (24%, n=21). Non-compliance of daily carbohydrate intake as well as the timing and composition of the recovery meal could negatively impact performance when recovery time is short. Coaches, family and friends as educators should be included as part of nutritional education programmes.

***Keywords*:** student-athletes, power-sports, post-exercise nutrition

Adequate energy and macronutrients at the right time, assists athletes to train intensely, facilitate speedy muscle recovery, ensure metabolic adaptations to exercise and reduce risk of injury (Slater & Phillips, 2011; Claasen, 2011 and Kreider et al., 2010). Dehydration and carbohydrate depletion are the most likely contributors to fatigue in team sport exercise events (Jeukendrup, 2011).

Previous research (Lambert & Borreson, 2006, Venter et al., 2010) mentioned inadequate recovery "a training error" preventing athletes reaching peak performance. Stellingwerff et al., 2011 stated that contemporary training programmes of team sport athletes involves diverse routines, placing large physiological demands on players. Competition schedules are demanding, with little recovery time between sessions. Natural means of recovery over a period of time, are no longer adequate (Hawley, Burke & Deakin, 1997) and a more aggressive approach is proposed (Stellingwerff, 2011 and Holway et al., 2011), starting recovery nutrition within 30 minutes after exercise and combining carbohydrates and protein, facilitating quicker recovery between sessions.

Ideally, team sport athletes should consume 1-1.5g/kg BW of moderate to high glycaemic index carbohydrates in combination with 20-25g protein within 30 minutes of exercise to promote quick resynthesis and restoration of glycogen stores, minimize protein breakdown and assist in protein synthesis, especially when recovery time is short. (Kersick, Harvey & Stout et al., 2008; Wrigth, Claasen, 2004; Beelen, Burke, 2010; Kreider et al., 2010)

University students' social interactions are influenced by peers. The use of alcohol and fast food, student budgets, physical appearances and academic pressure, all influence their choices and daily activities (Hinton et al., 2004 and Jonnalagada et al., 2001).

The purpose of this study was to assess current knowledge and nutritional practices of this unique student group of team sport athletes from NMMU, evaluate how their practices compare to current literature recommendations as well as identify sources of recovery nutrition information they use as well as the factors driving their choices.

This study was approved by the Research Ethics Committee of Stellenbosch University (registration number S14/04/112).

METHODS

Participants

A total of 86 athletes from NMMU, voluntarily participated (40 male and 46 female). Participating students qualified for inclusion provided they were 18 years or older, competent in English and part of any registered NMMU- hockey (29 players), netball (26 players) or rugby (31 players) team. All 86 athletes gave informed written consent. No names were recorded to maintain anonymity. Confidentiality was protected by destroying telephone details after data collection was completed.

Questionnaire and data collection

Data collection took place during athletes' competitive season, August-November 2014. A 36-point multiple-choice questionnaire developed specifically for this study and validated by two dietitian experts for content was used to gather descriptive information. Face validity of questionnaire was tested during a pilot study prior to the main study at Crusaders rugby club, Port Elizabeth, involving 15 volunteering rugby players.

The researcher was present during all data collection times. Questionnaires were completed by those willing and meeting inclusion criteria prior to athletes' training sessions. Each participant received a copy of consent form.

The second part of study consisted of two 24-hour diet recalls done telephonically with 74 (86%) consenting athletes on random days, including both week and weekend days after completion of questionnaire. Diet recalls were analysed with FoodFinder III, a software programme developed by the Medical Research Council www.mrc.ac.za of South Africa to analyse food intake of individuals or groups. Diet recalls were analysed for daily energy, carbohydrate, protein and fat intake, the timing of the recovery meals as well as the macronutrient composition of the recovery meal. All data was captured in Microsoft Excel

2010. Variables of interest (e.g. daily and recovery carbohydrate and protein intake) were based on the average intake for each individual. Mean and standard deviation were calculated and summarized in Table 3. Statistical significance was set at $p < 0.05$.

Data analysis

Statistical analysis was done by Prof. D.G. Nel, Centre for Statistical Consultation, at Stellenbosch University, using Statistica. For quality control purposes, all dietary information collected and analysed using Foodfinder III were completed by the researcher self. For descriptive purposes, means and standard deviation were reported on the selected variables for each of the 74 participating individuals. Data analysis was done for the group as a whole as well as for the following groups: hockey, netball, rugby, male and female athletes. Results were compared to literature. (reference constants used: daily carbohydrate =5g/kg/day; daily protein =1.5g/kg/day, recovery carbohydrate =1g/kg/day; recovery protein =20g; time between exercise and recovery meal =30 minutes). Statistical significance was set at $p < 0.05$.

Results

Demographic information

The total group of NMMU athletes consisted of 86 players; 53% (n=46) female and 47% (n=40) male; 36% (n=31) rugby, 30% (n=26) netball and 34% (n= 29) hockey. Most, (90%; n=78) participants were between 19 and 24 years of age. Of the participating students, 61% (n=51) were white, 22% (n=19) were black and 17% (n=17) were coloured. All (n=86) participants has been practising in their sport for more than 5 years with the highest level of competition over the previous two years; (a) representing a provincial team 59% (n=51) or (b) representing a national team 13% (n=11).

Nutritional recovery strategies

Fifty five present of all players (n=47) trained twice daily. (65%, n=17) netball, (28%, n=8) hockey, and (71%, n=22) rugby. Most athletes (92%, n=79) reported exercise sessions greater than an hour. On a scale of 1-10, 70% (n=61) of athletes rated the level of intensity of training sessions as high: 7 (29%, n=25) and 8 (42%, n=36) out of 10.

Most athletes train longer than an hour, with 92% (n=79) drinking only water during training. Seven (8%) will drink a carbohydrate containing sports drink. One of the athletes doesn’t drink any fluids during training.

Athletes trained 3-4 times (47%, n=30) or 5-6 times (43% n=37) a week. Forty-one percent (n=35) included weight training 3 times or more per week.

The majority of athletes (59%, n=51) will have a recovery meal after exercise: netball 23%; n=6; hockey 59%, n=17 and rugby 90%, n=28. The nutrient identified as most important nutrient after exercise, was protein (48%; n=41). Fluid was rated the second most important (37%, n=37); carbohydrate third (6%, n=5) and least important were fat, vitamins & minerals (5%, n=4). After weight training sessions, protein (64%, n=55) remained top priority.

Supplements post-exercise (45%, n=39) were popular amongst many athletes especially rugby players (87%, n=27; netball 15%, n=4; hockey 28%, n=8). Some athletes (32%; n=28) only drank water. Athletes took supplements post-exercise, (a) *believing that they will recover faster* (21%, n=18) and (b) *for muscle gain* (22%, n=19), with protein shakes (40%, n=34) being their first choice and meal replacement shakes (8%, n=7) their second choice. Supplements used, were found satisfactory, with 51% (n=44) rating the supplement effective in meeting their expectations.

Recovery time between training sessions ranged from 5-12-(29%, n=25) to 13-24 hours (30%, n=26). Forty of the participants (47%) indicated they will have a recovery meal within 30 minutes after exercise, 33% (n=28) within an hour and only thirteen of the athletes (15%) will wait 1-2 hours after exercise. The 24-hour diet recalls however revealed a significant delay amongst all groups of 40 minutes (±28.28, p=004) before a recovery meal was taken, especially netball players, with an average time delay of 60 minutes (±27.15, p=0.00). Male athletes seem to be more compliant with literature recommendations, consuming a recovery meal 29 minutes (±18.93, p=0.67) after exercise.

A third (35%, n=30) of players will consume alcohol immediately after exercise at least once a week, 7% (n=6) will have alcohol 2-3 times per week and only one athlete will drink alcohol after every training session. See graph 1 for frequency of alcohol consumption post exercise amongst male and female team sport athletes. Six athletes, (7%) demonstrated binge drink behaviour post-exercise, consuming five or more units of alcohol at a time.

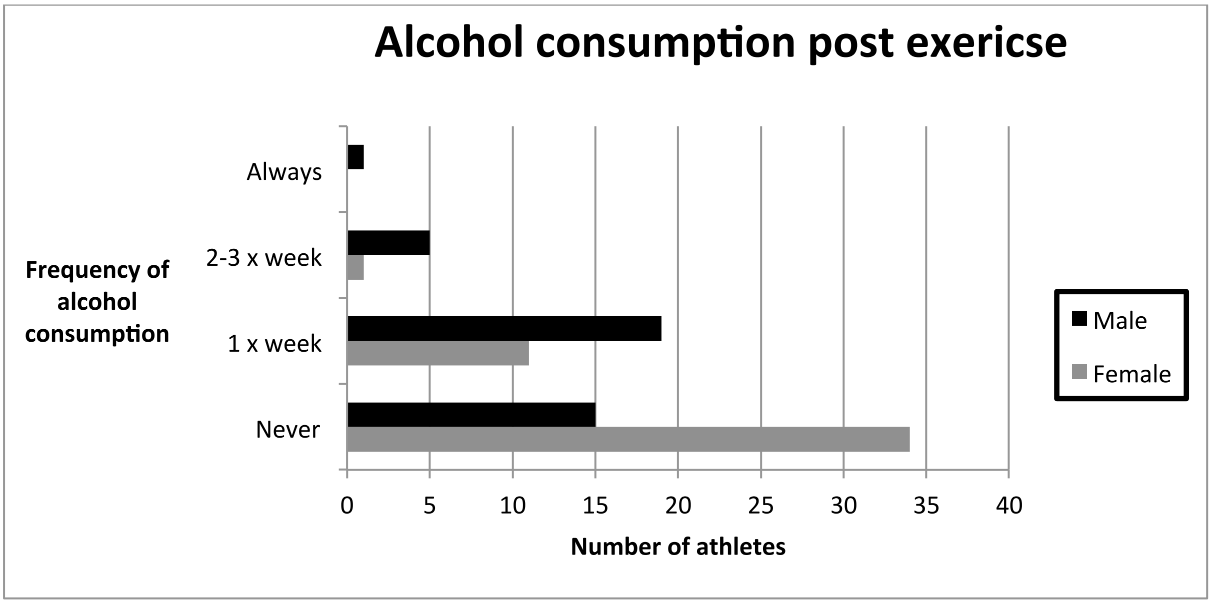

Figure 2: A graph indicating the frequency of alcohol consumptions after exercise amongst male and female athletes

Factors that drive recovery food choices

Most (64%, n=55) athletes indicated that their weight does not influence their choice of recovery meal. 50% (n=20) of male athletes however do consider their weight before choosing a recovery meal in comparison with only 22% (n=10) of female athletes. A third (33%, n=28) of the participants reported feeling tired 'all the time': netball 46%, n=12; hockey 17%, n=5 and rugby 35%, n=11. Only 7% (n=6) of athletes indicated a food allergy (pork, nuts and peanuts), or a medical condition (irritable bowel syndrome, low blood pressure and an underactive thyroid), influencing their food choices after exercise.

The majority of the players (86%, n=74) prepare their own recovery meals. Ten athletes' (12%) meals were prepared by family members. The three factors rated most important to recovery meal were: *nutritional composition* (35%, n=30), *easy to prepare* (34%, n=29) and it *must fill them up* (13%, n=11). An overview of the three sports modalities' feedback is summarized in Table 1.

Table 1: Choices of all athletes with regard to the important components associated with a recovery meal

	All Groups	Female	Male	Netball	Hockey	Rugby
Taste	7% (n=6)	7% (n=3)	8% (n=3)	7% (n=2)	4% (n=1)	10% (n=3)
Easy to prepare	34% (n=29)	46% (n=21)	20% (n=8)	50% (n=13)	41% (n=12)	13% (n=4)
Nutritional composition	35% (n=30)	20% (n=9)	52% (n=21)	8% (n=2)	35% (n=10)	58% (n=18)
Cost of the meal	6% (n=5)	4% (n=2)	8% (n=3)	8% (n=2)		10% (n=3)
Convenience	2% (n=2)	4% (n=2)		4% (n=1)	3% (n=1)	
Fill me up	13% (n=11)	15% (n=7)	10% (n=4)	19% (n=5)	14% (n=4)	6% (n=2)
Other**	3% (n=3)	4% (n=2)	2% (n=1)	4% (n=1)	3% (n=1)	3% (n=1)

** Other: Time it takes to prepare (n=1) ; no choice, depends on what family/mother prepared (n=2)

Athletes were asked to rate various factors according to importance in achieving exercise goals. Practice sessions with the team, endurance training sessions and rest were indicated as highly important to most. See a summary of the results in Table 2 where 1 = not important, and 5 = of critically important.

Table 2: A summary listing the important factors affecting performance as indicated by the players

	1 (not important)	2	3	4	5 (critical importance)
PRACTICE WITH TEAM					
Netball			4% (n=1)	31% (n=8)	65% (n=17)
Hockey			4% (n=1)	55% (n=16)	41% (n=12)
Rugby		3% (n=1)	3% (n=1)	32% (n=10)	61% (n=19)
ENDURANCE TRAINING					
Netball			12% (n=3)	57% (n=15)	31% (n=8)
Hockey			21% (n=6)	55% (n=16)	24% (n=7)
Rugby			10% (n=3)	55% (n=17)	35% (n=11)
STRENGTH TRAINING					
Netball		4% (n=1)	23% (n=6)	54% (n=14)	19% (n=5)
Hockey		7% (n=2)	45% (n=13)	34% (n=10)	14% (n=4)
Rugby			10% (n =3)	26% (n=8)	64% (n=20)
DIET (GENERAL)					
Netball	8% (n=2)	15% (n=4)	27% (n=7)	31% (n=8)	19% (n=5)
Hockey	3% (n=1)	3% (n=1)	24% (n=7)	38% (n=11)	31% (n=9)
Rugby	3% (n=1)		6% (n=2)	26% (n=8)	65% (n=20)
RECOVERY MEAL					
Netball	4% (n=1)	19% (n=5)	54% (n=14)	8% (n=2)	15% (n=4)
Hockey	7% (n=2)	21% (n=6)	28% (n=8)	41% (n=12)	3% (n=1)
Rugby			13% (n=4)	45% (n=14)	42% (n=13)
REST					
Netball		8% (n=2)	8% (n=2)	31% (n=8)	54% (n=14)
Hockey		7% (n=2)	24% (n=7)	24% (n=7)	45% (n=13)
Rugby		3% (n=1)	3% (n=1)	35% (n=11)	58% (n=18)
MOTIVATIONAL TALKS FROM COACH					
Netball	8% (n=2)	11% (n=3)	11% (n=3)	35% (n=9)	35% (n=9)
Hockey	7% (n=2)	10% (n=3)	38% (n=11)	41% (n=12)	3% (n=1)
Rugby	3% (n=1)	23% (n=7)	19% (n=6)	35% (n=11)	19% (n=6)
SUPPLEMENETS					
Netball	35% (n=9)	19% (n=5)	31% (n=8)	11% (n=3)	4% (n=1)
Hockey	41% (n=12)	7% (n=2)	38% (n=11)	10% (n=3)	3% (n=1)
Rugby			29% (n=9)	32% (n=10)	39% (n=12)
WEIGHT					
Netball		8% (n=2)	42% (n=11)	23% (n=6)	27% (n=7)
Hockey	7% (n=2)		48% (n=14)	34% (n=10)	10% (n=3)
Rugby	3% (n=1)	3% (n=1)	6% (n=2)	48% (n=15)	39% (n=12)

Source of nutritional information

Results indicated 35% (n=30) of participants received dietary advice from their coach and 24% (n=21) from family or friends. 16% (n=14) used the internet and 10% (n=9) used nutrition books. Other sources included: doctors (2%, n=2); physio- or massage-therapists (6%, n=5); magazines or newspapers (3%, n=2) or consulting a registered dietitian (4%, n=3). Female athletes (26%, n=12) were five times more likely to search the internet for advice than men (5%, n=2). Only a third of all the players (33%, n=28) consulted with a registered dietitian before of which 20% (n=9) were female athletes and 47% (n=19) were male athletes. All the athletes found the dietary advice from a registered dietitian helpful, and consequently made changes to their diet.

Current dietary intake and comparison to literature recommendations

Seventy-four (86%) athletes volunteered to take part in the 24 hour diet recall. Sixty-five (88%) of participating athletes exercised on the randomly selected days the diet recalls were done.

Percentage energy per day derived from fat was 33 ± 8.7; the total daily protein (g/kg/day) was 1.49 ± 0.81; the total daily carbohydrate (g/kg/day) intake was 2.57 ± 1.17; and the time (in minutes) between the exercise session and the recovery meal was 40.5 ±28.27; post-exercise recovery carbohydrate intake (g/kg) was 0.52 ± 0.42 and, post-exercise recovery protein intake (g) 29.96 ± 18.76.

Table 3 provides a summary of 24 hour diet recall mean values (averages) compared with literature recommendations.

Table 3: A comparison of the 24 hour diet recall mean values (averages) compared with literature recommendations

Variable	**Literature Recommendation**	**All Groups** (Std. Dev)	**Female** (Std. Dev)	**Male** (Std. Dev)	**Netball** (Std. Dev)	**Hockey** (Std. Dev)	**Rugby** (Std. Dev)
Fat as % of total daily energy (TE)	**20-35% of TE**	**33.61** (± 8.74)	**32.04** (± 8.5)	**35.66** (± 8.71)	**32.71** (± 8.69)	**31.76** (± 7.73)	**36.36** (± 9.37)
Total carbohydrate (g/kg/day)	**5-7**	**2.57** (± 1.17) ***P = 0.00***	**2.61** (± 1.27) ***P = 0.00***	**2.52** (± 1.05) ***P = 0.00***	**2.85** (± 1.37) ***P = 0.00***	**2.54** (± 1.19) ***P = 0.00***	**2.34** (± 0.93) ***P = 0.00***
Total protein (g/kg/day)	**1.2-1.7**	**1.50** (± 0.81) ***P = 0.02***	**1.15** (± 0.58) ***P = 0.61***	**1.95** (± 0.85) ***P = 0.00***	**1.01** (± 0.58) ***P = 0.12***	**1.42** (± 0.54) ***P=0.05***	**2.03** (± 0.92) ***P = 0.0001***
Minutes between exercise and recovery food	**<30**	**40.48** (± 28.28) ***P = 0.03***	**50.12** (± 31.01) ***P = 0.004***	**28.52** (± 18.92) ***P = 0.67***	**59.64** (± 27.15) ***P = 0.00***	**33.25** (± 30.02) ***P = 0.64***	**29.88** (± 19.03) ***P = 0.97***
Carbohydrate post-exercise (g/kg)	**1**	**0.52** (± 0.42) ***P = 0.00***	**0.65** (± 0.45) ***P = 0.00***	**0.34** (± 0.32) ***P = 0.00***	**0.72** (± 0.36) ***P = 0.001***	**0.49** (± 0.51) ***P = 0.0004***	**0.36** (± 0.33) ***P = 0.00***
Protein post-exercise (g)	**20-25**	**29.56** (± 18.76) ***P = 0.03***	**26.06** (± 15.01) **P = 0.67**	**34.79** (± 21.89) ***P = 0.02***	**26.72** (± 13.48) ***P = 0.56***	**25.31** (± 18.67) ***P = 0.94***	**36.21** (± 21.42) ***P = 0.015***

Average daily carbohydrate intake (g/kg BW) for all groups illustrated in Figure 3, was 2.57g/kg/day (2.23 ± 2.84), significantly ($p=0.00$) below recommended literature value (5-7g/kg/day) for team sport athletes. Category results (g/kg BW): males 2.52 (±1.05); females 2.61 (± 1.27), rugby 2.34 (±0.93), netball 2.85 (±1.37) and hockey 2.54 (± 1.19). $P<0.05$ in all categories indicated a significant insufficient daily carbohydrate intake for all participating groups.

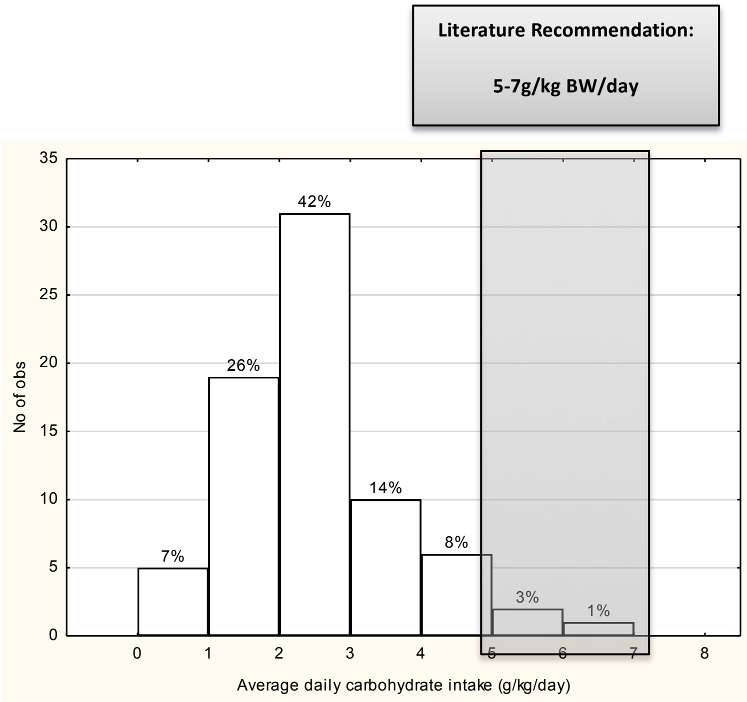

Figure 3: Average daily carbohydrate intake for all groups (g/kg BW/day)

All groups significantly failed (p=0.00) to meet recovery carbohydrate intake (g/kg BW) post-exercise, illustrated in Figure 4, with and average intake of 0.52g (± 0.42) compared to the literature recommendation of 1g/kg BW. Average category recovery carbohydrate intake (g/kg) was: male 0.34 (±0.32), female 0.65 (±0.45), rugby 0.36 (±0.33), netball 0.72 (±0.36) and hockey 0.49 (±0.51).

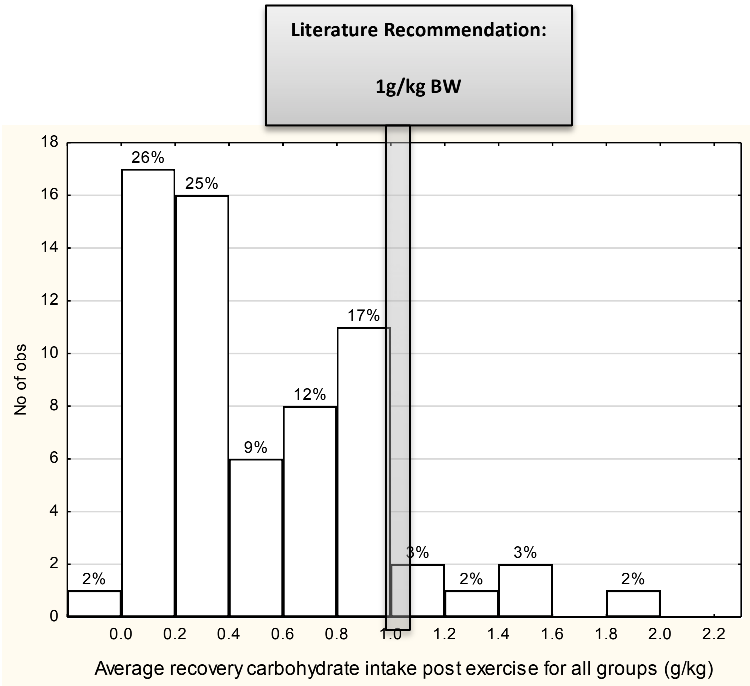

Figure 4: Average recovery carbohydrate intake post exercise for all groups (g/kg BW)

All groups met daily protein recommendations for team sport athletes. The daily protein intake (g/kg/day) of male athletes (1.95 ± 0.85) ($p=0.00$) and rugby players' (2.03 ± 0.92) were significantly ($p=0.00$) above the recommended range for power sport athletes (1.2-1.7g/kg BW) compared to slightly lower protein consumption (g/kg/day) by female athletes of 1.15 (± 0.58), netball 1.01 (±0.58) and hockey players 1.42 (±0.52).

Protein needs (grams) post-exercise were met or exceeded by all groups with an average intake of 29.96g (±18.75), significantly ($p=0.03$) more than the literature recommendation of 20-25g, confirming the results from the questionnaire were athletes valued protein as the most important nutrient post-exercise.

The average time delay (minutes) between exercise and recovery meal were: male 28.53 (±18.92), rugby 29.88 (±19.03) and hockey 33 (±30.02), all complying with literature recommendations of taking the recovery meal within 30 minutes after exercise. Female athletes' average time delay between exercise and recovery meal was 50.12 minutes (± 31.02) ($p=0.004$) and netball players 59.64 (±27.15) showing a significant delay between exercise and recovery food intake amongst females.

Discussion

This study successfully determined the daily macronutrient consumption as well as the timing and the macronutrient consumption of the recovery meal, of participating team sport athletes from NMMU. The study identified coaches, family and friends as well as the internet as the most important sources of dietary information used by this group of university going team sport athletes.

All NMMU team sport athletes participating in this study failed to meet the recommended daily carbohydrate intake as well as the recommended recovery carbohydrate after exercise necessary to support optimal recovery.

To ensure that athletes train and recover effectively and enhance their competitive performance, Potgieter (2013), reiterated the importance of scientific evidence-based guidelines to athletes, focussing on the quality, structure and timing of food intake.

Dehydration and carbohydrate depletion are the most likely contributors of fatigue, including loss of concentration and execution of motor skills in exercise events lasting 30 minutes or longer (Jeukendrup, 2011 & 2014), very relevant to team sport athletes training regimes.

The current study found most of the athletes, consumed only water during training sessions with no additional intake of carbohydrates and insufficient carbohydrates after exercise to support the quick recovery that is needed. Field based team sports require a combination of speed, power, endurance and variable motor skills with a unique utilization of substrates for energy (Venter et al., 2010). Burke et al., 2004 reported team sport activities rely heavily on muscle glycogen to provide working muscles with energy and therefore these athletes need to be aware of consuming adequate carbohydrates before, during and after exercise.

Participants in this study indicated protein to be the most important nutrient post-exercise, lacking sufficient carbohydrates in the recovery meal. Past surveys (Beelen et al., 2010, Bernadot, 2006) found a similar overreliance on protein and fat to reach optimal performance, demonstrating a lack of knowledge in the basics of exercise recovery nutrition. Excess protein intake post exercise, more than the recommended 20-25g after exercise, will not promote further protein synthesis (Slater & Phillips, 2011), but most likely will be at the expense of the necessary carbohydrates to optimise speedy glycogen resynthesis, especially when recovery times between exercise sessions are less than eight hours (Burke et al., 2011).

A significant delay between exercise and recovery food was found amongst the female athletes further delaying the recovery process. Many factors could delay recovery meals of athletes. (Meyer, et al., 2011; Stellingwerf, 2011). Recovery nutrition should start immediately after exercise, ideally within 30 minutes post-exercise. Co-ingestion with protein during the early recovery phase has shown positive results on muscle glycogen and muscle protein regeneration between exercise sessions (Wright & Claasen, 2004; Burke et al., 2011). Inadequate intake over repeated days will lead to a gradual depletion of glycogen stores and a subsequent impairment of athletic performance and overall wellbeing leaving athletes feeling tired all the time as indicated by some athletes (33%, n=28) in this study.

Proper assessment of student athletes' circumstantial limitations is necessary and should be addressed in collaboration with a registered sports dietitian providing applicable and practical sports specific advice. Very few of the athletes that participated in this study had consulted with a registered dietitian before, despite most athletes' emphasizing the importance of the composition of their recovery meals.

Previous research found a positive correlation between nutrition knowledge and diet quality, especially amongst female athletes (Worseley, 2002, Abood, 2004, & Spronk, 2015). Resources from academic institutions should be made available to athletes to lay a good foundation in the fundamentals of sport and recovery nutrition. Athletes rely heavily on sports nutrition advice from coaches, family and friends and therefore education on these nutrition principles should reach further than just the athletes but also include these members whose influence impact on the wellbeing and ultimately performance of the players.

A large number of players that participated in this study choose to use a supplement as recovery meal. Athletes sometimes look for quick fixes to support busy training and competition schedules leading to an over reliance on often non-scientifically supported performance enhancing supplements (Maughan et al., 2011, & Claassen, 2011). Interestingly, a study done in the United States of America by Cramer and his colleagues (2015), found no difference on the effective replenishment of glycogen stores after exercise when either commercially available sport supplements or fast foods were consumed. Whole foods in less affluent countries and most likely better suited to the average student athletes' budget, would provide a convenient and more economical recovery meal-alternative to expensive sport supplements.

Team sport athletes have a known tendency to socialize and consume alcohol after events whether it is seen as a reward for hard work they put into their training or as an integral part of team sport club culture (Barnes, 2014; NIAAA, 2013). A third of participants indicated they will consume alcohol at least once a week immediately after exercise. Alcohol consumption is part of student life.

Surveys previously done by the National Institute of Alcoholism and Abuse in the United States has found that 80% of all university going students consume alcohol with 50% reporting episodes of binge drinking within the past 14 days (NIAAA, 2013). College-going athletes indicated a higher incidence of alcohol use and binge drinking opportunities than their sedentary friends. This puts the student athlete at an even greater risk for alcohol-related harm (Barnes, 2014). The binge drinking numbers from this study however, were low.

Alcohol reduces athletes' reaction time, accuracy, hand-eye coordination, strength, power and endurance. Alcohol further negatively affects sleep, impairs balance and body temperature regulation with a vasodilator effect, potentially increasing bleeding time and swelling post-exercise delaying, recovery time and healing of soft tissue injuries (Barnes, 2014; Meltzer & Fuller, 2005). Alcohol in large quantities after exercise also has a negative effect on the restoration of fluid balance via its diuretic effect (Meltzer & Fuller, 2005). Dehydration has been shown to impair performance and it is vital for athletes to consume adequate fluids and electrolytes after exercise to restore fluid balance before their next training event (Bernadot, 2006; Barnes, 2014). Advice regarding alcohol consumption and the use of low-alcohol beers and beverages post exercise should form part of all nutritional education strategies to university team sport athletes (Debrow, 2013).

There might be many reasons why athletes did not follow literature guidelines with regards to the daily carbohydrate intake, and specifically the carbohydrate and protein content of their recovery meals as well as the timing of the recovery meal.

The most likely reason would be a lack of knowledge in the basics of recovery nutrition and general misconceptions in the field of nutrition, resulting in uninformed bad choices. Other factors identified, likely to contribute to the failed application of recovery nutritional guidelines in this unique student group is their personal circumstances; being college going students, dependent on academic schedules, time constraints, tight budgets, their limited food choices and dependence on food preparation done by family members, availability of different foods as well as strong influence by peers and trends.

Conclusions and practical application

Team sport athletes from NMMU failed to meet recovery and daily carbohydrate intake as per literature recommendations. Recovery protein was met by all groups with an average intake significantly more than literature recommendations. Most athletes, with the exception of females, comply with the literature guidelines regards to the timing of the recovery meal, having their recovery food within thirty minutes after exercise.

Nutritional recovery after exercise involves the restoration of muscle and liver glycogen stores, resynthesis, repair and adaptation of muscle tissue and the replacement of lost fluid and electrolytes between training sessions and becomes even more important for the team sport athlete competing in multiple workouts within a short period of time. The quality, structure and timing of the recovery meal is vital to ensure that athletes train more effectively, enhance their competitive performance, induce metabolic adaptations to training and at the same time, reduce their risk of injury and illness. Failing to follow literature guidelines for recovery carbohydrates as well as daily carbohydrate requirements as was found in this study, will prevent athletes and teams from reaching their peak performance.

The researcher would like to conclude that contemporary training and competition schedules and the unique circumstances of university athletes should be considered in the structuring of these athletes nutrition recovery strategies. A more aggressive approach to recovery nutrition should be taught, starting recovery nutrition as early as possible after exercise, to facilitate the speedy recovery between sessions. Nutritional intervention programmes should focus on both theory as well as the practical application of recovery nutrition advice and adapted to the students' circumstantial needs and budget. Better insight into the importance of carbohydrate, protein and the timing of the recovery meal will improve knowledge and self-efficacy of the student athlete, and as a result lead to better application and compliance, ultimately improving the performance of the individual athlete and their team.

Directions for future research

Recommendations for future would be to include team sport athletes from other universities in South Africa. A larger population including all regions would give more insight into the nutritional recovery strategies used by team sport athletes in South Africa as a whole, which ultimately could be compared to the nutritional recovery strategies used by the specific leading international teams.

The two day 24-hour diet recall is acknowledged as a limitation to the study. Even though most students follow quite monotonous daily diets, extending the two day, 24-hour diet recall to a minimum of three days, will provide researchers with more accurate habitual dietary intake of student team sport athletes.

Future research around the use of customized smart phone applications, in collecting sports nutrition data from athletes in real-time, could potentially be an interactive tool medical support teams can use to communicate and collect accurate data from individuals and teams.

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Authorship

The principle researcher, M.A. Malherbe developed the idea and the protocol, planned the study, undertook all data collection and capturing of data, and analysed data with the assistance of statistician, Prof. D.G. Nel, interpreted the data and drafted the thesis. Dr. S. Potgieter and Dr. R.E. Venter provided input at all stages and revised the protocol and thesis.

Declaration

I declare that the entirety of the work is my own, original work that I am the sole author thereof (unless otherwise stated) with no conflicts of interest to declare.

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CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

High intensity performance by team sport athletes require a combination of speed, power, endurance and variable motor skills which will be impaired by low pre-exercise glycogen levels. Optimal intake of recovery nutrients such as carbohydrate, protein and fluid is vital to prevent fatigue, including loss of concentration and execution of motor skills especially in team sport events lasting longer than thirty minutes with short recovery sessions between training..[21,23,35] Field-based team sport activities rely heavily on muscle glycogen to provide working muscles with energy and athletes should consume an adequate amount of carbohydrates before, during and after exercise.

This study found that in all three sports modalities, as well as sub categories for male and female, team sport athletes failed to meet daily carbohydrate intake as well as the necessary carbohydrate post-exercise as recommended in literature to support optimum recovery. Most athletes consumed only water during training sessions with no additional intake of carbohydrates during training even though the majority of sessions lasted longer than an hour. Similar results were found by Wierniuk and Wlodarek (2013) when dietary intake of males, participating in aerobic exercise, were reviewed and found to be insufficient for energy and carbohydrates compared to literature recommendations, stressing the importance of sports nutrition counselling and education.[71] The significant delay between exercise and the recovery meal, found amongst female athletes, will further delay the recovery process.

Team sport athletes that participated in this study placed the greatest importance on protein in the recovery meal, confirming similar results from previous research by Holway et al (2011) where power sport athletes consume excess amounts of protein after exercise.[26] Excess protein intake post exercise, more than the recommended 20-25g after exercise, will not promote further protein synthesis, but most likely will be at the expense of the necessary carbohydrates to optimise speedy glycogen resynthesis, especially important when recovery times between exercise sessions are less than eight hours.[3,16,43] A significant delay between exercise and recovery food was found amongst the female athletes further delaying the recovery process.

Recovery meals need to be easily available and quick to prepare or athletes might be tempted to rely on often non-scientifically supported performance enhancing supplements to full fill this need[19,29] In a country like South Africa, the student population is made up of various socio-economic groups. Specific attention should be given to the practical implementation of recovery nutrition advice. These should include options for convenient wholesome foods, such as flavoured bovine milk, that appeal to young student athletes as sustainable alternatives to expensive sport supplements.[4,43,73]

Alcohol consumption is part of student life but could potentially be detrimental to the team sport athlete's performance if used inappropriately by reducing reaction time, accuracy, hand-eye coordination, strength, power and endurance. Alcohol further impairs balance and body temperature regulation with a vasodilator effect potentially increasing bleeding time and swelling after exercise delaying recovery time and healing of soft tissue injuries.[39] Even though binge drinking numbers were low amongst this group of team sport athletes, a third of all participants indicated that they will consume alcohol at least once a week immediately after exercise and it is thus important that advice with regards to the consumption of alcohol and low alcohol beverages be incorporated in all nutritional education strategies to university team sport athletes.

Literature recommend recovery nutrition to start immediately after exercise, ideally within 30 minutes after exercise.[4,18] Co-ingestion with protein during the early recovery phase has shown positive results on muscle glycogen and muscle protein regeneration between exercise sessions. Male, rugby and hockey athletes complied with literature recommendations, yet the female athletes demonstrated a significant delay between exercise and the recovery meal.

There might be many reasons why the athletes didn't follow literature guidelines. This is most likely due to the lack of knowledge in the basics of recovery nutrition and existing misconceptions in the field of nutrition, resulting in uninformed choices. Other circumstantial factors identified by the researcher that influenced the recovery meal were: time constraints, athletes looking for food that is easy to prepare, something they can have on the run; tight budgets, food choices need to be inexpensive and fill them up; limited options, students being dependent on family with regards to meal preparation and choice of food.

Even though athletes placed high importance on the composition of the recovery meal, very few of the student athletes have consulted with a registered dietitian for sports nutrition advice before, identifying coaches, family and friends as the most likely sources of sports nutrition advice the athletes use. Research previously done by Spronk et al (2014) with 101 Australian athletes (72% team sports athletes) evaluated the relationship between nutritional knowledge and the dietary quality of these athletes. Scores on nutritional knowledge and diet quality were on average 5% better for all athletes who had previous dietetic intervention. This supports the researcher's recommendation to introduce nutritional intervention programmes to athletes and coaches, that will be led by a qualified nutritional professional, aiming to improve knowledge, and diet quality to optimize performance.[27,72] Key players in the application and education process of recovery nutrition such as coaching staff, family and close friends should therefore be included as part of all nutritional education programmes at universities. Educational sessions should include practical, age- and sport-specific advice and life skills, designed to accommodate a student budget and student life circumstances. Coaches should receive special training to be equipped with the skills to guide athletes through the basics of the nutritional recovery processes and make resources such as individualized sessions with interdisciplinary team members, like a registered sports dietitian, available to all. Better understanding and insight into the importance of carbohydrate, protein, fluid and the timing of the recovery meal, most likely would lead to better application, compliance and improved performance of individuals and team sport athletes.

Ideally, the findings from this study could lead to the development of a nutritional recovery plan specific to this unique student group of athletes. Nutritional recovery plans can then be adapted for each sport modality and gender, and can be implemented and used by team sport players and coaches to educate and ensure adequate awareness of the relationship between physical activity and diet, optimizing performance and eliminating dietary misconceptions associated with unbalanced dietary regimes.[75,76]

5.2 Conclusions

The aim of this study was to determine the nutritional recovery strategies used by field based team sport athletes participating in rugby, hockey and netball training at NMMU and compare dietary intake of macronutrients to literature recommendations. A further objective was to identify the most important factors influencing this group of athletes' recovery food choices as well as the usual sources of recovery nutrition advice they use.

This study found that team sport athletes from NMMU met literature recommendations for total daily- and recovery protein consumption, but did not comply with literature recovery nutrition guidelines for total daily carbohydrates and recovery carbohydrate intake, proving the null-hypothesis partly wrong. Male athletes comply with the literature guidelines regards to the timing of the recovery meal, having their recovery food within thirty minutes after exercise. The significant delay of the recovery meal after exercise, demonstrated by female athletes will negatively impact recovery time after exercise, important to athletes when recovery times are less than eight hours between sessions. Failing to follow literature guidelines for recovery carbohydrates as well as daily carbohydrate requirements and the timing of the recovery meal, as was found in this study, will prevent athletes and teams from reaching their peak performance.

Coaches, family and friends, were identified as the most influential sources of recovery nutrition advice. Availability, convenience and meal satiety are extremely important to the student team sport athlete when choosing a recovery meal and should be taken into consideration in the planning of their recovery schedules. The use of a supplement, mostly protein shakes, was popular with 45% of participating athletes including a supplement as part of their recovery nutrition regime, believing that it will assist in quicker recovery after exercise and gain of muscle mass. Advice to student team sport athletes should be practical, tailored by a registered dietitian, to the individual's needs and include guidelines with regards to the use of supplements and alcohol and perhaps the use of low alcohol beverages as part of the student athlete's diet.

The importance of early recovery nutrition intervention was re-iterated with most of the players that participated in this study indicating that they trained twice daily and 92% reported exercise sessions greater than an hour. The demanding training and competition schedules of the modern day team sport athletes require an aggressive sport specific nutrition recovery plan, starting recovery nutrition as early as possible after exercise and adapted to meet the university student circumstances. Better insight into the importance of carbohydrate, protein and the timing of the recovery meal will improving knowledge and self-efficacy of the student athlete, and as a result lead to better application and compliance, ultimately improving the performance of the individual athlete and their team.

Most of the participating athletes prepare their own meals. Important factors such as the nutritional composition of the food, the ease at which the meal can be prepared and whether it will fill them up, were identified with this survey, influencing the university going team sport athlete's choice of recover meal. These should be considered and individualize according to each athletes personal circumstances.

The author would like to conclude that the focus areas identified and described above, will assist coaches, sports managers and health care professionals working with student team sport athletes to tailor dietary advice. Sport and age appropriate dietary advice should be part of the team sports 'athlete's recovery regime to facilitate faster recovery times, better physiological adaptations to exercise and better health in general.

5.3 Limitations and recommendations

A limitation to the study would be the total sample size (n=86) of which seventy-four (86%) athletes completed the two day dietary recalls. Recommendations for future would be to include team sport athletes from other universities in South Africa. A larger population including all regions would give more insight into the nutritional recovery strategies used by team sport athletes in South Africa as a whole, which ultimately could be compared to the nutritional recovery strategies used by the sport specific leading international teams.

Another limitation would be the relative narrow observation window period of two random days selected by the researcher to collect an individual's habitual dietary intake and their recovery nutrition strategy. Extending the two day, 24-hour diet recalls over longer period of times to three or more 24 hour diet recalls, will provide researchers with more accurate habitual dietary intake of student team sport athletes.

Future research around the use of customized smart phone applications, in collecting sports nutrition data from athletes in real-time, could potentially be an interactive tool medical support teams can use to communicate and collect accurate data from individuals and teams.

Further research in the field of "fat-adaptation" and how the "ketosis-adapted" athlete's performance and recovery is affected by a high fat, low carbohydrate diet, will be of interest.

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ADDENDA

Addenda A

Questionnaire

A SURVEY TO DETERMINE NUTRITIONAL RECOVERY PRACTICES OF TEAM SPORT ATHLETES TRAINING AT THE NELSON MANDELA BAY METROPOLITAN UNIVERSITY

The purpose of this study is to investigate nutritional practices of team sport athletes after training and competition.

Findings from this study will be used to identify possible areas needed for further education and the need for a formal nutritional recovery plan to be used amongst team sport players in South Africa.

Participation in this study is voluntary and all information attained will be kept anonymous.

Please ensure that you have read, understood and signed the consent form before you complete this questionnaire.

QUESTIONAIRE

<u>Please circle **ONE** answer per question:</u>

1. Gender:
   - 1.1 male
   - 1.2 female

2. Main sport:
   - 2.1 rugby
   - 2.2 netball
   - 2.3 hockey
   - 2.4 soccer

3. Age:
   - 3.1 < 18 years
   - 3.2 19-24 years
   - 3.3 25-30 years
   - 3.4 > 30 years

4. Ethnic origin:
   - 4.1 Black
   - 4.2 White
   - 4.3 Coloured
   - 4.4 Indian

5. How many years have you been participating in your sport?
   - 5.1 < 1 year
   - 5.2 1-2 years
   - 5.3 3-5 years
   - 5.4 > 5 years

6. Highest level competed in during the last 2 years:
   - 6.1 social
   - 6.2 club
   - 6.3 provincial e.g. EP (Eastern Province)
   - 6.4 national
   - 6.5 international

7 Where do you get most of your sports nutrition advice from?

7.1 coach or trainer
7.2 doctor
7.3 physiotherapist or massage therapist
7.4 internet
7.5 friends and family
7.6 magazines/news paper
7.7 registered dietitian
7.8 nutrition books

8 Have you ever consulted a Registered Dietitian for sports nutrition advice?

8.1 yes
8.2 no

9 If answered "yes" in Q8…. Did you adjust your diet after your consultation with the dietitian?

9.1 yes
9.2 no
9.3 I have not consulted with a dietitian before

10 If you have consulted with registered dietitian before, was the information given by dietitian helpful?

10.1 yes
10.2 no
10.3 I have never consulted with a dietitian before

11 How many times a day do you exercise?

11.1 I don't exercise every day
11.2 1 x a day
11.3 2 x day
11.4 3 x day or more

12 How long will a typical training session be?

12.1 less than hour

12.2 more than hour

13 At what intensity on a scale of 1-10 will you train during your normal training session?

(where 10 = 100% VO2 max)

13.1 1

13.2 2

13.3 3

13.4 4

13.5 5

13.6 6

13.7 7

13.8 8

13.9 9

13.10 10

14 What will you typically drink during training?

11.1 water

11.2 fruit juice

11.3 carbohydrate containing sports drink e.g. Energade

11.5 milk

11.6 nothing

11.7 protein shake

11.8 other…….please specify_____________ __

15 How many weights training sessions will you do per week?

15.1 I don't train with weights

15.2 1 x week

15.3 2 x week

15.4 3 x week

15.5 > 3 x week

16 How many times in a week will you exercise in general, including competition days?

16.1 1-2 x week

16.2 3-4 x week

16.3 5-6 x week

16.4 everyday

17 Who prepare your recovery meals after exercise?

17.1 yourself

17.2 family

17.3 friends

17.4 partner

17.5 university residence

17.6 other e.g. 'ready-made-meal'……… please specify

18 What is most important to you when you choose a meal after exercise?

18.1 taste

18.2 easy to prepare

18.3 nutritional composition

18.4 cost/price of the meal

18.5 convenience, will have it on the run/whilst travelling

18.6 to fill me up

18.7 other……..please specify_______________________

19 What aspect of your recovery meal is most important to you after a <u>normal training</u> session?

19.1 protein

19.2 carbohydrate

19.3 vitamins/minerals

19.4 fluid

19.5 fat

20 After you have <u>exercise with weights</u>, what aspect of your recovery meal is most important to you?

20.1 protein
20.2 carbohydrate
20.3 vitamins/minerals
20.4 fluid
20.5 fat
20.6 I do not train with weights

21 How much time to you normally have before your next training session?

21.1 less than an hour
21.2 1-2 hours
21.3 3-4 hours
21.4 5-12 hours
21.5 13-24 hours

22 Do you eat a recovery meal/shake/snack after exercise?

22.1 yes
22.2 no

23 How soon after training will you eat something?

23.1 within 30 minutes after exercise
23.2 30-60 minutes after exercise
23.3 1-2 hours after exercise
23.4 3 hours or longer
23.5 whenever

24 After exercise, I will typically have:

24.1 a protein shake

24.2 a sports drink e.g. Energade or Powerade

24.3 just water

24.4 a meal replacement shake e.g. Herbal Life or Nutren Active

24.5 a meal e.g. pasta with chicken breast or tuna or sandwich

24.6 nothing, You will wait until the next meal

24.7 Other…Please specify:________________________________

25 Do you consider your weight before you eat after exercise?

25.1 yes

25.2 no

26 Do feel tired all the time?

26.1 yes

26.2 no

27 Do you have any food allergies or medical conditions that influence your food choices after exercise?

27.1 Yes Please list: ______________________

27.2 No

28 Do you use supplements to recovery from exercise?

28.1 no

28.2 yes

29 If you use a supplement to recovery after exercise, what type of supplements do you use?

29.1 meal replacement shake
29.2 protein shake
29.3 energy drink e.g. Energade or Coke
29.4 recovery shake with creatine
29.5 multi-vitamin/mineral
29.6 other; please specify___________________
29.7 I do not use a supplement

30 If you use a supplement to recover after exercise, what would be your reason for taking this supplement?

30.1 muscle gain
30.2 energy
30.3 weight loss
30.4 faster recovery
30.5 rehydration
30.6 cramps
30.7 increased speed
30.8 ability to train harder
30.9 other; please specify______________________
30.10 i do not use a supplement

31 Has this supplement given you the results you are after?

31.1 yes
31.2 no
31.3 I do not use a supplement

32 Rate how important you think each of the following is in helping you achieve your exercise goals.

1 = not important to me

2 = it helps a little

3 = fairly important

4 = very important

5 = critical, cannot achieve optimum performance without it

A: practice sessions with the team	1	2	3	4	5
B: endurance training	1	2	3	4	5
C: strength training	1	2	3	4	5
D: diet in general	1	2	3	4	5
E: what I eat after exercise	1	2	3	4	5
F: rest	1	2	3	4	5
G: motivational talks from coach	1	2	3	4	5
H: supplements I take	1	2	3	4	5
I: my weight	1	2	3	4	5

33 How often do you consume alcohol immediately after a match or practice session?

32.1	Never
32.2	1 x week
32.3	2-3 x week
32.4	Always

34 If you do have a drink after exercise, please indicate how many drinks do you have on average after exercise?

(1 unit = 340ml beer, 1 tot hard liquor or ½ glass of wine)

32.1.	0 units
32.2	1-2 units
32.3	3-4 units
32.4	5 or more units

35. What is your **weight?** ______________________

36: **Telephone number**: ______________________

THANK YOU FOR TAKING THE TIME TO COMPLETE THE QUESTIONAIRE

Addenda B

Consent Form

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

Nutritional recovery practices of team sport athletes training at Nelson Mandela Bay Metropolitan University, South Africa

REFERENCE NUMBER: S14/05/112

PRINCIPAL INVESTIGATOR: Marilette Malherbe

ADDRESS: 134 Kempston Road, Korsten, Port Elizabeth, 6070

CONTACT NUMBER: 082 954 3024

You are being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the **Health Research Ethics Committee at Stellenbosch University** and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

What is this research study all about?

This survey aims to investigate what foods soccer, netball, rugby and hockey players choose to eat or drink, especially after exercise and the reasons for choosing these specific foods.

The researcher will then use this information to identify focus areas for improving performance and recovery amongst this population of university students.

Specifically the following questions will be answered:

1. How long you have been participating in this sport?
2. How many hours do you train a day or per week?
3. If you have had any advice with regards to your diet?
4. Where do you get most of your dietary advice from?
5. What foods you regard as most important to you after exercise if any?
6. What factors influence your choice of food after exercise?
7. Alcohol consumption

Why have you been invited to participate?

This study specifically looks at the nutritional recovery strategies used by team sport athletes at university.

All 57 rugby, netball, soccer and hockey teams registered at the Nelson Mandela Bay Metropolitan University 2014 have been invited to participate in the survey voluntarily.

What will your responsibilities be?

Your participation requires the completion of a short questionnaire in a multiple choice format that should not take more than 10 minutes to complete.

The principle researcher would like to compare actual food intake of athletes to the current literature. In order to do the researcher will give you a phone call and ask you what foods you ate that day. She will then use all the information gathered from all participants to compare with current literature in order to make future recommendations. This will be done at the researchers cost. There is no right or wrong answer to any questions. Your answers will be kept strict confidential.

Will you benefit from taking part in this research?

There are no personal benefits or payment for participating in the study; however data obtained will be used to improve knowledge about the level of training, the availability of nutritional resources to athletes and the important factors that influence post exercise recovery food choices.

This will provide valuable information to coaches, sport physicians and dietitians as well as to the university, assisting in educational programmes and making resources available that could ultimately lead to improved performance.

Are there in risks involved in your taking part in this research?

No, there is no risk involved. You will simply be asked to complete the 10 minute questionnaire and answer a few questions over the phone. There will also be no cost to you for part taking in the survey.

If you do not agree to take part, what alternatives do you have?

Participation in this survey is completely voluntarily. Should you decide not to take part in this study, this will not count against you in any way.

Who will have access to my completed questionnaire?

Only the principle researcher will have access to the original questionnaires completed by you. Other personnel e.g. statisticians will have access to the raw data (no names) The final report created from the results will not identify any individual who has participated in the survey.

Will you be paid to take part in this study and are there any costs involved?

No you will not be paid to take part in the study. There will be no costs involved for you, if you do take part.

Is there any thing else that you should know?

You can contact the Health Research Ethics Committee at 021-938 9207 if you have any concerns or complaints that have not been adequately addressed by your researcher. Study leaders may visit the researcher during time of data collection to ensure sound research principles are followed.

You will receive a copy of this information and consent form for your own records.

Declaration by participant

By signing below, I (name)………………………………..………… agree to take part in a research study entitled **Nutritional recovery practices of team sport athletes training at Nelson Mandela Bay Metropolitan University, South Africa**

I declare that:

- I have read or had read to me this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) **NMMU, PE** on

....

Signature of participant **Signature of witness**

Declaration by investigator

I ***Marilette Malherbe*** declares that:

- I explained the information in this document the above
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did not use an interpreter. (*If a interpreter is used then the interpreter must sign the declaration below.*

Signed at (*place*) **NMMU, PE** 3/11/ 2014..

....

Signature of investigator **Signature of witness**

Addenda C

Author Guidelines

Submission Guidelines quoted directly of International Journal of Sport Nutrition and Exercise Metabolism's website:

"**Scope**: *IJSNEM* publishes a range of different types of papers, including original research investigations, rapid communications, reviews, methodology reviews and case studies. The common goal is to promote new and high-impact insights into sport nutrition and exercise metabolism, as well as the application of the principles of biochemistry, physiology, and nutrition to sport and exercise. Original research with human subjects will be emphasized, although relevant research with animal models may be published. Case studies that demonstrate systematic, rather than casual, observations made with appropriate instrumentation, as well as articles with clinical application, will be included. Please see the separate author guidelines for each type of article. Note that even when papers are commissioned, each will undergo peer review, and unless prior authorisation has been provided by the Editor in chief or Special Projects editor, all papers must conform to the submission guidelines.

General guidelines for manuscript preparation

Language: All manuscripts must be written in English, with attention to concise language, a logical structure and flow of information, and correct grammatical style. We appreciate that many of our authors do not speak English as their first language and may need assistance to reach the standards required by the journal. In addition, some younger authors may not be experienced in scientific writing styles. Since manuscripts that fail to meet the journal's writing standards **will not** be sent out for review, such authors should ensure that they seek assistance from native English speakers and/or experienced colleagues prior to submitting their paper. Many journals acknowledge the existence of companies which offer professional editing services. An example of such a service can be found at **www.aje.com/**. This information does not constitute endorsement of this service. Use of an editorial service is at the discretion and cost of the authors, and will not guarantee acceptance for publication in IJSNEM.

File type: All manuscripts should be submitted in Microsoft Word or another comparable word processing software program. Figure files can be submitted in other formats (see

Figures and tables section below).

Format: Manuscripts should include the following elements in the order indicated: 1. Title page, 2. Abstract and keywords, 3. Text, 4. Acknowledgments, authorships, declarations of funding sources and conflicts of interest, 5. References, 6. Tables, 7. Figure legends, and 8. Figures. The title page should include names and addresses of all authors and full contact details for the corresponding author. Manuscripts should be double-spaced with wide margins and should include continuous line numbers in the text. Pages should be numbered in the upper right corner. Each Table and Figure should be presented on a separate page; headings should be included with each Table while figure legends should be aggregated on a separate page at the conclusion of references.

Title page: The manuscript must have a separate title page including title of article, name(s) of author(s), institutional affiliation(s), running head, and e-mail address and phone number of the author who is to receive the galleys. The title of the paper should be limited to 25 words. The running title (an abbreviated version of the title that is printed at the top of the page in the formatted journal version) should be limited to 8 words.

Abstract: The abstract should be a maximum of 250 words and be written in one continuous paragraph without subheadings. Abstracts should showcase the new information presented in the paper, either in the form of original research data or as a novel insight into an established issue. Abstracts reporting original research must include sufficient data to support any conclusion reached. It is not satisfactory to simply describe what was found (such as, "the treatment group improved more than the control group") nor to say simply that "the results will be discussed". References should not be included.

Keywords: three keywords or phrases not included in the manuscript title.

Acknowledgement of support: All funding sources and potential conflicts of interest should be declared at the end of the text.

Authorship guidelines: Only individuals, who have made a substantial contribution to the manuscript, as described below, should be credited as co-authors. The Journals Division at Human Kinetics adheres to the criteria for authorship as outlined by the International Committee of Medical Journal Editors (Uniform requirements for manuscripts submitted to biomedical journals. *New England Journal of Medicine,* 1991, 324, 424–428). Each author should have participated sufficiently in the work to take public responsibility for the content. Authorship credit should be based only on substantial contributions to (1) conception and design, or collection, analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content; *and* (3) final approval of the version to be published. Individuals who do not meet the above criteria may be listed in the acknowledgments section of the manuscript.

At the end of the text, the acknowledgements section of the paper should identify the role played by each author: Example for a paper featuring four authors: LMB, GC, NR, and BP. "Acknowledgements: The study was designed by LMB and GC; data were collected and analysed by NR, GC and BP; data interpretation and manuscript preparation were undertaken by LMB, GC, BP, and NR. All authors approved the final version of the paper".

Use of human and animal subjects: *IJSNEM* requires that all submitted studies using human or animal subjects conform to the policies established by the U.S. Department of Health, Education, and Welfare and the American Physiological Society. Manuscripts should include a clear statement to the effect that studies had prior approval from a formally constituted ethics review board in the case of human studies and that informed consent was obtained in writing from participants (or guardians for participants under the age of 18 years), or that they adhered to current animal welfare legislation in the case of animal studies.

Studies using commercial products: *IJSNEM* recognizes the importance of studies that address the efficacy and safety of commercially-available products, including specialist sports foods, sports drinks, and dietary supplements. Such studies should, when relevant, include independent verification of the composition of the product under investigation. In the case of dietary supplements, this might reasonably include an analysis of the product to verify the content of the active ingredient and to exclude the presence of undeclared substances that might affect the outcome of the study. As with all studies, the inclusion of appropriate control groups or trials is important to the interpretation of any findings.

Methods in sport nutrition research: To assist with the design, implementation, and interpretation of studies in sport nutrition, *IJSNEM* has commenced the publication of a series of reviews on methodologies in sport nutrition research. These articles provide commentary from experts in a variety of fields on optimum ways to conduct and report studies on aspects of sport nutrition research. They can be downloaded from the *IJSNEM* Website and we recommend that all authors read these reviews before submitting manuscripts to the journal. Although the ultimate goal of these review papers is to promote better standards of sport nutrition research and help researchers enhance their outputs, they will also be used as a benchmark for reviewing papers sent to this journal. When submitted manuscripts describe methods that have been clearly shown to be inappropriate or fail to provide adequate description of methods according to recommendations in these methodology reviews, this is likely to result in rejection of the manuscript.

Figures and tables: Figures should be professional in appearance and have clean, crisp lines. Hand drawings and hand lettering are not acceptable. Colour is not permitted: figures should use black and white or grey shading only. Labels should be proportionate with the size of the figures on the journal page. Digital photos should be 300 dpi at full size, and digital line art should be 600 dpi. Figures can be submitted electronically in TIFF or PDF file formats.

When tabular material is necessary, it should not duplicate the text. Tables should be formatted using the table function of the word-processing program rather than by aligning columns in text with tabs and spaces or using text boxes. Tables should be double-spaced on separate sheets and each should include a brief title and a legend that highlights any statistically significant findings.

Statistical analysis: Papers submitted to the journal may be sent for review to a statistician if the Editor is not satisfied that appropriate procedures have been followed. When data sets are normally distributed, variance should be given as the *SD* rather than *SEM*. Nonparametric statistical analysis should be used when data sets are not normally distributed.

Reference style: *IJSNEM* follows a modified version of the style laid out in the *Publication Manual of the American Psychological Association* (APA), 6th ed. Please consult the APA manual. References should be listed in alphabetical order at the end of the text and should be cited in the text using author name(s) and date of publication. In the case of in-text citations, where there are more than two authors, the first author's name can be followed by "et al." Example: "Burke, Clooney, Pitt, and Riewoldt (2009) found that supplementation achieved positive outcomes" can be replaced by "Supplementation was found to achieve positive outcomes (Burke et al., 2009)." References should not be numbered in the reference list. Examples of the three most common forms of references are shown below. variations, please consult the APA manual.

Burke, L M., Clooney, G., Pitt, B., & Riewoldt, N. (2009). Cacao supplementation does not affect sprint performance in elite team sport players. *Journal of Clinical Inspiration, 67,* 1966–1971.

Wadler, G.I., & Hainline, B. (1989). *Drugs and the athlete*. Philadelphia: F.A. Davis.

Haymes, E. Proteins, vitamins, and iron. (1983). In M.H. Williams (Ed.),*Ergogenic aids in sport* (pp. 27–55). Champaign, IL: Human Kinetics.

Submission: Manuscripts should be submitted electronically via *IJSNEM*'s Manuscript Central site at mc.manuscriptcentral.com/hk_ijsnem. The Manuscript Central system manages the electronic transfer of manuscripts throughout the article review process, providing step-by-step instructions and a user-friendly design.

The review process: Manuscripts are read by an editor and two reviewers; reviews will not be blind. Authors are required to provide the names and email addresses of a minimum of two potential peer reviewers when they submit their manuscripts. The review process should not take more than about 6-8 weeks.

Copyright: Authors of manuscripts accepted for publication are required to transfer copyright to Human Kinetics. **The copyright form can be downloaded from the IJSNEM Document Library, located under the Support tab above** or will be sent to the author once a submitted paper is accepted.

Specific guidelines are provided for the following papers:

Original Research

Scope: Original Research papers should cover topics of novelty and high impact in relation to sport nutrition or exercise metabolism. Even in cases where research has been conducted carefully and has been appropriately written up, a manuscript may be rejected if it is deemed to be of insufficient interest and quality to attract attention.

Title: Where possible, the title should be brief but instructive of the outcome of the study: Example: "Caffeine fails to improve 200 m swimming time in elite swimmers" is preferred to "Effect of caffeine on swimming performance in elite swimmers"

For other

Text:

Length. 3,000 words (excludes title page, abstract, acknowledgements, references, figures, tables)

Sections. Sections include Introduction, Methods, Results, and Discussion; each of these sections should follow the standard processes. Where appropriate, the text should conclude with two brief sections: **novelty statement** (one or two sentences should sum up the new information that has been gained as a result of the study) and **practical application statement** (one or two sentences should sum up the way that this information could be put into practice).

Acknowledgements: Note that the contribution of each author to the paper should be outlined.

References: A maximum of 40 references can be cited.

Figures and tables: A total of six figures and/or tables may be used to illustrate the data in this study. The total of six assumes no more than one page for each figure. If a figure has multiple panels requiring more than one page, the total number of figures should be reduced accordingly. If you feel that additional panels or figures are needed, please be sure to address this in your cover letter.

Acknowledgements: Note that the contribution of each author to the paper should be outlined."