# Associations Between Low Energy Availability, Stress and Anxiety Profiles and Sleep Patterns

Jennifer Megan Groom

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Dietetics

At the University of Otago, Dunedin, New Zealand

November 2018

# Abstract

**Background:** Low Energy Availability (LEA) is the given term when an insufficient energy intake, often combined with excessive exercise, results in the bodies inability to perform normal physiological functions and a down regulation of some physiological processes as the body tries to conserve energy for life dependent processes. Which if left untreated can consequently impair health and athletic performance. Historically, the physiological impacts of LEA on reproductive hormones and bone health have been well investigated however; the associations with psychological aspects of ones mental and emotional state are becoming increasingly researched. Understanding the impact of LEA on important psychological aspects may not only benefit athletes' performance but also their health.

**Objective:** This study aimed to describe the association between LEA, stress profiles and sleep patterns within the New Zealand Rugby sevens squad.

**Design:** For this cross-sectional observational study twenty-four contracted New Zealand women's Rugby sevens players were recruited. Participants completed electronic estimated food diaries and comprehensive questionnaires containing the Low Energy Availability in Females Questionnaire (LEAF-Q), the Perceived Stress Score questionnaire (PSS-Q) as well as the Pittsburgh Sleep Quality Index Questionnaire (PSQI-Q).

**Results**: This study was comprised of two groups, those not at risk of developing LEA and those that were at risk of developing LEA. Half (50%) of the study population had a LEAF-Q score of ≥8, suggesting they were at risk of developing LEA. There is a pattern in responses whereby more athletes at risk of LEA report undesirable outcomes for six of the PSS-Q items. Subjective sleep quality global scores, as assessed by the PSQI-Q did not differ between the two groups. However, using a global PSQI-Q score of ≥5 relating to poor sleep quality, a total of fourteen participants were classified as "poor" sleepers. Indicating a significant difference ($p < 0.05$) in the number of players at risk reporting a poor sleep quality compared to those not at risk. Two members (17%) of the group at risk of developing LEA reported sleep latency as

>1 hour. When comparing sleep duration in hours using self reported sleep and wake times, the mean difference was 0.7 hours (95% CI: -0.1, 1.5), equivalent to 42 minutes more in those not at risk. Where those not at risk slept for 8.5 ± 1.0 hours and those at risk slept for 7.8 ± 0.8 hours. Additionally, from the estimated food diaries we found no differences in daily energy intake or carbohydrate intake between the two groups.

**Conclusion:** The current study provided valuable insight into the impact LEA may have on aspects of elite athletes psychological health. It suggests that being at risk of developing LEA may be associated with increased feelings of stress and have a negative impact on athletes sleeping patterns compared to those not at risk of developing LEA. However, the sample size is small and the area of LEA and psychological health requires a lot more investigation before conclusions can be drawn, as the association may be multidirectional. Future research will aid in the treatment and prevention of the negative physical and psychological consequences of LEA and in turn keep our athletes healthy.

# Preface

This 6-month, full time equivalent, Masters of Dietetics thesis was conducted within the Department of Human Nutrition, University of Otago, New Zealand.
The candidate's supervisors, Dr Katherine Black and Dane Baker designed and obtained ethical approval for the study. Dane Baker recruited participants and provided advice regarding the interpretation of the results.

The current candidate, under supervision was the primary researcher for this project and was responsible for the following:

- Sleep data collection
- Mood data collection
- Entry of diet records into Kaiculator
- Obtaining copyright permissions
- Data entry
- Preparing LEAF questionnaire data for statistical analysis
- Preparing mood questionnaire data for statistical analysis
- Preparing sleep questionnaire data for statistical analysis
- Statistical analysis using Stata software with supervision from Dr Jill Haszard
- Interpretation and presentation of results
- Preparation of this thesis

The candidate worked alongside a Masters of Science student throughout data collection and analysis, who were investigating another research area using the same group of participants.

# Acknowledgements

I would like to thank my supervisor Katherine Black. I have learnt so much from you throughout this process and you have been very encouraging and helpful. It has been great having someone with a relaxed mentality throughout what could have been a stressful time.

Dr Jill Haszard, thank you for all your advice regarding my results, tables and statistical analysis, I really appreciate it. Thank you to Lynne Knapp for all your help with endnote and referencing over the past year.

To the MDiet tutors, Hawkes-Bay dietitians and Dr Tracy Perry, thank you for all your feedback and encouragement. With your help I feel like I can tackle any problem if I apply myself (and the evidence). I thoroughly look forward to working along side you all.

Thank you to the entire Masters of Dietetics class, you guys got me through the last 2 years. I could not have got this far without all your jokes, encouragements and critical feedback.

To my flat mates and best friends, thank you all for putting up with me throughout the past 5 years. Whether it is encouragement to let lose or to keep my head up and keep going, it has never gone unnoticed. It has been a long time coming. Love you all.

Lastly, a massive thank you to my family, Mum, Dad, Catherine, Glenn and baby Ella. You guys are my rock and I could not have got out of bed each day (for the past 5-years) if it weren’t for your snap chats, texts, phone calls and of course financial aid… I love you all so much, I promise I’ll try and make some of my own money now.

# Table of Contents

# List of Tables

# List of Figures

**List of Abbreviation**

| | |
|---|---|
| ACSM | American College of Sports Medicine |
| CI | Confidence Interval |
| EA | Energy Availability |
| EEE | Exercise Energy Expenditure |
| EI | Energy Intake |
| FFM | Fat Free Mass |
| IOC | International Olympic Committee |
| ISAK | International Society for the Advancement of Kinanthropometry |
| Kg | Kilogram |
| kJ | Kilojoule |
| LEA | Low Energy Availability |
| LEAF-Q | Low Energy Availability in Females – Questionnaire |
| N | Number |
| NZ | New Zealand |
| POMS | Profile Of Mood States |
| PSQI-Q | Pittsburgh Sleep Quality Index – Questionnaire |
| PSS-Q | Perceived Stress Scale – Questionnaire |
| RED-S | Relative Energy Deficiency in Sport |
| SD | Standard Deviation |
| TEE | Total Energy Expenditure |
| Triad | Female Athlete Triad |

# 1. Introduction

Exercise is known to be efficacious for the prevention of many chronic diseases, increase feelings of happiness and decrease feelings of pain (1). For most individuals sport and exercise play a crucial role in maintaining body weight (2), reducing stress and anxiety, improving overall mood (1) and enhancing sleep quality (3). Participation in physical activity has been a focus for the public health sector for many years. Team sports historically have been very popular to watch in New Zealand (NZ) especially Rugby union. Recently, Rugby sevens has attracted increased attention, being one of the fastest growing sports worldwide (4) since its introduction to the Olympic games in 2016.

Despite the well-known benefits of exercise, some athletes ingest an insufficient amount of energy (in the form of calories) to meet the demands of exercise and normal physiological functions. The body believes it is a state of starvation and acts to conserve energy thereby altering hormonal milieu and reducing energy expended at rest. This can lead to a state of Low Energy Availability (LEA), whereby there is insufficient energy to fuel the normal processes of metabolically active tissue, which is commonly observed in female athletes (5). Athletes at a higher risk of LEA are those that participate in sports emphasising leanness (6, 7). Research has shown LEA could be more common with increasing levels of competition, likely due to the pressures on body image, pressure to succeed and high training frequency (8). Furthermore, some athletes may have a poor knowledge on food preparation and meal timing around training and/or competition as well as being subject to several time restraints which makes meeting nutrition recommendations difficult, thus placing them at risk of developing LEA (9).

The impact LEA has on health unfortunately outweighs the benefits of exercise. The first recorded suggestion that exercising females maybe putting their health and performance at risk was as long ago as the 60's when it was recognised that there maybe disruptions in the onset, timing and regularity of menarche with competitive female athletes (10). As research progressed it was established that females could have serious health issues from inappropriate nutritional intakes. Originally this was called the Female Athlete Triad (Triad), with three clinical endpoints of focus: eating disorders or disordered eating, menstrual irregularity, and stress fractures. However it is now apparent that LEA's associated health consequences include decreased bone health outside of osteoporosis, cardiovascular function, reproduction, gastrointestinal function, mental health, immunological function and a decrease in physical performance (11, 12). In elite athletes there are many potential causes of LEA which could include: heavy training loads, lack of time, poor nutritional or cooking knowledge, eating disorders or disordered eating and appetite suppression following exercise. Therefore it is important not only to recognise the signs and symptoms of LEA, but also to prevent LEA from progressing towards harsh clinical endpoints (13). Two areas that have been identified as influenced by LEA but are currently under-researched in the field of LEA are its associations with stress profiles and sleep patterns.

Psychology is fast becoming a key determinant of athletic performance. Researchers have investigated the effect exercise has on mental states and found that exercise has a positive effect on an individuals stress level, feelings of depression, and anxiety levels (1, 14, 15). However, to my knowledge there is no research investigating the impact LEA has on somebody's mood profile at present. Recently studies have been conducted involving the relationship between exercise and sleep however, findings are inconsistent (3, 16, 17). Again, there is a lack of research on the effects of LEA on sleep patterns and/or sleep quality. Therefore, the current study aims to determine the prevalence of female athletes at risk of LEA and demonstrate any links to discrepancies in stress and anxiety and/or sleep patterns those at risk express when compared to athletes not at risk of developing LEA.

# 2. Literature Review

## 2.1 Introduction

Athletes are being pushed to be stronger, faster, leaner, more muscular and work harder than ever before. From previously published literature we know that regular exercise is a key component of a healthy lifestyle (1, 18, 19). For a large majority, exercise generates positive outcomes for general health and wellbeing. However, some individuals are putting their health at risk by ingesting insufficient energy to meet the body's needs. Previously there has been a lot of research broadly investigating LEA in athletes however, there are gaps surrounding mood profiles and sleep patterns. Therefore, the purpose of this literature review is to examine existing articles regarding LEA, stress profiles and sleep patterns in sport and exercise.

## 2.2 Literature search strategy

Literature was identified from the following online databases, Medline via Ovid, Web of Science and PubMed using a combination of the search phrases "low energy availability", "Energy availability", "female athlete triad", "restriction of energy in sport", "athletes", "exercise", "overtraining", "energy balance", "energy intake", "healthy lifestyle", "female(s)", "questionnaire", "mood", "stress", "stress profile", "anxiety", "mood profiles", "sleep", "sleeping", "sleep patterns" and "human". Further literature was discovered from reference lists of relevant journal articles. This data search was conducted from august 25$^{th}$ 2017 to the 1st of November 2018.

## 2.3 Rugby Sevens

Rugby sevens is a variant of Rugby union whereby; two teams made up of seven a side play two seven-minute halves separated by a two-minute half time. Throughout the fourteen minutes there are opportunities for timeouts whereby a limited number of player substitutions can be made. The scoring system is the same as Rugby union, five-points for a try, three for a drop goal and two for a conversion. There is a common misconception that because the game has a shorter duration that the energy demands are not as great as those of Rugby union players. However this is not the case, the players' work to rest ratio is much higher and Rugby sevens' is played as weekend tournaments, usually three games per day at international level (20). Sevens players spend over 75% of the game at a "heart rate of >80% of their maximum heart rate" (4). This high work rate could potentially result in many players being at risk of Low Energy Availability (LEA).

### 2.4 Low energy availability

Typically, in New Zealand (NZ) a healthy lifestyle is defined as, engaging in physical activity and eating foods that align with the NZ Ministry of Health's healthy eating guidelines (21). There are numerous benefits of exercise for an individual's physiological and psychological health (22) however, some individuals unintentionally or intentionally place themselves at risk of LEA by ingesting insufficient calories in relation to the calories they expend through metabolic processes and exercise.

The energy an individual requires for normal physiological functions such as cellular maintenance, thermoregulation, growth, reproduction, immunity, gastrointestinal functions, cardiovascular functions and locomotion is usually determined through the simple balance of Energy Intake (EI) and Total Energy Expenditure (TEE) over time (Energy Balance = EI - TEE) (23). However, this does not account for the fact that it is the fat free mass that is metabolically active nor that the body may modify resting metabolism depending on energy intakes. Energy Availability (EA) is the energy left within the body after adjusting for Exercise Energy Expenditure (EEE) during exercise in relation to fat free mass (FFM), therefore, the amount of energy remaining for homeostatic physiological functions (EA = (EI – EEE)/FFM) (23). LEA is essentially an early state of starvation caused by a larger expenditure of energy from exercise possibly in conjunction with a low intake of calories (23).

Fundamentally, with LEA the physiological functions not necessary for survival are ceased to allow crucial organs to function. The most commonly reported functions within the body to shut down in a state of LEA are reproduction, skeletal, cardiovascular, gastrointestinal and immune functions (24). Effects of LEA are commonly believed to occur at an intake of <30kcal.kg.FFM$^{-1}$.day$^{-1}$, research suggests with intakes <30kcal.kg.FFM$^{-1}$.day$^{-1}$ women are at risk of developing several of the health implications related to LEA (8, 13, 23, 25). When there is an increased period of time in a state of LEA with or without disordered eating a negative impact has been seen in performance (13). According to recent evidence females are 5.4 times more likely to be at risk of low energy availability when compared to males (8). Therefore, this condition was initially described in female athletes as the Triad, which consisted of three interrelated aspects, disordered eating, amenorrhea and osteoporosis (26). Over the years the definition of the Triad has been amended and modified from the original, released by the American College of Sports Medicine (ACSM) in the 90's. Since then, in 2007 the ACSM has published a "revised position stand" on the Triad (13). More recently, a new term released in 2014 by Mountjoy et al. is Relative Energy Deficiency in Sport (RED-S), which includes male athletes, though majority of the evidence comes from females, and includes a wider array of complications (27). In 2018 Mountjoy et al. released an update on RED-S where recent literature was taken into consideration (12). RED-S negatively influences physiological function, overall health and could be greatly detrimental possibly long term however, more research is needed (12). These negative consequences include: reduced reproductive function, increased risk of stress fractures and decreases in bone mineral density, poorer cardiovascular health, altered gastrointestinal function, decreases in the effectiveness of immune systems leading to increased risk of illness and potentially many more as yet to be determined (12, 24). **Figure 2.1** shows these negative health consequences of LEA.

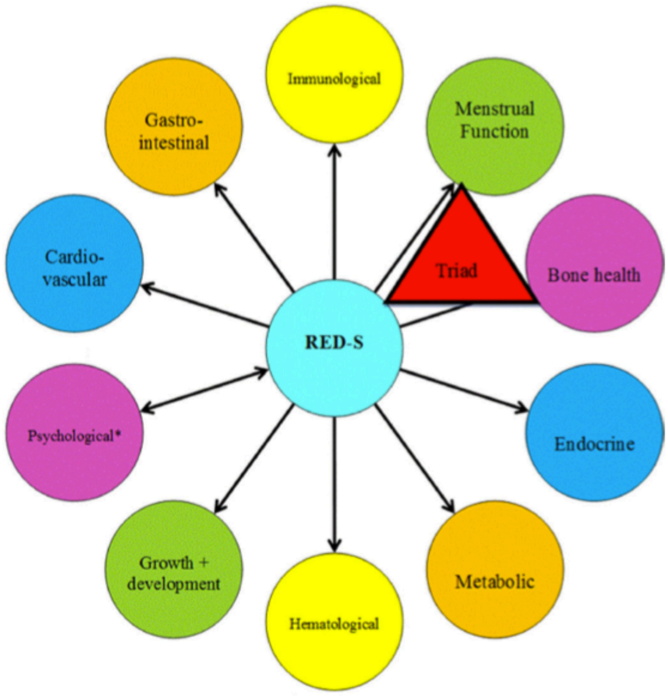



*Figure 2.1 Health consequences of Relative Energy Deficiency in Sport (RED-S). Reprinted with the permissions from Br J Sports Med.*
*(Mountjoy et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update, Br J of Sports Med, 52, 11, 687-97 https://bjsm.bmj.com/content/48/7/491.long)*

As a consequence of LEA detrimental cardiovascular outcomes include unfavourable lipid profiles and endothelial dysfunction (28); these increase the risk of negative cardiovascular outcomes later in the athlete's life (29). From a nutritional standpoint if any individual is ingesting insufficient energy (<30kcal/kg.FFM$^{-1}$.day$^{-1}$) they are at a higher risk of developing several micronutrient and macronutrient deficiencies such as zinc, vitamin C and E, linking to decreased immunity thus increased illnesses and infections, which is a negative consequence of RED-S (12). There has been extensive research on LEA regarding the physical and functional outcomes but the psychological aspects such as mood and sleep are yet to be investigated.

### 2.4.1 Assessing Low Energy Availability

Although energy availability is a combination of EI and EEE relative to FFM (23), these aspects are all difficult to accurately measure. Therefore, other measures are utilised to determine the risk of LEA in a population; these include biochemical markers and validated questionnaires. Biochemical markers could determine if an individual had healthy hormonal patterns over their menstrual cycle, however, they require a blood sample and repeated measures throughout the menstrual cycle, which is not possible at the elite athlete setting. Therefore, questionnaires such as the Low Energy Availability in Females Questionnaire (LEAF-Q) are utilised.

The LEAF-Q is designed as a screening tool to identify females at risk of LEA with or without eating disorders. With high levels of sensitivity (78%) and specificity (90%) the LEAF-Q is able to identify all three aspects of the Triad, energy availability, bone health and menstrual function (30). The LEAF-Q can be an effective tool to detect LEA and the crucial need to promote early treatment (30). A total LEAF-Q score of ≥8 will be indicative of those individuals at risk of developing LEA. It is now thought that the health consequences of LEA transpire across a spectrum, beginning at healthy and progressing toward disease **Figure 2.2** (13). Being able to identify athletes' symptoms across a spectrum can enable early detection, treatment and prevent the progression towards all three harsh clinical endpoints (13). However, due to the sensitivity and specificity of the LEAF-Q (78% and 90% respectively) there is potential for error whereby some athletes may be misclassified as at risk and some misclassified as no at risk of developing LEA (30).

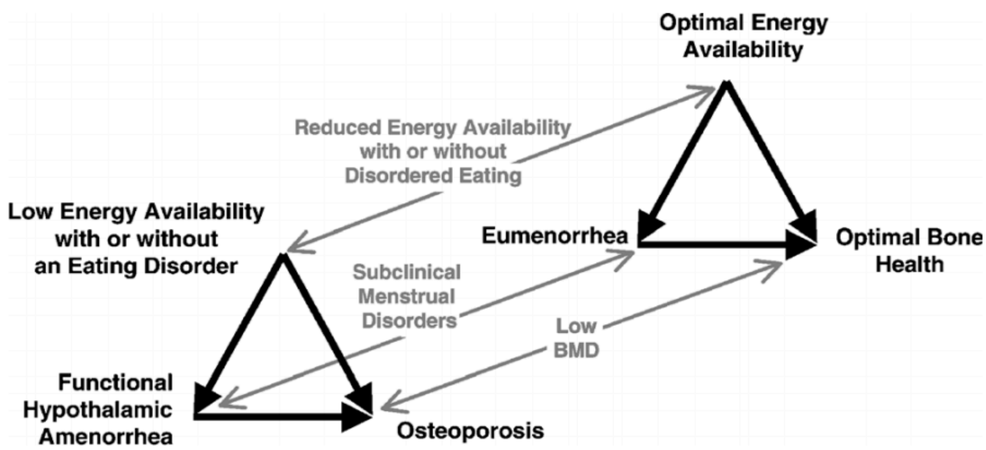



*Figure 2.2 The Female Athlete Triad updated model. Reprinted with the permissions from Medicine & Science in Sports & Exercise.*
*(Nattiv, A. et al. American College of Sports Medicine position stand. The female Athlete Triad. Med Sci Sports Exerc. 2007;39(10):1867-1882. )*

## 2.5 Stress

Exercise or physical activity can release endorphins, which interact with receptors to diminish the sensation of pain and upsurge the feeling of positivity (1). It is commonly believed that exercise makes you happier as it may increase the brains sensitivity to serotonin and norepinephrine, which together can relieve feelings of depression and anxiety (1, 15). A study conducted in America by Meyer et al. concluded, regardless of the intensity or duration of exercise, acute improvements in mood have been seen in individuals with a major depressive disorder (31). Recently investigations regarding the influence of psychological factors on sports performance have increased greatly, with emphasis on athletes' mood states (32, 33). Studies have reported mood states as a key determinant in predicting sports performance, whereby certain mood states are thought to positively influence performance (34) such as, low tension, depression, anger, fatigue and confusion and high scores for vigour . Therefore, to ensure athletes are performing at their optimum, it is important not only to be physically fit but also psychologically fit.

A mood is different to an emotion in the way emotions are short lived, volatile and tend to dissipate at a faster rate than a mood (35). Whereas, mood is often influenced by an emotion, are long term, can impact cognitive or behavioural responses and usually are deemed as positive or negative (35, 36). An individual's mood can be defined as a temporary state of feeling that can be influenced by a plethora of factors. Morgan and his associates first established mood profiling within the exercise realm in the 1970's (37-39), from there the "Iceberg Profile" was developed (40). This profile is described as the desired emotional status of athletes. Characterised by low scores for tension, depression, anger, fatigue and confusion and high scores for vigour when utilising the Profile of Mood States (POMS) questionnaire (38). There is considerable research demonstrating the positive effects of exercise on POMS questionnaire subscales such as: tension, depression, anger, confusion and occasionally on vigour and fatigue (41). For those that exercise regularly, the cessation of exercise has been seen to cause negative mood profiles and fatigue (42). Stress is defined as a mental or emotional strain or tension resulting from how an individual perceives adverse or demanding circumstances (43). Stressors in life can only have an impact if someone was to regard them as threatening or if coping mechanisms were inadequate. Mood and stress are different however stress could determine a mood state. Due to limited research on stress and LEA, this study will look at stress and mood in conjunction, as they interlink whereby stress is a construct of a mood profile.

### 2.5.1 Measures of stress in athletes

The Perceived Stress Scale Questionnaire (PSS-Q) can be used to objectively determine the degree of stress an individual is feeling as it measures the degree of which an individual's life situations are perceived as stressful over the past month (44). The questionnaire was developed in 1983, since then it has been validated as a reliable tool to assess ones perceived stress (44). The PSS-Q is an important tool to assess stress and can be used in nonathletic and athletic populations (45). The PSS-Q consists of fourteen questions that are rated against a 5-point Likert scale (0= never, 1= almost never, 2= sometimes, 3= fairly often and 4= very often) however; seven questions are scored in reverse. There are no defined cut offs for the scoring of this questionnaire nonetheless; higher scores are suggestive of chronic stress. The questionnaire is easy to follow, can be completed by those with a lesser education level and by any gender at any stage of life (44). The PSS-Q has been seen to "be a better predictor of health and health related outcomes" when compared to other life event scales (44). The PSS-Q uses a one-month time frame meaning; in contrast to other life-event scales such as "The Social Readjustment Rating" by Holmes and Rahe, which gathers information from a 6 to 12 month span (46). Therefore, the PSS-Q may pick up stressful life events that are still affecting the individual whereas the Social Readjustment Rating may in turn pick up previous stressful events that are not currently affecting the individual. The PSS-Q can be used as an outcome variable, measuring ones experienced stress, coping resources and personality factors.

### 2.5.2 Stress and overtraining

It is not uncommon for athletes to become overtrained, as they are attempting to reach their greatest potential. Overtraining syndrome can be defined as "high volume and/or high intensity training with inadequate recovery" (47). Overtraining syndrome symptoms include increased levels of fatigue, increased injury risk, inability to recover, increased likelihood of illness, decreased performance level and changes in mood (48-50). These symptoms are similar to those previously outlined for LEA. It has been reported that increased training loads correspond with mood disturbances (50-53) furthermore, mood states have been utilised to identify signs of distress due to intense training (54). Although there is copious research looking at the impacts of different quantities of exercise on mood and other psychological aspects, to the best of my knowledge there is no current literature highlighting the impact LEA has on mood or stress. It is important to investigate the short and possibly long-term effects LEA has on an individual's mental and emotional state. With this information the signs and symptoms could be identified thus used to protect the psychological state of athletes and furthermore, optimise performance.

## 2.6 What is sleep?

Sleep is necessary for basic human health and recovery (55). Sleep is a natural process for all humans whereby you are less able to react to stimuli (56). The Oxford dictionary describes sleep as a condition of the "mind and body, normally recurring every night and lasting several hours, in which the nervous system is inactive, eyes are closed, muscles relaxed, and consciousness is nearly suspended" (43). The state of sleep is comprised of two categories that "alternate cyclically across a sleep cycle", non-rapid eye movement also referred to as a deep sleep and rapid eye movement also known as the dream state (56). The body enters a state where restoration of physiological and psychological systems can occur (57, 58). Adults

(18-64 years) are believed to require 7 to 9 hours of sleep each night; people who do not get sufficient sleep may be at an increased risk of health problems and/or decreased wellbeing (58). Unfortunately, there are currently no sleep duration guidelines available for athletes at any level of competition.

Sleep quality is a highly subjective measure that looks at the sleep latency, habitual sleep efficiency, sleep duration, use of sleeping medication, sleep disturbances, and daytime dysfunction, therefore it is difficult to measure across individuals (59). Research has shown that women are more "likely to report more intense somatic sensations in response to sleep restriction" when compared to males (60). Sleep may be the single most valuable strategy for recuperative and restorative recovery however; this is based on anecdotal evidence alone (61). A lack of sleep has been seen to negatively impact athletic performance, whereby a single night of insufficient sleep is correlated to, decreased anaerobic performance the subsequent afternoon (62), reaction times (63) and cognitive processes including mood (64).

### 2.6.1 What does sleep effect?

Poor sleep quality effects several psychological outcomes, including, negatively impacting an athlete's mood state (65), reaction times (66, 67), decision-making skills, decreased immune function, the development of pain (61), increased blood pressure (68), impaired glucose tolerance (69) and fatigue (70, 71). Sleep at night has been proven to predict exercise duration on the subsequent day (72). These negative effects of poor sleep quality somewhat align with the symptoms previously outlined for LEA. As a result of inadequate sleep the development of mood disorders such as anxiety and depression could occur (73) thus, reinforcing how important sleep is for everyday health.

As previously mentioned, LEA has negative impacts on cardiovascular health. Similarly, poor sleep quality also has an adverse effect on the cardiovascular-system. Yuksel and colleagues investigated healthy members of the general population in a cross sectional study and concluded, those with poor sleep quality were more likely to have higher heart rates, blood-pressure, were predisposed to have a hypertensive response to exercise and less of an increase in heart rate in response to exercise (74). Many epidemiological studies have investigated the association between decreased sleep duration and increase in cardiovascular events and morbidity. Ayas et al. findings are similar to those of Yuksel, whereby short "sleep duration is associated with an increased risk of cardiac heart disease" (75). Although cause and effect cannot be proved explicitly in this observational study, the association is still present after adjustments (75). Further evidence using males concluded the same; heart rate was significantly higher following insufficient sleep (68). Thus, suggesting a lack of sleep may increase blood pressure due to increased activation of the sympathetic nervous system the day after an insufficient sleep. These negative cardiac outcomes may only be further exacerbated in conjunction with LEA.

Sleep deprivation can result in a decrease in cognitive processes specifically memory and insight formation which are crucial for learning and development for all individuals (76). In a recent study by Telzer et al. inefficient sleep resulted in inferior decision-making as well as people becoming more likely to take part in risky behaviours (77). The age of the subjects included in Telzer's cross sectional study overlap with that of elite athletes. Research concludes that a better sleep quality overall has a positive effect on cognition and physiological effects therefore, it is important to ensure optimal sleep quality (76). From the evidence above it is obvious how crucial sleep is in terms of overall health, wellbeing and overall performance. It appears sleep is crucial for all humans however may be paramount for athletes (78) for its restorative and psychological effects (79).

#### 2.6.2 What effects sleep?

Exercise influences sleep by increasing subjective tiredness, slow wave sleep, sleep duration and decreasing sleep latency (80). Conversely, in 2012 it was suggested that sleep duration in athletes may not differ when compared to the nonathletic population however, sleep quality is reduced (55). Therefore, it is necessary to define what could negatively influence sleep quality to enable the prevention or treatment of these influences, which will hopefully result in positive health and performance outcomes. Drew and colleagues established gastrointestinal disturbance (in the previous month) to be associated with poor sleep quality (PSQI-Q score ≥5) (81). Hyper-hydration also has been seen to negatively impact sleep quality, whereby sleep is interrupted to urinate throughout the night (61). One reason for hyper-hydration could be the result of over rehydrating post training or exercise. Both conclusions are unsurprising as most humans are likely to experience gut disturbances or the need to urinate during the night in their lifetime. Psychological and physiological stresses have been related to ”increased variability” of sleep fragmentation, meaning you wake more frequently during sleep but this has no effect on sleep duration (82). Both alcohol and caffeine have also been linked to poorer sleep quality (61). Alcohol has been proven to not only affect overall sleep quality but also sleep duration and sleep latency as well (61). Alcohol in the form of binge drinking is part of the NZ culture; athletic celebrations are not exempt from this tradition. Although there are different thresholds for individuals, caffeine is a nervous system stimulant and acts to keep the mind awake thus impacting sleep latency, decreasing slow-wave sleep and decrease total sleep time (61). These effects of caffeine can occur with doses of 86 ± 74 mg taken within two hours before bedtime (83). To enhance ergogenic performance athletes have used caffeine, in the form of “coffee, energy drinks, pharmaceutical preparations and caffeinated sports supplements” (84). Athletes at a higher level namely elite or competitive sportspeople are most likely to use caffeine for this purpose (84). It has been hypothesised that as core body temperature is declining sleep occurs and as core body temperature is raised sleep is ceased (85). Therefore, body temperature is understood as an influencing factor of sleep quality whereby, warming in cooler conditions is advantageous and vice versa (61). There is a lot of controversy in the literature regarding the effects of exercise on sleep quality. A systematic review (2015) denotes that exercise has a modest positive effect on sleep quality, (indicated through lower Pittsburgh Sleep Quality Index (PSQI) scores) however, participants did not sleep for a longer duration in the absence of exercise compared to when they were exercising they simply perceived a better sleep quality (17). Similarly, a review of the literature shows a beneficial relationship between self-reported exercise and sleep (3). In contrast, reports of almost all athletes (73%) having poor sleep quality (PSQI ≥5) may indicate there is no beneficial effect of exercise on sleep quality (16). Furthermore, Trinder et al. showed the failure of studies to prove any significant increase in sleep as a result of exercise (86). "Chronically intense levels of exercise or overtraining can disturb sleep" (87) thus, exercise beyond a particular point may be disruptive to sleep quality however; there may be a possible effect up until this crucial point (3).

### 2.6.3 Sleep and overtraining

Interestingly, acute sleep deprivation has been seen to increase hunger hormones (ghrelin) and decrease satiating hormones (leptin) (88). This may indicate an inverse relationship between LEA and sleep duration and quality. Overtraining syndrome has been linked to sleep deprivation with research indicating "a negative relationship between sleep quality and training loads", however it remains unknown whether the relationship is causal or symptomatic (55). Therefore, it is possible that physiological mechanisms may influence psychological response and for this reason psychological monitoring may be advantageous in relation to overtraining (52). With inadequate recovery or sleep, there is depletion in restoration of glycogen for use during times of wakefulness (57). Although LEA and overtraining are fundamentally different, similarities between the two can be seen. Prolonged heavy training symptoms could develop into complex and complicated chronic symptoms, which may include illness, chronic loss of performance and eventually leading to death (48). This indicates the need for early diagnosis or treatment and prevention of both LEA and overtraining syndrome.

### 2.6.4 Measures of sleep in athletes

Measuring sleep within the athletic population is increasingly popular due to sleeps potential influence on performance and health (89). The gold standard for sleep measurement is polysomnography (89). Polysomnography records brain activity breathing, blood oxygen levels, eye movements and heart rate. However, this measure is labour intensive and is extremely difficult to utilise when investigating multiple athletes and/or sleep over more than a single night as it requires the participant to be attached to a machine throughout the night (89). Actigraphy is a non-invasive measure, using wrist activity monitors and sleep diaries researchers are able to quantify sleep (90). This technique is, easy to conduct and can be utilised over long time periods (90), therefore is great for scientific studies. In 2015 Sargent et al. validated actigraphy against polysomnography and concluded activity monitors are a valid sleep measure for elite athletes, the high threshold (>80 activity counts is scored as wake) had the highest agreement (90%) and best combination of sensitivity (92%) and specificity (67%) (89). However, for the present study, this method of sleep measurement would increase participant burden considerably plus measurements would be indicative of sleep during the training camp, and not suggestive of normal practice.

Previously sleep questionnaires have been used to determine sleep quality in psychiatric populations and more recently within clinical populations. A lot of these questionnaires have similar limitations. Such as not having a global score to allow comparisons across groups or individuals, having no time interval specification, moreover some do not assess accuracy and reproducibility (59). The Pittsburgh Sleep Quality Index Questionnaire (PSQI-Q) is a self reported assessment of sleep quality over the previous month. Developed by Daniel Buysse et al. (1989) for the purpose of providing a standardised sleep questionnaire that researchers could use across populations (59). It is difficult to investigate the quality of sleep however; the PSQI-Q has developed a global score to allow the comparison of groups and individuals within the clinical setting. The PSQI-Q is based on eighteen self-reported questions about the person's own sleep quality. It has been extensively utilised within the sports and exercise realm by many researchers (91-94). The PSQI-Q assesses subjective sleep quality, latency, duration, efficiency and disturbances, medication use and daytime dysfunction. For analysis, a cut-off score for poor sleep quality of ≥5 is utilised (59). The PSQI-Q using this cut-off score was validated with a sensitivity of 90% and specificity of 87% which means there is only a very small risk for misclassification (95-97) and therefore is very well used in the research and sleep communities.

## 2.7 Mood and Sleep

Mood and sleep have an intertwining relationship whereby; an earlier sleep onset yields a better mood (98). Additionally, a later sleep onset has been linked to a decrease in "happiness; alertness, higher dissatisfaction and more time spent alone the following day"(98). Therefore, subjective sleep quality has been seen as a key determinant for a more positive mood on the subsequent day (98). Furthermore, a better overall sleep quality has strong links to physiological and emotional effects (55). The opposing point remains true, where sleep deprivation occurs, mood state is altered significantly "with increases in depression, tension, confusion, fatigue and anger, and decreases in vigour" (65). It has also been reported that mood regulation could be the mechanism by which exercise impacts sleep (99).

# 3. Objective Statement

Although there is some literature amongst athletes on sleep, anxiety and LEA there is currently no literature that has investigated all three within elite athletes, despite all three aspects being included in the Relative Energy Deficiency in Sport (RED-S) statement. The primary aim of the current study was to determine if there are any associations between Low Energy Availability (LEA) and stress profiles and sleeping patterns in the female New Zealand (NZ) Rugby sevens team.

The secondary aim was to comprehend the number of elite NZ female rugby sevens athletes at risk of developing LEA.

# 4. Subjects and Methods

## 4.1 Study design

This study is a cross sectional pilot study of elite female Rugby players. Data on the prevalence of Low Energy Availability (LEA), perceived stress and sleep indices was collected during a preseason training camp. All participants completed an online questionnaire consisting of 72 questions including information on demographics, Low Energy Availability in Females (LEAF) and the 13 item Perceived Stress Scale Questionnaire (PSS-Q) (**Appendix B**), as well as the 9-question Pittsburgh Sleep Quality Index Questionnaire (PSQI-Q) (**Appendix C**). They all then completed a five-day food and exercise diary which was collected during the preseason training camp, information was gathered using an electronic App (Meal logger).

## 4.2 Ethical approval and informed consent

Prior to commencing the study, ethical clearance was obtained from The University of Otago Human Ethics Committee (reference number: 17/168) (**Appendix D**). Participants were informed of the study and given the opportunity to ask questions prior to providing written informed consent.

## 4.3 Participants

The participants of this study were contracted players of the New Zealand womens' sevens squad whom were not currently pregnant or injured. Twenty-six participants aging from 16-40 years of age agreed to take part in this study.

### 4.3.1 Recruitment

Upon approval from the team coaches, the study was explained to the players on the first day of training camp. All players were provided with information sheets (**Appendix E**) and consent forms to sign once all queries were answered. After obtaining written informed consent from the athletes or athletes parents, the questionnaires were distributed.

### 4.3.2 Confidentiality

All information collected from the athletes including consent, names, and data were kept secure in locked draws in locked rooms or on password protected computers.

### 4.3.3 Inclusion and exclusion criteria

Two participants were excluded from all analysis due to cofounding factors, likely to impact the results of thesis. One excluded participant had a newborn child likely to influence her mood profiles and sleeping patterns. The other did not fully complete the LEAF-Q therefore, could not be placed in a group for analysis. All other participants provided adequate responses, thus the final sample size was twenty-four. One participant responded to the sleep duration question with multiple answers, therefore this participant was excluded for the sleep analysis.

### 4.3.4 Demographics and body composition

Demographic questions were asked regarding age, height, weight, desired weight, ethnicity and the use of medications (excluding contraception).

Other body composition data such as percentage body fat was measured by the team dietitian who is ISAK (International Society for the Advancement of Kinanthropometry) Level 1 accredited whereby, skinfolds are taken at eight sites on the right-hand side of the body using skinfold callipers. The eight skin fold sites include: triceps, subscapular, bicep, iliac crest, supraspinale, abdominal, thigh and calf. Height and weight are also measured in this process. The sum of 6 skinfolds was used to calculate body density, through the use of Durnin and Womersely's equations (100). The per-cent body fat was then calculated using the Yuhasz equation (101). From this the dietitian was able to determine each player's fat mass and fat free mass. The following equation was used to predict body fat percentage in females:

% Body Fat = (0.1548 x sum of triceps, subscapular, supraspinale, abdominal, front thigh, medial calf) + 3.580

## 4.4 Data collection

### 4.4.1 Low Energy Availability Questionnaire (LEAF-Q)

The LEAF-Q is a is a validated screening tool used to detect LEA and Triad conditions (30) and has been modified to reflect the New Zealand English language where some questions have been reworded to suit local terminology (8). The LEAF-Q consists of twenty-five questions based on: injuries, gastrointestinal function, use of oral contraception and menstrual function. From twenty of the twenty-five questions a score is derived (0-49). If the participant scores ≥8 they are considered to be at risk of LEA. For this study the LEAF-Q was incorporated into a larger questionnaire consisting of 72 questions (**Appendix B**).

### 4.4.2 Perceived Stress questionnaire

The Perceived Stress Score questionnaire (PSS-Q) uses a shorter time frame (one month) than other questionnaires to ensure the stress is still affecting the participant (44). Subjects indicate how often they have found their lives unpredictable, uncontrollable, and overloaded in the past month. From the 14-items, seven are scored in reverse, the rest are scored as follows: 0= never, 1= almost never, 2= sometimes, 3= fairly often and 4= very often. The higher total score indicates a greater stress level.

### 4.4.3 Pittsburgh Questionnaire

The Pittsburgh Sleep Quality Index (PSQI) has 18 self-reported questions regarding an individual's sleep quality (59). There are seven rated components derived from 18 questions, which include subjective sleep quality, sleep latency, habitual sleep efficiency, sleep duration, use of sleeping medication, sleep disturbances, and daytime dysfunction. Each component is determined by the following: subjective sleep quality is determined by sleep quality over the past month, sleep latency is determined by the time it takes to fall asleep, habitual sleep efficiency is determined by the precent of time sleeping and total time in bed, sleep duration is the number of hours of sleep each night, use of medication is determined by the use of medication in the last month to help with sleep, sleep disturbance is based on a range of things that could disturb sleep and finally daytime dysfunction is determined by ability to stay awake and enthusiasm levels. From all seven components a global score is derived ranging from 0 to 21. Any global score ≥5 indicates a severe difficulty within 2 or more areas (59). Sleep duration for all participants was reported as start sleep time and wake up time, the time difference here (reported in hours) was used for the duration analysis. Additionally, sleep duration data was collected at three other time points (the following training camps) via verbal questioning and note taking.

Questionnaires were completed under supervision of a trained researcher, who was there to answer any questions or explain meaning when participants were unsure.

### 4.5 Dietary analysis

Participants completed 5-day food and exercise diaries using the mobile App "Meal logger" (New Jersey, United States of America). Prior to eating participants would each take a photo of their meals and provide a brief description. The use of a mobile application was to reduce burden nonetheless ensure accurate data. Information entered by participants was uploaded to the App for the research team to observe. For every engagement in exercise the type, duration and intensity could have been entered into "Meal logger" in a similar fashion to the meals. If a participant did not provide sufficient information on any particular day then they were phoned and either more information will be requested or a 24-hour recall of food, fluid and exercise was completed. This data entry took approximately 20-30 minutes each day. Once researchers were content with the description of intake and exercise, the sleep duration for each night was also asked and recorded. Dietary intakes were analysed using New Zealand food data files via Kaiculator (Department of Human Nutrition, Dietary assessment software) to provide energy, macronutrient and micronutrient information as well as food group information.

### 4.6 Data entry

Once all questionnaires were collected the data was collated in an excel spreadsheet. Each participant was given initials and number identification for confidentiality. Demographical data and long answer responses were recoded as such however all other data was coded numerically.

LEAF-Q data was coded 1 = yes and 0 = no and vice versa, this yielded a total score for each participant. All data was reordered or "sorted" from those least at risk of LEA (a lower total score) to those most at risk of LEA (a higher score). For statistical analysis a variable column was made whereby, 0 = not at risk and 1 = at risk.

PSS scores were scored from zero through four across a Likert scale. Through addition of each of the 14 answers, a total score for each participant was gathered.

Collected sleep data was received in varying units of time, consequently were all converted into hours for analysis. Other sleep data were assigned numbers (0= not in past month, 1= less than once a week, 2= once to twice a week, 3 = three or more times a week) (0=very good, 1= good, 2 = fairly bad, 3 = very bad) from here a total sleep score was calculated using the scoring instructions for the Pittsburgh Sleep Quality Index Questionnaire (**Appendix F**).

### 4.7 Statistical analysis

Means, standard deviations, maximum values, minimum values, mean differences and percentages presented as results were calculated using Microsoft Excel (version 14.7.7 170905, Microsoft Excel, 2011). Statistical analysis was performed using Stata 15.1 (StataCorp, College Station, TX) for p-values and confidence intervals using t-tests and the Fisher's exact test.

# 5. Results

## 5.1 Participant Characteristics

A total of twenty-four participants were included in this study. Baseline demographics of the study population prior to their initial training camp in August 2017 are displayed in **Table 5.1**. The age of the female athletes ranged from 17 to 30 years and body weight ranged from 50.0 to 90.8 kg. Desired body weight of each group shows that those not at risk of LEA may be more likely to want to lose weight when compared to those at risk. Two participants did not state their height, thus were given the mean height for the overall group (1.69 m). Demographic results show no obvious difference between groups, indicating there maybe no association between being at risk of Low Energy Availability (LEA) and age, weight, sum of 6 skinfolds or ethnicity.

## 5.2 Response rate

After exclusion criterion, all participants that gave consent to take part in this study returned adequate information at baseline.

## 5.3 The Low Energy Availability in females Questionnaire (LEAF-Q)

The cut off for LEA was classified as scoring ≥8 for the LEAF-Q. A total of twelve athletes (50%) meet this criterion. The overall LEAF-Q scores ranged from 1 to 13 with the mean score for the LEAF-Q was 7.6 ± 3.3. The mean global score for those not at risk was 4.9 ± 1.9 and 10.3 ± 2.0 for those at risk of LEA. Three participants at risk of LEA had a score of 13, which is five points greater than the cut off for LEA, indicating a very high risk of developing LEA.

*Table 5.1 Demographics of the study population at baseline*

| | Not at risk[a] *n =12* | At risk[b] *n =12* | Total *n =24* |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD |
| Age (yr) | 21.9 ± 3.3 | 22.6 ± 3.8 | 22.3 ± 3.5 |
| Body Weight (kg) | 72.6 ± 10.2 | 70.2 ± 6.1 | 71.4 ± 8.3 |
| Body Height (cm) | 169.3 ± 6.0 | 169.3 ± 5.0 | 169.3 ± 5.0 |
| Desired weight gain (kg) | -0.5 ± 4.4 | 0.0 ± 2.0 | -0.3 ± 3.4 |
| Body fat percentage (%) | 15.4 ± 2.8 | 15.0 ± 2.7 | 15.2 ± 2.7 |
| Ethnicity | | | |
| Non-Maori n (%) | 6 (50.0) | 3 (25.0) | 9 (37.5) |
| Maori n (%) | 6 (50.0) | 9 (75.0) | 15 (62.5) |
| Medication use n (%) | 4 (33.3) | 5 (41.7) | 9 (37.5) |
| Oral contraception use n (%) | 2 (16.7) | 4 (33.3) | 6 (25.0) |

## 5.4 Perceived Stress Score Questionnaire (PSS-Q)

The differences in stress levels between groups and overall mean difference and 95% Confidence Intervals (CI's) for each of the 14-items in the PSS-Q are highlighted in **Table 5.2**. There are no statistically significant results between stress scores and risk of LEA however, there is a trend. As this is a small sample size, the study was not powered to detect small but 'statistically significant' (usually $p<0.05$) differences so conclusions are reliant on judgment of the mean differences between the groups. As the differences, in general, are small, there is unlikely to be a difference between those with LEA and those without. However, there was a trend in responses whereby, more athletes at risk of LEA report undesirable outcomes for the following statements: "Dealt unsuccessfully with irritating life hassles", "Felt that things were not going your way", "Felt that you were on not top of things", "Found yourself thinking about things that you have to accomplish", "Not able to control the way you spend your time" and "Felt difficulties were piling up so high that you could not overcome them", observed in **Table 5.2**.

---

[a] *A LEAF_Q score of <8 determined the athletes who were not at risk of developing LEA.*
[b] *A LEAF-Q score ≥8 determined those athletes at risk of developing LEA.*

*Table 5.2 Perceived Stress Scale (PSS) questionnaire responses for those not at risk and those at risk of developing Low Energy Availability (LEA) [ab]*

| | Not at risk of LEA *n* =12 | At risk of LEA *n* =12 | Mean difference (95% CI) |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | |
| Been upset because of something that happened unexpectedly | 1.6 ± 0.5 | 1.6 ± 0.9 | -0.0 (0.6, -0.6) |
| Felt that you were unable to control the important things in your life | 1.9 ± 1.1 | 1.6 ± 1.0 | -0.3 (1.1, -0.6) |
| Felt nervous and "stressed" | 2.3 ± 0.9 | 2.3 ± 0.8 | -0.0 (0.7, -0.7) |
| Dealt unsuccessfully with irritating life hassles [c] | 1.3 ± 0.8 | 1.6 ± 0.7 | 0.3 (0.3, -0.9) |
| Felt that you were not effectively coping with important changes were occurring in your life | 1.4 ± 0.8 | 1.3 ± 0.7 | -0. 08 (0.7, -0.5) |
| Felt unconfident about your ability to handle your personal problems | 1.3 ± 0.8 | 1.3 ± 0.7 | -0.0 (0.6, -0.6) |
| Felt that things were not going your way [c] | 1.4 ± 0.9 | 1.5 ± 0.7 | 0.08 (0.6, -0.8) |
| Found that you could not cope with all the things that you had to do | 1.58 ± 0.90 | 1.33 ± 0.78 | -0.25 (0.96, -0.46) |
| Been unable to control irritations in your life | 1.6 ± 1.0 | 1.4 ± 1.0 | - 0.17 (1.0, -0.7) |
| Felt that you were on not top of things [c] | 1.4 ± 0.7 | 1.6 ± 0.7 | 0.17 (0.4, -0.7) |
| Angered because of things that happened that were outside of your control | 2.0 ± 1.0 | 1.9 ± 1.3 | - 0.08 (1.1, -0.9) |
| Found yourself thinking about things that you have to accomplish [c] | 3.17 ± 0.72 | 3.25 ± 0.75 | 0.08 (0.54, -0.71) |
| Not able to control the way you spend your time [c] | 1.08 ± 0.52 | 1.5 ± 0.80 | 0.42 (0.15, -0.99) |
| Felt difficulties were piling up so high that you could not overcome them [c] | 1.33 ± 1.07 | 1.42 ± 1.00 | 0.08 (0.79, -0.96) |
| Total Stress Score[d] | 23.4 ± 5.5 | 23.7 ± 6.6 | 0.25 (4.9, -5.4) |

[a] *All questions are phrased "How often in the past month have you…"*
[b] *Possible score ranges from 0 to 4, where a higher score is indicative of more stress.*
[c] *These questions have been reworded from the original questionnaire, as they were scored in reverse.*
[d] *Possible score ranges form 0-56*

**Figure 5.1** shows the athlete's response rate to the statement: "How often have you successfully dealt with irritating life hassles?" Whereby 50% athletes at risk of LEA report they are sometimes or less often (scoring ≥2) able to deal with life hassles in comparison with 42% of their not at risk equivalents.

Similarly, **Figure 5.2** shows the athletes' response to the statement: "How often have you felt that things were going your way?" Indicating 58% of athletes at risk of LEA reported sometimes or less frequently (a score ≥2) things were going their way in the past month compared to 50% of their not at risk counterparts.

Comparably, **Figure 5.3** shows the athlete's response rate to the statement:" How often have you felt that you were on top of things?" This suggests those not at risk of LEA are more likely to feel on top of things, indicated by 8% of the athletes in this group reporting "very often" (score of 0) compared to 0% of the at risk population reporting this outcome.

**Figure 5.4** shows the athlete's response rate to the statement: "How often have you found yourself thinking about things that you have to accomplish?" Whereby 42% of athletes at risk of LEA report "very often" (score of 4) spending time concerned about the tasks they have to accomplish when compared to 33% of the not at risk group.

**Figure 5.5** shows the athlete's response rate to the statement: "How often have you been able to control the way you spend time?" The number of those at risk of LEA scoring sometimes or less frequently (score of ≥2) for this item was 50% compared to 17% of those not at risk of LEA. Additionally, only one athlete reported "almost never" being able to control the way they spend time, this one report was from an athlete at risk of LEA.

Lastly, **Figure 5.6** shows the athlete's response rate to the statement: "How often have you felt difficulties were piling up so high that you could not overcome them?" Whereby 25% of the not at risk group report "never" (score of 0) having felt difficulties pile up so high they couldn't overcome them when compared to 17% of the at risk athletes reporting the same outcome.

Overall, the group of athletes at risk of LEA depict no clear difference in stress levels when compared to the group not at risk of LEA as the confidence intervals include 1 (-5.4, 4.9) demonstrated in **Table 5.2**. However, there may be a trend present, indicating more stress could be present in athletes at risk of LEA.

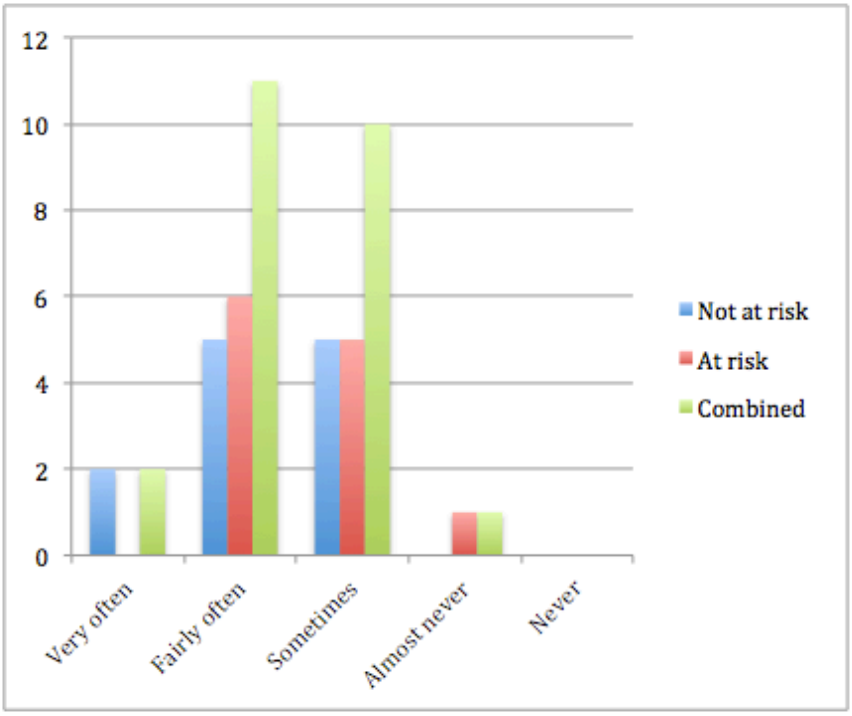



*Figure 5.1 How often have you successfully dealt with irritating life hassles?*

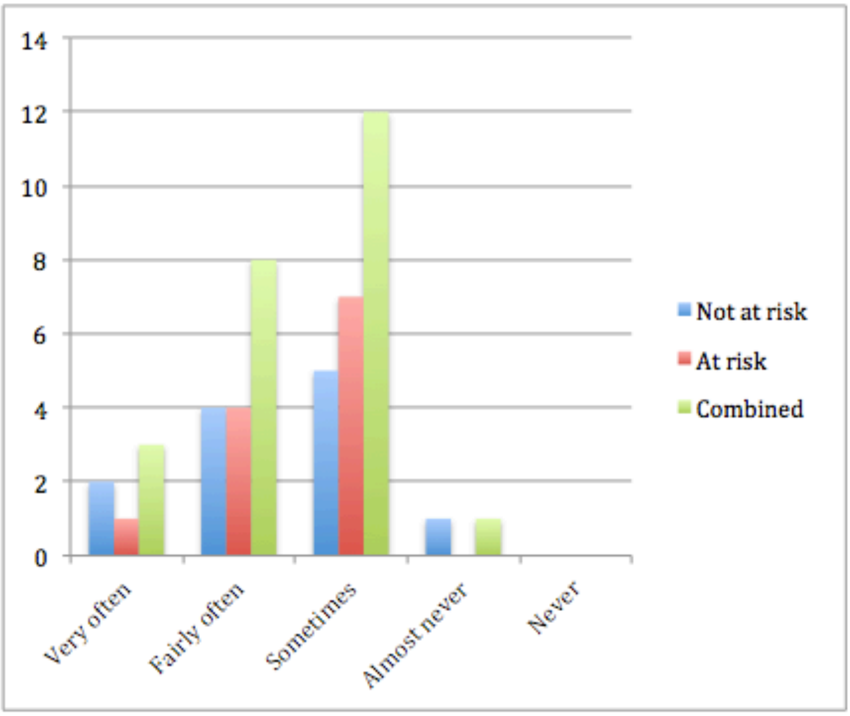



*Figure 5.2 How often have you felt things were going your way?*

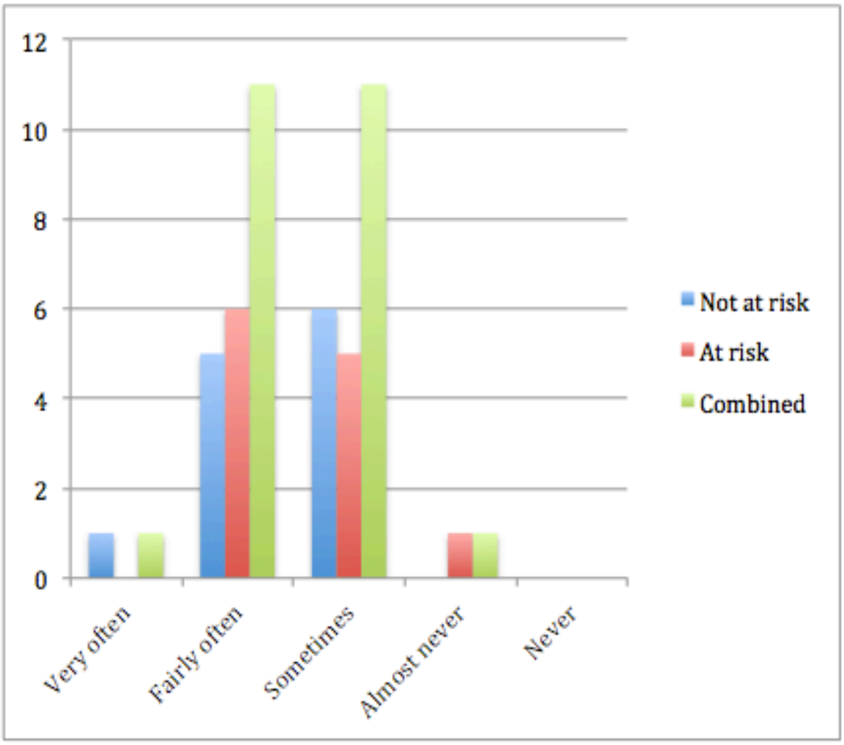



*Figure 5.3 How often have you felt on top of things?*

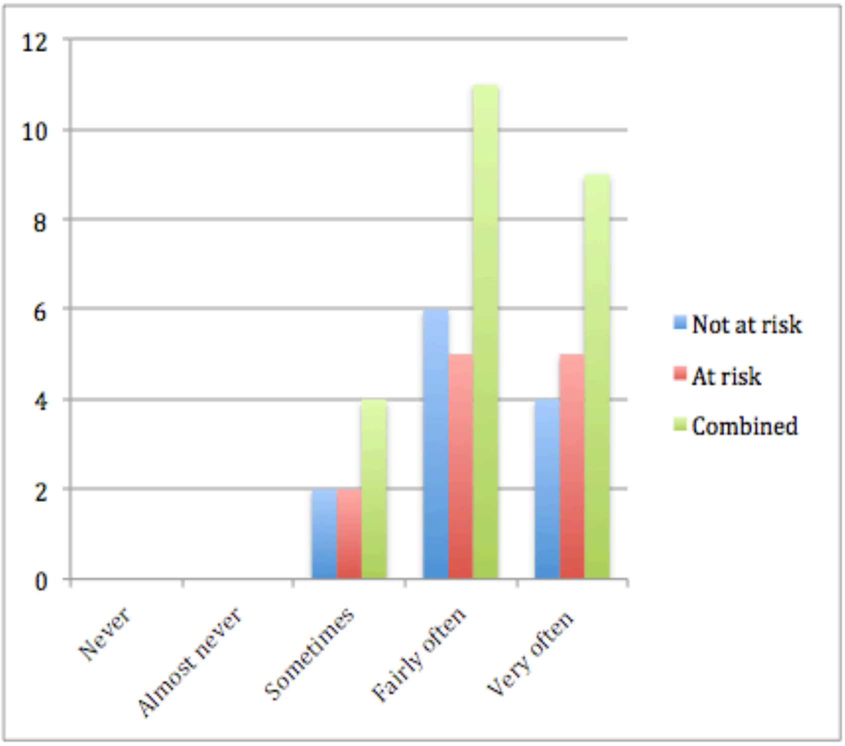



*Figure 5.4 How often have you found yourself thinking about things you need accomplished?*

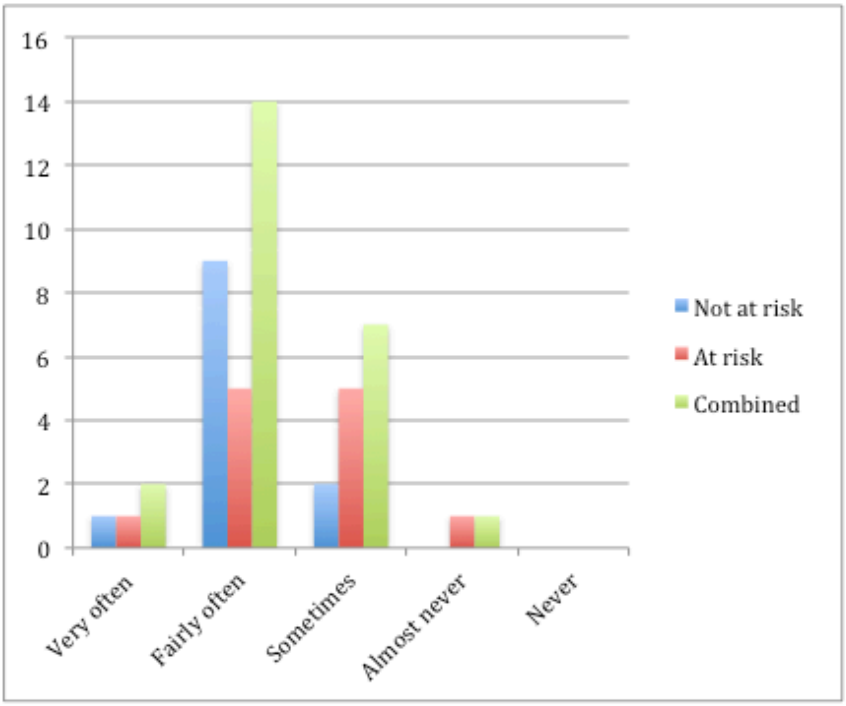



*Figure 5.5 How often have you been able to control the way you spend time?*

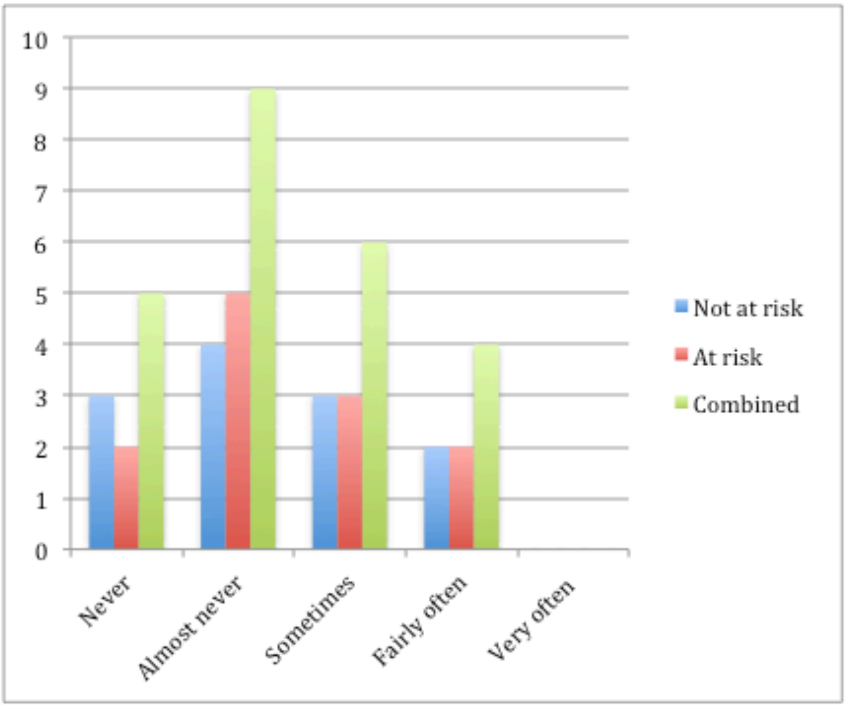



*Figure 5.6 How often have you felt difficulties were piling up so high you can't overcome them?*

## 5.5 Sleep Quality

Pittsburgh Sleep Quality Index Questionnaire (PSQI-Q) results were available from 100% of the athletes, as baseline response rate was high. Across all twenty-four athletes, the sleep quality score is based on a range of 0-21 where a higher score is indicative of subjective poor sleep quality. There was no meaningful difference in subjective sleep quality scores between those not at risk and those at risk of developing LEA ($4.8 \pm 1.4$ and $6.8 \pm 2.3$), assessed by the PSQI-Q as there is only a two-unit difference. Nevertheless, the mean global score for the athletes at risk of LEA is slightly greater than those not at risk of LEA therefore, could be indicative of a relationship between LEA and subjective sleep quality with a larger sample size. Although there is no difference in mean sleep quality between groups, **Table 5.3** displays the results by the number of participants, indicating numerical differences between groups. Using a criterion of a global PSQI-Q score of ≥5 relating to poor sleep quality, a total of fourteen participants were classified as "poor" sleepers at baseline. For the athletes that are deemed at risk of LEA there is a significant difference ($p < 0.05$) in the number of athletes reporting a poor sleep quality, **Table 5.3**. Of those at risk of LEA 83% reported a poor sleep quality, which may indicate a relationship between LEA and subjective sleep quality in athletes.

*Table 5.3 Sleep quality and sleep latency by number of participants in groups both not at risk and at risk of developing low energy availability*

| | | Not at risk of LEA *n =12* | At risk of LEA *n =12* | *(p-value)*[a] |
|---|---|---|---|---|
| Sleep Quality (>5) | | 4 (33.3%) | 10 (83.3%) | *(<0.017)* |
| Latency | | | | *(0.590)* |
| | <15 minutes | 1 (8%) | 0 (0%) | |
| | 15-30 minutes | 10 (83%) | 9 (75%) | |
| | 31-60 minutes | 1 (8%) | 1 (8%) | |
| | >61 minutes | 0 (0%) | 2 (17%) | |

[a] *p-values were formed from the Fisher's exact test*

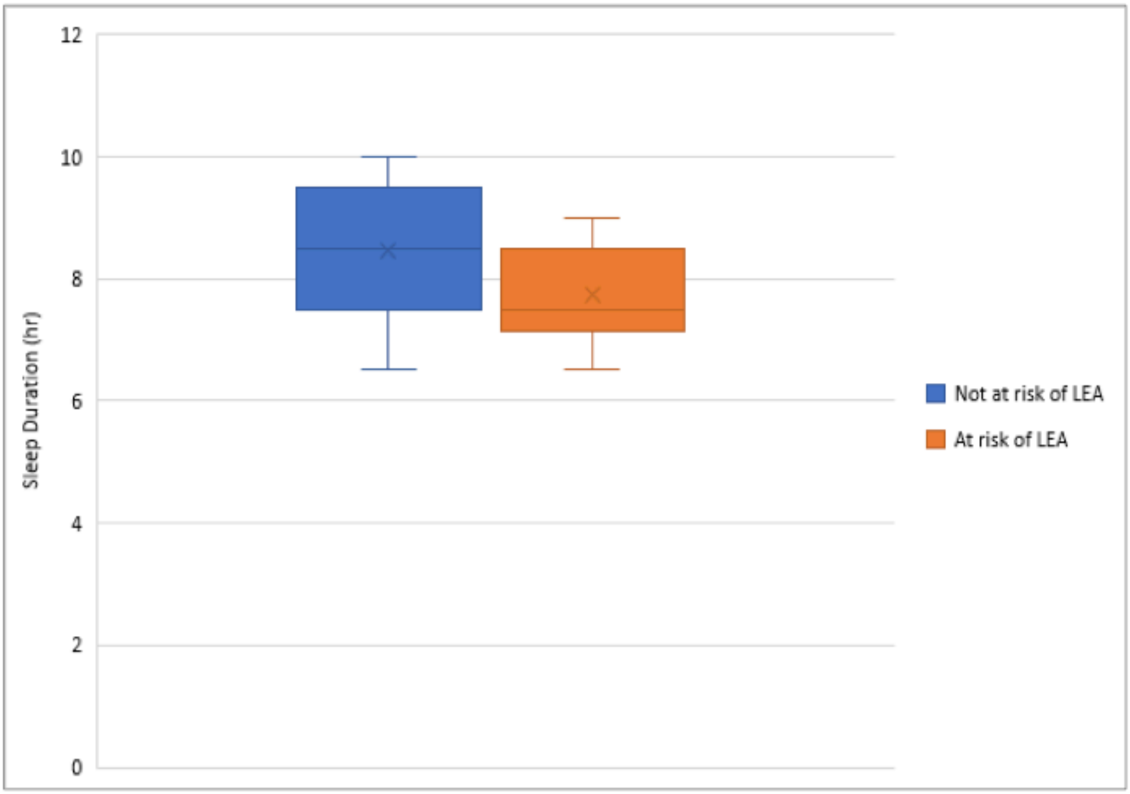
## 5.6 Sleep Latency

Even though there are no significant differences for sleep latency there is a concerning result concluded here. Two members (17%) of the group at risk of LEA reported sleep latency was >1 hour, as seen in **Table 5.3**. Conversely in the not at risk population, only one athlete reported a sleep latency time >30 minutes. Mean sleep latency was 19.3 ± 10.3 minutes for those not at risk of developing LEA and 34.8 ± 30.7 minutes for those at risk of developing LEA, this could indicate a possible difference, but we cannot detect the true difference here due to small participant numbers.

## 5.7 Sleep Duration

Sleep duration data produced an outlier, one athletes sleep duration averaged at four hours each night. For the analysis of sleep duration alone this athlete was excluded. The exclusion of this participant only made a minor difference to the mean and standard deviation for the not at risk population however, did not make any effect on the overall trend. After the exclusion of this participant, there were eleven participants in the not at risk of LEA group leaving a total of twenty-three participants. When comparing sleep duration using self-reported sleep and wake times, the mean difference was 0.7 hours (42 minutes) (95% CI: -0.1, 1.5) between the not at risk of LEA and at risk groups. **Figure 5.7** shows: those not at risk slept for 8.5 ± 1.0 hours and those at risk slept for 7.8 ± 0.8 hours indicting no real difference between groups. However, it is possible the group at risk of LEA sleep for less time as the maximum duration of 9 hours is less than the not at risk groups' upper quartile of 9.3 hours and maximum duration of 10 hours.

*Figure 5.7 Mean sleep duration (hrs) of those not at risk and those at risk of developing low energy availability*




### 5.8 Dietary data

For the dietary data, unfortunately not all participants collected data across all five days, therefore they were not included in analysis. Two members of each group were excluded from the dietary analysis yielding a total of 20 participants, with 10 from each group, whom provided 3 meals on all five days of data collection. Despite aiming to obtain five days of data, we were only able to obtain four days therefore; data is representative of participants 4-day diet record. **Table 5.4** compares energy intakes (Kilojoules) between both groups.

The estimations from the 4-day food diaries illustrate no statistical difference between those at risk and those not at risk of developing LEA for total energy intake. The average energy intake for all the elite athletes was 9169 kJ which is more than those at risk of developing LEA but not significantly different. **Table 5.4** also depicts the macronutrient distribution of players not at risk and at risk of developing LEA respectively. Data is based off a 4-day diet-record and as shown, those who were at risk of developing LEA had a similar daily intake of carbohydrates as their counterparts not at risk *(p = 0.91)*. Moreover, there is no difference in carbohydrate intake per kilogram of body mass between the two groups.

*Table 5.4 Estimated dietary intake using five day food diaries for those at risk and those not at risk of developing low energy availability*

| | Not at risk *n =10* | At risk *n =10* | Mean Difference (95% CI) | *P value*[a] |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | |
| Energy (kJ) | 9270 ± 2412.9 | 9068 ± 1714.0 | 202 (-1764 - 2169) | *0.83* |
| Carbohydrates (g.day$^{-1}$) [b] | 237 ± 65.4 | 234 ± 44.5 | 3 (-50 - 56) | *0.91* |
| Carbohydrates (g.kg$^{-1}$.bw.d$^{-1}$) [c] | 3.4 ± 1.1 | 3.2 ± 0.9 | 2 (-0.7 - 1.2) | *0.62* |

[a] *P-values were formed from the Fisher's exact test*
[b] *Values presented in grams per day*
[c] *Values presented in grams per kilogram of bodyweight per day*

# 6. Discussion

To our knowledge this is the first study to describe these potential associations between LEA and stress and sleep disturbances. The results demonstrated a high occurrence of LEA with 50% registering as at risk of developing LEA. There appeared to be a higher prevalence of feeling stressed amongst those at risk of developing LEA compared to those not at risk, with greater feelings of negativity, not having things under control and lack of confidence in coping abilities, although none of these reached statistical significance, possibly due to the low sample size. We also uniquely show that elite female Rugby sevens' players have a high rates of self-reported poor sleep quality, defined as a PSQI-Q global score of >5, with 14 of the 24 athletes being classed as poor sleepers of which 83% were at risk of developing LEA. Further, sleep latency results show important differences with 17% of those at risk of developing LEA taking longer than an hour to get to sleep and on average they slept for 42 minutes less than those not at risk. Finally, we found no difference in caloric or carbohydrate intake between the two groups, likely due to the possibility of LEA occurring in absence of energy restriction.

This study looked at stress outcomes and LEA as there is more literature linking the two compare to the limited evidence investigating mood and LEA. The overall mean Perceived Stress Scale Questionnaire (PSS-Q) score was 23.5 ± 6.0, which is higher than previously reported (18.4 ± 6.5) amongst similar age university students in the USA (102) and higher than a sample of fit healthy women (aged 40 ± 12) (103). Similarly when compared to 94 adults (23 to 61 years of age) who took part in a health promotion group at the University of Massachusetts Medical Centre, the elite athletes from the present study perceive more stress (104). This could be due to sports related internal and external pressure to maintain the ideal body composition, which may lead to a poor body image (105), poor body image in athletes may be associated with behaviours that affect both performance and health (106) such as disordered eating, which may explain the slight difference between the groups. Additionally, elite athletes can have perfectionist and determined personality traits when it comes to maintaining body composition (106-108). However; with elite sport everything is extremely well planned out. Furthermore, athletes who compete at high levels are likely to hold a job and have family and personal lives to consider, balance and prioritising life could add to the level of perceived stress.

We know from previously published literature that LEA can be linked to changes in stress hormones (109). LEA has been shown to increase cortisol and decrease testosterone (12). The International Olympic Committee (IOC) Relative Energy Deficiency in Sport (RED-S) statement suggests that LEA causes increased irritability, decreased concentration and depression (110, 111), yet evidence of the effects on psychological symptoms is somewhat limited. Nevertheless, it would appear that stress and mood are impacted by LEA and this is supported to a limited extent by our findings, although, much further research in this area is required to fully elucidate the full effects of LEA on mood and stress and the mechanisms which lead to these associations.

Potential reasons for this link between LEA and stress include menstrual disturbance, which is a common consequence of LEA. Menstrual disturbances that are associated with exercise have been linked to neuroendocrine abnormalities other than oestrogen such as: “reduction in resting metabolic rate, thyroid hormones, leptin, insulin, glucose”, and “elevations in, ghrelin, growth hormone and cortisol” which lead to a hypo-metabolic state and negative health outcomes (112-114). As we know, hypothyroidism is known to occur as a result of LEA (12) therefore, this low level of thyroid hormone could influence an individual’s mood and stress states.

The corticotrophin-releasing factor system is the central mediator during stressful states; as it coordinates behavioural, endocrine, and autonomic responses to stress. Corticotrophin-releasing factor receptor agonists strongly reduce food intake, thus if elite athletes are experiencing high levels of stress their caloric intake may be suboptimal putting them at increased risk of developing LEA (115). Furthermore, this relationship between food intake and stress could be multidirectional. As we know LEA has similar effects to being in a state of starvation (23) and starvation can cause an increase in cortisol (116).

Although there are no studies currently directly linking stress and LEA, there may be a potential link via stress hormones such as cortisol and corticotrophin-releasing hormone. Stress changes the concentration of stress hormone levels within the body and LEA also impacts stress hormone levels. This link could potentially explain the outcomes observed in the current study. Whereby, as a result of high risk of developing LEA stress hormones are altered causing them to perceive more stress in everyday life. However, the opposing argument may also be true, that the outcomes observed might be due to high stress levels leading to a higher risk of developing LEA. From the current study we cannot say one causes the other as stress outcomes were not significantly greater in either group.

As mentioned in the results of this study, six of the 14-items were showing there may be a potential for more stress in those at risk of developing LEA. There were no statistically significant differences and the trend was not observed across all measures. Therefore, these results should be interpreted with caution as results are speculative and require more data and physiological measures. It has previously been reported that fasting such as during Ramadan can alter mood profiles. Chaouachi et al. showed fatigue and tiredness are usually greater during the fast (117). Zerguini et al. found a great number of athlete's perceptions of adverse effects of Ramadan on training and competition (118). Although, LEA is different from Ramadan in that some food is consumed the effects of Ramadan on sleep and stress and energy restriction highlight the interrelationship of all three. The athletes from the present study on average consumed 128.4 kJ per Kg of body weight (± 33.8 $kJ^{-1}.Kg.d^{-1}$) compared to those male athletes fasting during Ramadan 198.8 kJ per Kg of body weight (± 36.8 $kJ^{-1}.Kg.d^{-1}$) (117). The difference in caloric intake between the two groups, although different genders, means that mood and stress profiles may be altered by this lack of intake within the female athletes of the present study.

There is a possibility that stress and sleep influence one another, as observed in **Figure 6.1.** As mentioned in the literature review, mood and sleep have an intertwining relationship whereby; an earlier sleep onset yields a better mood and later sleep onset has been linked to decreased happiness (98). Additionally, when sleep deprivation occurs, stress state is altered significantly (65). It has also been reported that stress regulation could be the mechanism by which exercise impacts sleep (99).

The athletes in the current study appear to be within the guidelines for adequate sleep as evidenced by being within the recommendation of seven to nine hours of sleep each night. This compares to a mean sleep duration of eight hours in Australian elite athletes (16). However, the group at risk of developing LEA slept for 42 minutes less than those not at risk which may be problematic. Of greater concern were the sleep quality results, indicating that 83% of players at risk of developing LEA perceived a poor sleep quality. Leeder et al. mentioned athletes had an inferior quality sleep when compared to controls, due to training volume (55). Of extra concern is, the quality of sleep is likely to reduce when coming up to a competition due to being excited, eager or anxious (119), which can only add to the detrimental outcomes of performance. Chaouachi et al. concluded that fasting during Ramadan can decrease sleep quality and sleep time (120). Another noteworthy result of the present study was that two athletes at risk of developing LEA reported taking >1 hour to fall asleep indicating an issue as the rest of the study population too <35 minutes to fall asleep.

Although, Leeder et al. mentioned longer sleep latency in athletes none of their participants had sleep latencies >1 hour (55).

Starvation is a stressor that may cause perceived stress and stress and sleep are also linked. As there is no current literature investigating sleep and LEA, looking at sleep and eating disorders may provide some explanation for the link between the two, as eating disorders are common with LEA. In a recent review by Lauer et al. the association between sleep and eating disorders was well researched (121). They report that food consumption stimulates an increase in sleepiness, decreases sleep latency and increases slow wave sleep (121) furthermore, prolonged starvation results in an increased wake time and decreased slow wave sleep (121). This being said the understanding of the interaction between energy metabolism and sleep regulation is still limited and requires future research. Additionally, individuals with eating disorders have increased plasma cortisol levels which are directly involved with sleep regulation (121). However, it must be remembered that LEA can occur without a clinical eating disorder and therefore the psychological/physiological mechanisms may differ.

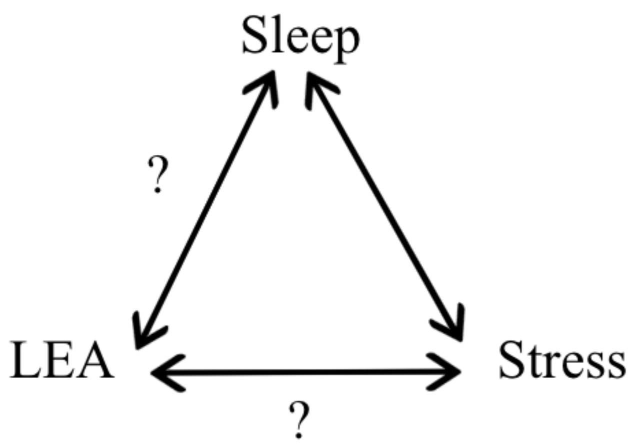



*Figure 6.1 Multi-directional model of the potential associations between low energy availability and stress and sleep.*

**Figure 6.1** shows the potential directions in which the three aspects could be interrelating. Unfortunately, due to the observation cross sectional design of this study we cannot definitively say what direction the outcomes are acting in.  However, we can say there are possible associations between LEA and sleep and potential associations between LEA and stress. Previous research (65, 98, 99, 122), would strongly suggest that there is a multidirectional effect between stress and sleep. Currently it is understood that LEA impacts several systems within the body, however the understanding is unclear whether one outcome of LEA instigates another, or if it is in fact LEA itself causing each outcome.

### 6.1 Strengths

This study has a number of strengths, firstly the use of the LEAF-Q, a previously validated screening tool. The LEAF-Q and PSS-Q were chosen as they have low respondent burden, such as short duration to complete, which aided with compliance. Furthermore, any questions athletes had about the survey could be answered at the time of completion, this meant literacy or education level did not affect the response rate. The LEAF-Q has previously been utilised within the NZ population reporting the prevalence of recreational athletes at risk of LEA (8, 123, 124) however, in future the questionnaire should be validated with the NZ athletic population in addition to North America and Europe where it is currently known as highly specific and sensitive. For this study the data collected was subjective, it has been concluded that subjective data such as mood and perceived stress is superior to objective data such as blood markers, heart rate, oxygen consumption, heart rate response, when investigating athlete wellbeing (125). Furthermore, there was a 100% participation rate from the elite Rugby sevens players. The studies' participants were truly elite, as they were required to be in the current New Zealand representative squad to be included. This was a major strength of the current study as elite athletes are poorly defined in sports nutrition research. Elite athletes are likely to have unique: routines, nutritional upbringings or habits, sports nutrition education, nutritional assistance, and attitudes towards health therefore, it was important to gage the prevalence of LEA and assess the impacts it holds on their stress and sleep.

### 6.2 Limitations

The current study also had several limitations. Firstly, the PSS-Q does not measure mood specifically instead perceived stress was measured. Thus, we cannot say the findings relate directly to mood however, stress outcomes can be linked to LEA via hormonal changes additionally the feelings of stress can influence a mood state. Sample size was relatively small which may have caused limited statistical power to find significant differences between the groups, plus these results cannot be related to other populations. All participants were female Rugby players, therefore we cannot be certain they are representative of all female athletes and are definitely not comparable to the non-athletic population. Lastly, we measured risk of LEA, in order to be sure about actual presence of LEA hormonal changes will need to be measured to help understand mechanisms, which may lead to these results.

### 6.3 Conclusion

It is important we encourage New Zealanders to take part in physical activity as the health benefits are well established including mood (1, 14, 15) and sleep (3). This research observed a potential association between LEA and stress outcomes. This study also found interesting outcomes between those at risk of developing LEA and sleep patterns whereby, 83% of athletes at risk of LEA had poor subjective sleep quality and 17% of the population at risk had extremely long sleep latencies. As we know it is essential to monitor athletes well-being to guide training or competition and "to detect any progression towards negative health outcomes and associated poor performance" (125). It is possible that perceived stress and sleep will impact physical performance and is known that they both impact an individuals' health, therefore based on the results of this investigation, several areas of future research are warranted. Future prospective longitudinal studies are needed to increase our understanding of LEA in NZ athletes and furthermore, investigations into the true impact LEA has on ones stress and anxiety profiles and sleeping patterns. This future research can be used to develop appropriate prevention and treatment options to minimise the health and performance implications for New Zealand's athletes. The information from this study and future studies alike could be used to inform sports dietitians, coaches and the athletes themselves.

# 7. Application to Practice

The term LEA is still a relatively new concept that may be under discussed across all levels of competition. However, it is established that increased total energy expenditure possibly in the presence of calorie deficit causes LEA. In modern times athletes are involved in more scientific research to ensure optimal performance. Therefore, a fundamental aspect of a sports dietitian's role is to take into consideration the EEE and EI and evaluate the risk of LEA of each athlete to ensure their health and performance are protected. Additionally, research is suggesting that nutrient intakes influence the risk of LEA consequences (12) . The potential for LEA to effect mood and perceived stress as well as sleep quality needs to be recognised by the dietitian so that the ingestion of particular foods at particular timing is of high significance to sports dietitians to aid in recovery, can potentially also impact sleep and stress levels which can also improve recovery. This should form part of the discussions with athletes when explaining dietary intakes. The athletes that took part in this study have received their results and the team sports dietitian will use them to educate the players on their current diets and the potential negative impacts of this intake, furthermore the importance of sleep and the associations between risk of LEA thus poor nutritional intake and sleep. As observed in this study and previous studies, New Zealand's athletes may not be consuming enough food to meet their needs.

Through this thesis we hope to increase awareness of LEA and its consequences on psychology, amongst dietitians, coaches, support staff and athletes engaging in frequent vigorous and strenuous exercise. As EI and EEE influence LEA, dietitians could work as part of a multidisciplinary team to predict and prevent any energy imbalances during the training season. Now we can see a potential association between LEA and psychological outcomes, it will be crucial to monitor in future for the athletes health and performance.

Mood profiling is becoming increasingly popular in the sporting realm; thus, dietitians should be required to understand how perceived stress impacts well-being. As athletes are often under a great deal of stress and physical pressures to perform optimally, sports dietitians should also be furthering their knowledge in the field of psychology. As the current study highlights, LEA could have detrimental effects on stress outcomes or vice versa. Therefore, sports dietitians should be able to identify stress patterns as a symptom for diagnosis and treatment of LEA or contrariwise. As we know sleep is a crucial part of recovery for all individuals but may be paramount for athletes. This study highlights the possible effects LEA could have on sleep or vice versa, which may be detrimental to the athletes' health and performance. Dietitians, coaches and support staff could work together to ensure athletes are receiving the desired quantity of sleep. This could be achieved by ensuring energy balances with EEE and by appropriately timing training sessions and meal times around sleep periods.

# 8. References


1. Anderson E, Shivakumar G. Effects of exercise and physical activity on anxiety. Front Psychiatry. 2013;4:27.
2. Church T. Exercise in obesity, metabolic syndrome, and diabetes. Prog Cardiovasc Dis. 2011;53(6):412-8.
3. Driver HS, Taylor SR. Exercise and sleep. Sleep Med Rev. 2000;4(4):387-402.
4. Suarez-Arrones L, Nuñez FJ, Portillo J, Mendez-Villanueva A. Match running performance and exercise intensity in elite female Rugby Sevens. The Journal of Strength & Conditioning Research. 2012;26(7):1858-62.
5. De Souza MJ, Nattiv A, Joy E, Misra M, Williams NI, Mallinson RJ, et al. 2014 Female Athlete Triad Coalition Consensus Statement on treatment and return to play of the female athlete triad. Br J Sports Med. 2014;48(4):289-309.
6. Sundgot-Borgen J, Torstveit MK. Prevalence of eating disorders in elite athletes is higher than in the general population. Clin J Sport Med. 2004;14(1):25-32.
7. Barrack MT, Gibbs JC, De Souza MJ, Williams NI, Nichols JF, Rauh MJ, et al. Higher incidence of bone stress injuries with increasing female athlete triad–related risk factors: a prospective multisite study of exercising girls and women. Am J Sports Med. 2014;42(4):949-58.
8. Slater J. Low Energy Availability In New Zealand Recreational Athletes. New Zealand: University of Otago; 2015.
9. Heaney S, O'Connor H, Naughton G, Gifford J. Towards an Understanding of the Barriers to Good Nutrition for Elite Athletes. International Journal of Sports Science & Coaching. 2008;3(3):391-401.
10. Erdelyi GJ. Gynecological survey of female athletes. J Sports Med Phys Fit. 1962;2:174-9.
11. Matzkin E, Curry EJ, Whitlock K. Female athlete triad: past, present, and future. J Am Acad Orthop Surg. 2015;23(7):424-32.
12. Mountjoy M, Sundgot-Borgen JK, Burke LM, Ackerman KE, Blauwet C, Constantini N, et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. Br J Sports Med. 2018;52(11):687-97.
13. Nattiv A, Loucks AB, Manore MM, Sanborn CF, Sundgot-Borgen J, Warren MP. American College of Sports Medicine position stand. The female athlete triad. American college of sports medicine. 2007;39(10):1867-82.
14. Aldana SG, Sutton LD, Jacobson BH, Quirk MG. Relationships between leisure time physical activity and perceived stress. Percept Mot Skills. 1996;82(1):315-21.
15. Biddle S. Exercise and psychosocial health. Res Q Exerc Sport. 1995;66(4):292-7.
16. Drew MK, Vlahovich N, Hughes D, Appaneal R, Peterson K, Burke L, et al. A multifactorial evaluation of illness risk factors in athletes preparing for the Summer Olympic Games. J Sci Med Sport. 2017;20(8):745-50.
17. Yang P-Y, Ho K-H, Chen H-C, Chien M-Y. Exercise training improves sleep quality in middle-aged and older adults with sleep problems: A systematic review. J Physiother. 2012;58(3):157-63.
18. Hillman CH, Erickson KI, Kramer AF. Be smart, exercise your heart: exercise effects on brain and cognition. Nature reviews neuroscience. 2008;9(1):58.
19. Berger BG. Psychological benefits of an active lifestyle: What we know and what we need to know. Quest. 1996;48(3):330-53.
20. Dziedzic CE, Higham DG. Performance nutrition guidelines for international rugby sevens tournaments. Int J Sport Nutr Exerc Metab. 2014;24(3):305-14.

21. Ministry of Health. Eating and Activity Guidelines for New Zealand Adults. Wellington: Ministry of Health; 2015.
22. Russell R. Pate PMP, MD, MPH; Steven N. Blair, PED; et al. Physical activity and public health: A recommendation from the centers for disease control and prevention and the American College of Sports Medicine. JAMA. 1995;273(5):402-7.
23. Loucks AB, Kiens B, Wright HH. Energy availability in athletes. J Sports Sci. 2011;29(sup1):S7-S15.
24. Sundgot-Borgen J, Garthe I. Elite athletes in aesthetic and Olympic weight-class sports and the challenge of body weight and body compositions. J Sports Sci. 2011;29(sup1):S101-14.
25. Slater J, Brown R, McLay-Cooke R, Black K. Low energy availability in exercising women: historical perspectives and future directions. Sports Med. 2017;47(2):207-20.
26. Otis CL, Drinkwater B, Johnson M, Loucks A, Wilmore J. American College of Sports Medicine position stand. The female athlete triad. Med Sci Sports Exerc. 1997;29(5):i-ix.
27. Mountjoy M, Sundgot-Borgen J, Burke L, Carter S, Constantini N, Lebrun C, et al. The IOC consensus statement: beyond the female athlete triad—Relative Energy Deficiency in Sport (RED-S). Br J Sports Med. 2014;48(7):491-7.
28. Rickenlund A, Eriksson MJ, Schenck-Gustafsson K, Hirschberg AL. Amenorrhea in female athletes is associated with endothelial dysfunction and unfavorable lipid profile. J Clin Endocrinol Metab. 2005;90(3):1354-9.
29. Pencina MJ, D'Agostino Sr RB, Larson MG, Massaro JM, Vasan RS. Predicting the thirty-year risk of cardiovascular disease: the Framingham Heart Study. Circulation. 2009;119(24):3078.
30. Melin A, Tornberg AB, Skouby S, Faber J, Ritz C, Sjodin A, et al. The LEAF questionnaire: a screening tool for the identification of female athletes at risk for the female athlete triad. Br J Sports Med. 2014;48(7):540-5.
31. Meyer JD, Koltyn KF, Stegner AJ, Kim JS, Cook DB. Influence of exercise intensity for improving depressed mood in depression: A dose-response study. Behav Ther. 2016;47(4):527-37.
32. Beedie CJ, Terry PC, Lane AM. The profile of mood states and athletic performance: Two meta-analyses. J Appl Sport Psychol. 2000;12(1):49-68.
33. Lane AM, Terry PC. The nature of mood: Development of a conceptual model with a focus on depression. J Appl Sport Psychol. 2000;12(1):16-33.
34. Keikha BM, Yusof SM, Jourkesh M. The relationship between pre-competition state anxiety components and mood state sub-scales scores and the result of among college athletes through temporal patterning. International Journal of Sports Science. 2015;5(1):8-15.
35. Morris WN, Schnurr PP. The concept of mood. 2012 [cited 2018 Oct 30]. In: Mood: The frame of mind [Internet]. New Hamshire: Springer Science & Business Media, [cited 2018 Oct 30]; p. 1-10. Available from: https://link-springer-com.ezproxy.otago.ac.nz/content/pdf/10.1007%2F978-1-4612-3648-1_1.pdf.
36. Thayer R. The biopsychology of mood and arousal. New York: Oxford University Press; 1989. 234 p.
37. Morgan WP, Johnson RW. Personality characteristics of successful and unsuccessful oarsmen. Int J Sport Psychol. 1978;9(2):119-33.
38. Morgan WP, Pollock ML. Psychologic characterization of the elite distance runner. Ann N Y Acad Sci. 1977;301(1):382-403.
39. Nagle FJ, Morgan WP, Hellickson RO, Serfass RC, Alexander JF. Spotting success traits in Olympic contenders. Phys Sportsmed. 1975;3(12):31-4.

40. Morgan WP. Selected psychological factors limiting performance: A mental health model. In: Clarke D, Eckert H, editors. Limits of human performance. Champaign: Human Kinetics; 1985. p. 70-80.
41. Berger BG, Motl RW. Exercise and mood: A selective review and synthesis of research employing the profile of mood states. J Appl Sport Psychol. 2000;12(1):69-92.
42. Glass JM, Lyden AK, Petzke F, Stein P, Whalen G, Ambrose K, et al. The effect of brief exercise cessation on pain, fatigue, and mood symptom development in healthy, fit individuals. J Psychosom Res. 2004;57(4):391-8.
43. Oxford University Press. English Oxford Living Dictionaries [Internet]: Oxford University Press; 2018 [cited 2018 1 November]. Available from: https://en.oxforddictionaries.com/definition/stress.
44. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav. 1983;24(4):385-96.
45. Chiu Y-H, Lu FJ-H, Lin J-H, Nien C-L, Hsu Y-W, Liu H-Y. Psychometric properties of the perceived stress scale (PSS): measurement invariance between athletes and non-athletes and construct validity. PeerJ. 2016;4:e2790.
46. Holmes TH, Rahe RH. The social readjustment rating scale. J Psychosom Res. 1967;11(2):213-8.
47. Hooper SL, Mackinnon LT. Monitoring overtraining in athletes. Sports Med. 1995;20(5):321-7.
48. Fry RW, Morton AR, Keast D. Overtraining in athletes: An update. Sports Med. 1991;12(1):32-65.
49. Kuipers H, Keizer HA. Overtraining in elite athletes: Review and directions for the future. Sports Med. 1988;6(2):79-92.
50. Lehmann M, Foster C, Keul J. Overtraining in endurance athletes: A brief review. Med Sci Sports Exerc. 1993;25(7):854-62.
51. Morgan W, Brown D, Raglin J, O'connor P, Ellickson K. Psychological monitoring of overtraining and staleness. Br J Sports Med. 1987;21(3):107-14.
52. Fry R, Grove J, Morton A, Zeroni P, Gaudieri S, Keast D. Psychological and immunological correlates of acute overtraining. Br J Sports Med. 1994;28(4):241-6.
53. O'Connor PJ, Morgan WP, Raglin JS, Barksdale CM, Kalin NH. Mood state and salivary cortisol levels following overtraining in female swimmers. Psychoneuroendocrinology. 1989;14(4):303-10.
54. Raglin J, Morgan W. Development of a scale for use in monitoring training-induced distress in athletes. Int J Sports Med. 1994;15(2):84-8.
55. Leeder J, Glaister M, Pizzoferro K, Dawson J, Pedlar C. Sleep duration and quality in elite athletes measured using wristwatch actigraphy. J Sports Sci. 2012;30(6):541-5.
56. Kryger MH, Roth T, Dement WC. Normal Human Sleep: An Overview. In: Kryger MH, Roth T, editors. Principles and practice of sleep medicine. Sixth edition. ed: Elsevier; 2017.
57. Beersma DG. Models of human sleep regulation. Sleep Med Rev. 1998;2:31-43.
58. Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, DonCarlos L, et al. National Sleep Foundation's updated sleep duration recommendations: final report. Sleep Health. 2015;1(4):233-43.
59. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193-213.
60. Ablin JN, Clauw DJ, Lyden AK, Ambrose K, Williams DA, Gracely RH, et al. Effects of sleep restriction and exercise deprivation on somatic symptoms and mood in healthy adults. Clin Exp Rheumatol. 2013;31(sup79):S53-9.

61. Halson SL. Nutrition, sleep and recovery. European Journal of sport science. 2008;8(2):119-26.
62. Abedelmalek S, Chtourou H, Aloui A, Aouichaoui C, Souissi N, Tabka Z. Effect of time of day and partial sleep deprivation on plasma concentrations of IL-6 during a short-term maximal performance. Eur J Appl Physiol. 2013;113(1):241-8.
63. Taheri M, Arabameri E. The effect of sleep deprivation on choice reaction time and anaerobic power of college student athletes. Asian J Sports Med. 2012;3(1):15-20.
64. Blumert PA, Crum AJ, Ernsting M, Volek JS, Hollander DB, Haff EE, et al. The acute effects of twenty-four hours of sleep loss on the performance of nationalcaliber male collegiate weightlifters. J Strength Cond Res. 2007;21(4):1146-54.
65. Sinnerton S, Reilly T. Effects of sleep loss and time of day in swimmers. Biomechanics and medicine in swimming: swimming science VI. 1992:399-404.
66. Reilly T, Deykin T. Effects of partial sleep loss on subjective states, psychomotor and physical performance tests. Journal of Human Movement Studies. 1983;9:157-70.
67. Tilley AJ, Wilkinson RT. The effects of a restricted sleep regime on the composition of sleep and on performance. Psychophysiology. 1984;21(4):406-12.
68. Tochikubo O, Ikeda A, Miyajima E, Ishii M. Effects of insufficient sleep on blood pressure monitored by a new multibiomedical recorder. Hypertension. 1996;27(6):1318-24.
69. Spiegel K, Tasali E, Leproult R, Van Cauter E. Effects of poor and short sleep on glucose metabolism and obesity risk. Nat Rev Endocrinol. 2009;5(5):253.
70. Banks S. Behavioral and physiological consequences of sleep restriction. J Clin Sleep Med. 2007;3(5):519-28.
71. Goel N, Rao H, Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. Semin Neurol. 2009;29(4):320.
72. Baron KG, Reid KJ, Zee PC. Exercise to improve sleep in insomnia: exploration of the bidirectional effects. J Clin Sleep Med. 2013;9(8):819-24.
73. Owens JF, Matthews KA. Sleep disturbance in healthy middle-aged women. Maturitas. 1998;30(1):41-50.
74. Yuksel M, Yildiz A, Demir M, Bilik MZ, Ozaydogdu N, Aktan A, et al. Effect of sleep quality on hemodynamic response to exercise and heart rate recovery in apparently healthy individuals. Clinical & Investigative Medicine. 2014;37(6):352-62.
75. Ayas NT, White DP, Manson JE, Stampfer MJ, Speizer FE, Malhotra A, et al. A prospective study of sleep duration and coronary heart disease in women. Arch Intern Med. 2003;163(2):205-9.
76. Ellenbogen JM. Cognitive benefits of sleep and their loss due to sleep deprivation. Neurology. 2005;64(7):E25-E7.
77. Telzer EH, Fuligni AJ, Lieberman MD, Galván A. The effects of poor quality sleep on brain function and risk taking in adolescence. Neuroimage. 2013;71:275-83.
78. Walker MP, Stickgold R. Sleep-dependent learning and memory consolidation. Neuron. 2004;44(1):121-33.
79. Brandt R, Bevilacqua GG, Andrade A. Perceived sleep quality, mood states, and their relationship with performance among Brazilian elite athletes during a competitive period. J Strength Cond Res. 2017;31(4):1033-9.
80. Shapiro C. Sleep and the athlete. Br J Sports Med. 1981;15(1):51-5.
81. Drew M, Vlahovich N, Hughes D, Appaneal R, Burke LM, Lundy B, et al. Prevalence of illness, poor mental health and sleep quality and low energy availability prior to the 2016 Summer Olympic Games. Br J Sports Med. 2018;52(1):47-53.
82. Mezick EJ, Matthews KA, Hall M, Kamarck TW, Buysse DJ, Owens JF, et al. Intra-individual variability in sleep duration and fragmentation: associations with stress. Psychoneuroendocrinology. 2009;34(9):1346-54.

83. Bonnet MH, Arand D. Caffeine use as a model of acute and chronic insomnia. Sleep. 1992;15(6):526-36.
84. Chester N, Wojek N. Caffeine consumption amongst British athletes following changes to the 2004 WADA prohibited list. Int J Sports Med. 2008;29(6):524-8.
85. Raymann RJ, Swaab DF, Van Someren EJ. Cutaneous warming promotes sleep onset. Am J Physiol Regul Integr Comp Physiol. 2005;288(6):R1589-R97.
86. Trinder J, Montgomery I, Paxton S. The effect of exercise on sleep: The negative view. Acta Physiol Scand Suppl. 1988;574:14-20.
87. Taylor SR, Rogers GG, Driver HS. Effects of training volume on sleep, psychological, and selected physiological profiles of elite female swimmers. Med Sci Sports Exerc. 1997;29(5):688-93.
88. Brondel L, Romer MA, Nougues PM, Touyarou P, Davenne D. Acute partial sleep deprivation increases food intake in healthy men. Am J Clin Nutr. 2010;91(6):1550-9.
89. Sargent C, Lastella M, Halson SL, Roach GD. The validity of activity monitors for measuring sleep in elite athletes. J Sci Med Sport. 2016;19(10):848-53.
90. Halson SL. Sleep and the elite athlete. Sports sci. 2013;26(113):1-4.
91. Juliff LE, Halson SL, Peiffer JJ. Understanding sleep disturbance in athletes prior to important competitions. J Sci Med Sport. 2015;18(1):13-8.
92. Brand S, Gerber M, Beck J, Hatzinger M, Pühse U, Holsboer-Trachsler E. High exercise levels are related to favorable sleep patterns and psychological functioning in adolescents: a comparison of athletes and controls. J Adolesc Health. 2010;46(2):133-41.
93. Benloucif S, Orbeta L, Ortiz R, Janssen I, Finkel SI, Bleiberg J, et al. Morning or evening activity improves neuropsychological performance and subjective sleep quality in older adults. Sleep. 2004;27(8):1542-51.
94. Driller MW, Mah CD, Halson SL. Development of the athlete sleep behavior questionnaire: A tool for identifying maladaptive sleep practices in elite athletes. Sleep Science. 2018;11(1):37.
95. Domino G, Blair G, Bridges A. Subjective assessment of sleep by sleep questionnaire. Percept Mot Skills. 1984;59(1):163-70.
96. De La Vega R, Tomé-Pires C, Solé E, Racine M, Castarlenas E, Jensen MP, et al. The Pittsburgh Sleep Quality Index: Validity and Factor Structure in Young People. Psychol Assess. 2015;27(4):e22-e7.
97. Grandner MA, Kripke DF, YOON IY, Youngstedt SD. Criterion validity of the Pittsburgh Sleep Quality Index: Investigation in a non‐clinical sample. Sleep Biol Rhythms. 2006;4(2):129-36.
98. Totterdell P, Reynolds S, Parkinson B, Briner RB. Associations of sleep with everyday mood, minor symptoms and social interaction experience. Sleep. 1994;17(5):466-75.
99. Dzierzewski JM, Buman MP, Giacobbi PR, Jr., Roberts BL, Aiken-Morgan AT, Marsiske M, et al. Exercise and sleep in community-dwelling older adults: evidence for a reciprocal relationship. J Sleep Res. 2014;23(1):61-8.
100. Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr. 1974;32(1):77-97.
101. Yuhasz M. Physical fitness and sport appraisal. Laboratory Manual London, Ontario, University of Western Ontario. 1974.
102. Roberti JW, Harrington LN, Storch EA. Further psychometric support for the 10‐item version of the perceived stress scale. Journal of College Counseling. 2006;9(2):135-47.

103. Dishman RK, Nakamura Y, Garcia ME, Thompson RW, Dunn AL, Blair SN. Heart rate variability, trait anxiety, and perceived stress among physically fit men and women. Int J Psychophysiol. 2000;37(2):121-33.
104. Pbert L, Doerfler LA, DeCosimo D. An evaluation of the perceived stress scale in two clinical populations. J Psychopathol Behav Assess. 1992;14(4):363-75.
105. Krentz EM, Warschburger P. Sports-related correlates of disordered eating in aesthetic sports. Psychol Sport Exerc. 2011;12(4):375-82.
106. Gibson C, Hindle C, McLay-Cooke R, Slater J, Brown R, Smith B, et al. Body Image Amongst Elite Rugby Union Players. J Strength Cond Res. 2017.
107. Engel SG, Johnson C, Powers PS, Crosby RD, Wonderlich SA, Wittrock DA, et al. Predictors of disordered eating in a sample of elite Division I college athletes. Eating Behaviors. 2003;4(4):333-43.
108. Thompson RA, Sherman RT. "Good athlete" traits and characteristics of anorexia nervosa: Are they similar? Eating Disorders. 1999;7(3):181-90.
109. Fuqua JS, Rogol AD. Neuroendocrine alterations in the exercising human: implications for energy homeostasis. Metabolism. 2013;62(7):911-21.
110. Bomba M, Gambera A, Bonini L, Peroni M, Neri F, Scagliola P, et al. Endocrine profiles and neuropsychologic correlates of functional hypothalamic amenorrhea in adolescents. Fertil Steril. 2007;87(4):876-85.
111. Marcus MD, Loucks TL, Berga SL. Psychological correlates of functional hypothalamic amenorrhea. Fertil Steril. 2001;76(2):310-6.
112. Hilton L, Loucks A. Low energy availability, not exercise stress, suppresses the diurnal rhythm of leptin in healthy young women. Am J Physiol. 2000;278(1):E43-E9.
113. Loucks A, Heath E. Dietary restriction reduces luteinizing hormone (LH) pulse frequency during waking hours and increases LH pulse amplitude during sleep in young menstruating women. J Clin Endocrinol Metab. 1994;78(4):910-5.
114. Loucks AB. Energy availability, not body fatness, regulates reproductive function in women. Exerc Sport Sci Rev. 2003;31(3):144-8.
115. Zorrilla EP, Taché Y, Koob GF. Nibbling at CRF receptor control of feeding and gastrocolonic motility. Trends Pharmacol Sci. 2003;24(8):421-7.
116. Palmblad J, Levi L, Burger A, Melander A, Westgren U, Von Schenck H, et al. Effects of total energy withdrawal (fasting) on the levels of growth hormone, thyrotropin, cortisol, adrenaline, noradrenaline, T4, T3, and rT3 in healthy males. Acta Med Scand. 1977;201(1‐6):15-22.
117. Chaouachi A, Coutts AJ, Chamari K, Wong dP, Chaouachi M, Chtara M, et al. Effect of Ramadan intermittent fasting on aerobic and anaerobic performance and perception of fatigue in male elite judo athletes. J Strength Cond Res. 2009;23(9):2702-9.
118. Zerguini Y, Kirkendall D, Junge A, Dvorak J. Impact of Ramadan on physical performance in professional soccer players. Br J Sports Med. 2007;41(6):398.
119. Erlacher D, Ehrlenspiel F, Adegbesan OA, Galal El-Din H. Sleep habits in German athletes before important competitions or games. J Sports Sci. 2011;29(8):859-66.
120. Chaouachi A, Leiper JB, Chtourou H, Aziz AR, Chamari K. The effects of Ramadan intermittent fasting on athletic performance: Recommendations for the maintenance of physical fitness. J Sports Sci. 2012;30(sup1):S53-S73.
121. Lauer CJ, Krieg J-C. Sleep in eating disorders. Sleep Med Rev. 2004;8(2):109-18.
122. Âkerstedt T. Psychosocial stress and impaired sleep. Scand J Work Environ Health. 2006:493-501.
123. Slater J, McLay-Cooke R, Brown R, Black K. Female recreational exercisers at risk for low energy availability. Int J Sport Nutr Exerc Metab. 2016;26(5):421-7.
124. Black K, Slater J, Brown R, Cooke R. Low energy availability, plasma lipids, and hormonal profiles of recreational athletes. J Strength Cond Res. 2018.

125. Saw AE, Main LC, Gastin PB. Monitoring the athlete training response: subjective self-reported measures trump commonly used objective measures: a systematic review. Br J Sports Med. 2015:bjsports-2015-094758.

# 9. Appendices

A. Copyright Permissions
B. Low Energy in Athletic Females Questionnaire (LEAF-Q) also containing the Perceived Stress Scale Questionnaire (PSS-Q)
C. Pittsburgh Sleep Quality Questionnaire
D. Ethical Approval Letter
E. Information Sheet for participants (include all versions)
F. Scoring Instructions for the Pittsburgh Sleep Quality Index Questionnaire

# Appendix A

**BMJ PUBLISHING GROUP LTD. LICENSE
TERMS AND CONDITIONS**

Oct 10, 2018

This Agreement between Miss. Jenni Groom -- Jenni Groom ("You") and BMJ Publishing Group Ltd. ("BMJ Publishing Group Ltd.") consists of your license details and the terms and conditions provided by BMJ Publishing Group Ltd. and Copyright Clearance Center.

| | |
|---|---|
| License Number | 4420991141879 |
| License date | Sep 02, 2018 |
| Licensed Content Publisher | BMJ Publishing Group Ltd. |
| Licensed Content Publication | British Journal of Sports Medicine |
| Licensed Content Title | The IOC consensus statement: beyond the Female Athlete Triad—Relative Energy Deficiency in Sport (RED-S) |
| Licensed Content Author | Margo Mountjoy,Jorunn Sundgot-Borgen,Louise Burke,Susan Carter,Naama Constantini,Constance Lebrun,Nanna Meyer,Roberta Sherman,Kathrin Steffen,Richard Budgett,Arne Ljungqvist |
| Licensed Content Date | Apr 1, 2014 |
| Licensed Content Volume | 48 |
| Licensed Content Issue | 7 |
| Type of Use | Dissertation/Thesis |
| Requestor type | Individual |
| Format | Print and electronic |
| Portion | Figure/table/extract |
| Number of figure/table/extracts | 1 |
| Descriptionof figure/table/extracts | Figure 1 |

**WOLTERS KLUWER HEALTH, INC. LICENSE**
**TERMS AND CONDITIONS**

Oct 02, 2018

---

This Agreement between Miss. Jenni Groom -- Jenni Groom ("You") and Wolters Kluwer Health, Inc. ("Wolters Kluwer Health, Inc.") consists of your license details and the terms and conditions provided by Wolters Kluwer Health, Inc. and Copyright Clearance Center.

| | |
|---|---|
| License Number | 4418491071460 |
| License date | Aug 29, 2018 |
| Licensed Content Publisher | Wolters Kluwer Health, Inc. |
| Licensed Content Publication | Medicine & Science in Sports & Exercise |
| Licensed Content Title | The Female Athlete Triad |
| Licensed Content Date | Oct 1, 2007 |
| Licensed Content Volume | 39 |
| Licensed Content Issue | 10 |
| Type of Use | Dissertation/Thesis |
| Requestor type | Individual |
| STM publisher name | |
| Portion | Figures/table/illustration |
| Number of figures/tables/illustrations | 1 |
| Figures/tables/illustrations used | Figure 1 |
| Author of this Wolters Kluwer article | No |
| Title of your thesis / dissertation | Low energy availability effects on mood and sleep |

# Appendix B

## Appendix: Questionnaire

Section 1: Demographics
Section 2. Knowledge and Appetite
Section 3: LEAF
Section 4: Anxiety
Section 5: Cooking confidence

## Section 1: Demographics

1. Age: (years)
2. Height: (cm)
3. Weight: (kg)

4. What is your desired weight (kg)?

5. Which ethnic group do you belong to? (Please tick any boxes which apply to you)

- ☐ New Zealand European
- ☐ Maori
- ☐ Samoan
- ☐ Cook Island Maori
- ☐ Tongan
- ☐ Niuean
- ☐ Chinese
- ☐ Indian
- ☐ Other (please specify): ___________________________

6. Do you use any medication (excluding oral contraceptives)?

Yes

No

If yes, what kind of medication?

## Section 2: Knowledge and appetite

7. Have you ever heard of Low Energy Availability?
   - ☐ YES
   - ☐ NO

   If yes please describe Low Energy Availability and its symptoms

8. What do you believe are the consequences of consuming insufficient energy?

9. Before a heavy training session or matches what do you normally eat or drink?

10. After a heavy training session or matches what do you normally eat or drink?

11. Describe a good pre-heavy training session food and/or drink?

12. Describe a good post-heavy training session food and/or drink?

13. After a heavy training session or matches how hungry do you usually feel?
    - ☐ Extremely hungry
    - ☐ Very hungry
    - ☐ Neither hungry nor full
    - ☐ Not very hungry
    - ☐ Not hungry at all

14. Skipping my period makes my bones weak.
    - ☐ Yes
    - ☐ No

15. Skipping my period is my body's way of saying I'm training too hard and not eating correctly.
    - ☐ Yes
    - ☐ No

16. Teenagers with weaker bones will likely still have weaker bones as adults.
    - ☐ Yes

- ☐ No

17. I feel that skipping my period while playing sports is normal.
    - ☐ Yes
    - ☐ No

18. I'm not old enough to have weak bones.
    - ☐ Yes
    - ☐ No

19. Not eating enough could cause me to lose my period.
    - ☐ Yes
    - ☐ No

20. Stress fractures (very small cracks or breaks) occur more often in girls that skip their period.
    - ☐ Yes
    - ☐ No

21. How much I eat does not affect bone health.
    - ☐ Yes
    - ☐ No

22. Not eating enough calories could cause me to have brittle bones.
    - ☐ Yes
    - ☐ No

23. Can you identify the 3 distinct conditions that are associated with the female athlete triad?
    - ☐ Yes
    - ☐ No
    - ☐ Not sure
    - ☐ Do not know

24. If you can, please list the 3 conditions associated with the female athlete triad.
    a. ________________________________
    b. ________________________________
    c. ________________________________

25. Do you believe that irregular menstruation or absent menstruation is a normal consequence of exercise and diet in female athletes?
    - ☐ Yes
    - ☐ No
    - ☐ Not sure
    - ☐ Do not know

26. Having an irregular menstrual cycle is often a sign that I am in peak competitive shape.

- ☐ never
- ☐ almost never
- ☐ sometimes
- ☐ fairly often
- ☐ very often
- ☐ Always

**Section 3: LEAF**

**Injuries**

27. Have you had absences from your training, or participation in competitions during the last year due to injuries?
    - ☐ No, not at all **(go to question 30)**
    - ☐ Yes, once or twice **(go to question 28)**
    - ☐ Yes, three or four times **(go to question 28)**
    - ☐ Yes, five times or more **(go to question 28)**

28. If yes, for how many days absence from training or participation in competition due to injuries have you had in the last year?
    - ☐ 1-7 days
    - ☐ 8-14 days
    - ☐ 15-21 days
    - ☐ 22 days or more

29. If yes, what kind of injuries have you had in the last year?

☐ Muscle – please describe
When did you first experience this injury? _______________

How long did this injury last? ______________

☐ Ligament – please describe
When did you first experience this injury? _______________

How long did this injury last? ______________

☐ Fracture – stress fracture or other, please describe.
When did you first experience this injury? _______________

How long did this injury last? ______________

☐ Other - please describe
When did you first experience this injury? _______________

How long did this injury last? _____________

Do you have any further comments or information regarding your injuries:

**Gastro intestinal function**

30. Do you feel gaseous or bloated when you do not have your period?
    - ☐ Yes, several times a day
    - ☐ Yes, several times a week
    - ☐ Yes, once or twice a week or more seldom
    - ☐ Rarely or never

31. Do you get cramps or stomach aches that are not related to your menstruation?
    - ☐ Yes, several times a day
    - ☐ Yes, several times a week
    - ☐ Yes, once or twice a week or more seldom
    - ☐ Rarely
    - ☐ Never

32. On average how often do you have bowel movements?
    - ☐ Several times a day
    - ☐ Once a day
    - ☐ Every second day
    - ☐ Twice a week
    - ☐ Once a week or more rarely

33. How would you describe your normal stool?
    - ☐ Normal (soft)
    - ☐ Diarrhoea-like (watery)
    - ☐ Hard and dry

Comments regarding gastrointestinal function:

**Use of contraceptives**

34. Do you use oral contraceptives?
    - ☐ Yes **(go to question 35)**
    - ☐ No **(go to question 36)**

35. Why do you use oral contraceptives?
    - ☐ Contraception
    - ☐ Reduction of menstruation pains
    - ☐ Reduction of bleeding
    - ☐ To regulate the menstrual cycle in relation to performances etc..
    - ☐ Otherwise menstruation stops
    - ☐ Other

36. Have you used oral contraceptives in the past?
    - ☐ Yes **(go to question 37)**
    - ☐ No **(go to question 38)**

37. When and for how long?

38. Do you use any other kind of hormonal contraceptives? (e.g. hormonal implant or coil)
    - ☐ Yes **(go to question 39)**
    - ☐ No **(go to question 40)**

39. What kind?
- ☐ Hormonal patches - Ortho Evra
- ☐ Hormonal ring – Nuva Ring
- ☐ Hormonal coil – Mirena, copper IUD
- ☐ Hormonal implant – e.g. Jadelle, Implanon
- ☐ Other

**<u>Menstrual function</u>**

40. How old were when you had your first period?
- ☐ 11 years or younger
- ☐ 12-14 years
- ☐ 15 years or older
- ☐ I don't remember
- ☐ I have never menstruated **(go to question 53)**

41. Did your first menstruation come naturally (by itself)?
- ☐ Yes **(go to question 43)**
- ☐ No **(go to question 42)**
- ☐ I don't remember **(go to question 43)**

42. What kind of treatment was used to start your menstrual cycle?
- ☐ Hormonal treatment
- ☐ Weight gain
- ☐ Reduced amount of exercise
- ☐ Other

43. Do you have normal menstruation - (regular monthly period)
- ☐ Yes, go to **(go to question 44)**
- ☐ No I'm pregnant **(go to question 49)**
- ☐ No **(go to question 49)**
- ☐ I don't know **(go to question 49)**

44. When was your last period?
- ☐ 0-4 weeks ago
- ☐ 1-2 months ago
- ☐ 3-4 months ago
- ☐ 5 months ago or more

45. Are your periods regular? (Every 28th to 34th day)
- ☐ Yes, most of the time
- ☐ No, mostly not

46. **F**or how many days do you normally bleed?
- ☐ 1-2 days
- ☐ 3-4 days
- ☐ 5-6 days
- ☐ 7-8 days
- ☐ 9 days or more

47. Have you ever had problems with heavy menstrual bleeding?
- ☐ Yes
- ☐ No

48. How many periods have you had during the last year?
- ☐ 12 or more **(go to question 50)**
- ☐ 9-11 **(go to question 50)**
- ☐ 6-8 **(go to question 50)**
- ☐ 3-5 **(go to question 50)**
- ☐ 0-2 **(go to question 50)**

49. If no or “I don’t remember”, when did you have your last period?
- ☐ 2-3 months ago
- ☐ 4-5 months ago
- ☐ 6 months ago or more

50. Have your periods ever stopped for 3 consecutive months or longer (besides pregnancy)?
- ☐ No, never
- ☐ Yes, it has happened before
- ☐ Yes, that’s the situation now

51. Do you experience that your menstruation changes when you increase your exercise intensity, frequency or duration?
- ☐ Yes **(go to question 52)**
- ☐ No **(go to question 53)**

52. If yes, how? (Check one or more options)
- ☐ I bleed less
- ☐ I bleed fewer days
- ☐ My menstruations stops
- ☐ I bleed more
- ☐ I bleed more days

## Section 4: Perceived Stress Scale

53. In the last month, how often have you been upset because of something that happened unexpectedly?
   ☐ **never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

54. In the last month, how often have you felt that you were unable to control the important things in your life?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

55. In the last month, how often have you felt nervous and "stressed"?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

56. In the last month, how often have you dealt successfully with irritating life hassles?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

57. In the last month, how often have you felt that you were effectively coping with important changes were occurring in your life?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

58. In the last month, how often have you felt confident about your ability to handle your personal problems?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

59. In the last month, how often have you felt that things were going your way?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

60. In the last month, how often have you found that you could not cope with all the things that you had to do?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

61. In the last month, how often have you been able to control irritations in your life?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

62. In the last month, how often have you felt that you were on top of things?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

63. In the last month, how often have you been angered because of things that happened that were outside of your control?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

64. In the last month, how often have you found yourself thinking about things that you have to accomplish?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

65. In the last month, how often have you been able to control the way you spend your time?
   ☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

66. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

☐**never** ☐**almost never** ☐**sometimes** ☐**fairly often** ☐**very often**

## Section 5: Cooking confidence

67. What kind of cooking do you do at the moment? (Please tick **any** boxes that apply to you)

☐ Cook convenience foods and ready-made meals
☐ Put together ready-made ingredients to make a complete meal (e.g. packet/jar sauces)
☐ Prepare dishes from basic ingredients (e.g. raw veg, pasta and raw meat)
☐ Don't cook at all

☐ Other, please specify

_______________________________________________

68. In a normal week, how often do you prepare and cook a main meal from basic ingredients, for example, Spaghetti Bolognaise, starting with raw mince and tomatoes? Please tick one.

☐ Daily ☐ Once a week
☐ 4-6 times a week ☐ Less than once a week
☐ 2-3 times a week ☐ Never

69. How confident do you feel about being able to cook from basic ingredients? (Please select **one** number)

| **Not at all confident** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | **Very confident** |
|---|---|---|---|---|---|---|---|---|

70. How confident do you feel about following a simple recipe? (Please select **one** number)

| **Not at all confident** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | **Very confident** |
|---|---|---|---|---|---|---|---|---|

71. How confident do you feel about tasting foods that you have not eaten before? (Please select **one** number)

| **Not at all confident** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | **Very confident** |
|---|---|---|---|---|---|---|---|---|

72. How confident do you feel about preparing and cooking new foods and recipes? (Please select **one** number)

| **Not at all confident** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | **Very confident** |
|---|---|---|---|---|---|---|---|---|

# Appendix C

# The Pittsburgh Sleep Quality Index (PSQI)

**Instructions:** The following questions relate to your usual sleep habits during the past month *only*. Your answers should indicate the most accurate reply for the *majority* of days and nights in the past month. Please answer all the questions.

1. During the past month, when have you usually gone to bed at night?

   **Usual bed time**______________________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   **Number of minutes**___________________

3. During the past month, when have you usually got up in the morning?

   **Usual getting up time**_________________

4. During the past month, how many hours of *actual* sleep did you get at night? (This may be different than the number of hours you spend in bed).

   **Hours of sleep per night**_______________

For each of the remaining questions, check the one best response. Please answer *all* questions.

5. During the past month, how often have you had trouble sleeping because you……

   a. Cannot get to sleep within 30 minutes

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | three or more times a week_____ |
|---|---|---|---|

   b. Wake up in the middle of the night or early morning

| Not during the past month____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

   c. Have to get up to use the bathroom

| Not during the past month____ | Less than once a week_____ | Once or twice a week_____ | three or more times a week_____ |
|---|---|---|---|

   d. Cannot breathe comfortably

| Not during the past month____ | Less than once a week_______ | Once or twice a week_____ | three or more times a week_____ |
|---|---|---|---|

   e. Cough or snore loudly

| Not during the past month____ | Less than once a week_____ | Once or twice a week_____ | three or more times a week_____ |
|---|---|---|---|

   f. Feel too cold

**Not during the past month____** **Less than once a week_____** **Once or twice a week_____** **three or more times a week_____**

g. Feel too hot

**Not during the past month____** **Less than once a week_____** **Once or twice a week_____** **three or more times a week_____**

h. Had bad dreams

**Not during the past month____** **Less than once a week_____** **Once or twice a week_____** **three or more times a week_____**

i. Have pain

**Not during the past month____** **Less than once a week_____** **Once or twice a week_____** **three or more times a week_____**

j. Other reason(s), please describe______________________________________
_______________________________________________________________
_______________________________________________________________

How often during the past month have you had trouble sleeping because of this?

**Not during the past month____** **Less than once a week_____** **Once or twice a week_____** **three or more times a week_____**

6. During the past month, how would you rate your sleep quality overall?

**Very good______Fairly good________Fairly bad_________Very bad__________**

7. During the past month, how often have you taken medicine (prescribed or " over the counter") to help you sleep?

**Not during the past month____** **Less than once a week_____** **Once or twice a week_____** **three or more times a week_____**

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

**Not during the past month____** **Less than once a week_____** **Once or twice a week_____** **three or more times a week_____**

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

**No problem__________**
**Only a very slight problem_______________**
**Somewhat of a problem____________**
**A very big problem_________**

# Appendix D

Academic Services
Manager, Academic Committees, Mr Gary Witte

Dr K Black 28 August 2017

Department of Human Nutrition Division of Sciences

Dear Dr Black,

I am again writing to you concerning your proposal entitled "**Monitoring of elite female rugby 7s players: An observational feasibility case study.**", Ethics Committee reference number **17/120**.

Thank you for your email of today with response attached addressing the issues raised by the Committee. Thank you also for confirming that Alice Sharples will join the research team as a research assistant.

On the basis of this response, I am pleased to confirm that the proposal now has full ethical approval to proceed.

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

The Human Ethics Committee asks for a Final Report to be provided upon completion of the study. The Final Report template can be found on the Human Ethics Web Page

http://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

Yours sincerely,

Gary Witte

Mr Gary Witte

**Manager, Academic Committees**
Tel: 479 8256
Email: gary.witte@otago.ac.nz

c.c. Professor S Samman Department of Human Nutrition

# Appendix E

[Reference Number: *17/120*]
[*Date: August 2017*]

**Monitoring of elite female rugby 7s players: An observational feasibility case study.**
**INFORMATION SHEET FOR PARTICIPANTS.**

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

**What is the Aim of the Project?**
This project is being undertaken as part of the requirements for Jonathan Kumar's and Jenni Groom's Master of Dietetics (MDiet) qualification.

Dietary intakes are an important concept for sporting performance. Of particular importance are energy availability and the macronutrients (carbohydrate and protein).
The aims of this study are to: -

1) Describe the current dietary practices of elite female rugby 7s players.
2) Describe the current knowledge of energy needs amongst elite female rugby 7s players.
3) Inform future research and nutritional recommendations for elite female rugby 7s players.

**What Type of Participants are being sought?**

- *Recruitment method*

The study will be explained to you at a training camp. Following this we will personally invite you to participate in the study.

- *Selection criteria*

To participate in this study you must be female, currently training with the New Zealand 7s squad and aged between 16 and 40 years old.

- *Exclusion criteria*

Anyone who does not meet the inclusion criteria will be unable to participate in this study.

- *Number of participants to be involved*

20

- *Description of any benefit or information which the participant will have access to as a result of participating in the research*

The data/information we collect will be used by the team dietitian and support staff to provide you with more individualised advice.

**What will Participants be Asked to Do?**

Should you agree to take part in this project, you will be asked to

- *The procedures in which the participants will be involved*
  Initially you will be asked to complete an online questionnaire, which should take no more than 20-30 minutes to complete. The questionnaires will ask you about your dietary habits, stress, appetite, nutrition, cooking knowledge and health including questions about your menstrual cycle and gastrointestinal function, bowel movements.

  You will be asked to complete a five day weighed food and exercise record. You will do this via the Meal logger App. You will record, weigh and take a photo of all food and drink you consume and upload them to the App along with a description of the food and the weight of each item consumed.
  Any exercise you undertake during this time should also be uploaded to the App, alongside a description of the exercise session including exercise type, duration and intensity.
  Completing the food and exercise diary will add 1-5 minutes to each eating and drinking occasion, which means it may take up to 30 minutes of your time per day.

  During the five days you complete your food diary you will also be asked to wear an accelerometer on your non-dominant wrist. This device looks like a watch and can be worn at all times except when you are undertaking water based activities. This will provide us with information on your activity levels and sleep.

  We will obtain your body composition measures from the team dietitian who will be taking skinfolds as part of the normal team protocol.

- *Description of any discomforts, risks or inconvenience to participants as a result of participation.*
  This study may add inconvenience to your daily routine as uploading information on what you eat and drink as well as your exercise will add a few minutes to each eating and exercise occasion.
  Please be aware that you may decide not to take part in the project without any disadvantage to yourself of any kind.

**What Data or Information will be Collected and What Use will be Made of it?**

• *What raw data or information will be collected?*
We will collect information on your body composition, age, ethnicity, playing experience, dietary intakes, anxiety and stress, cooking and nutrition knowledge.
This data will be used to calculate scores and average and ranges, which will be used to write a research paper.

• *Who will have access to the data or information?*
Katherine Black, Brett Smith, Melinda Manore, Dane Baker, Stacey Sims, Jonathan Kumar, Jenni Groom and Alice Sharples will have access to this data.

• *How will data or information be securely managed, stored and destroyed?*
The data collected will be securely stored in such a way that only those mentioned above will be able to gain access to it. Data obtained as a result of the research will be retained for **at least 5 years** in secure storage. Any personal information such as contact details may be destroyed at the completion of the research even though the data derived from the research will, in most cases, be kept for much longer or possibly indefinitely.

• *What data or information will be reflected in the completed research?*
The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity.

• *Will the participants have the opportunity to correct or withdraw the data/information?*
Should you wish to view the data relating to you then you may do so for up to one month following the completion of your food and exercise diary. If this is the case then you should contact one of the researchers in writing.

• *Will participants be provided with the results of the study?*
The results of this study will be present to the squad as part of the nutrition program.

**Can Participants Change their Mind and Withdraw from the Project?**
You may withdraw from participation in the project up to two months following completion of your food diary and without any disadvantage to yourself of any kind.

**What if Participants have any Questions?**
If you have any questions about our project, either now or in the future, please feel free to contact either:-

*Dr Katherine Black* and *Alice Sharples*
Department of Human Nutrition Department of Human Nutrition
University Telephone Number:-03 479 8358
Email Address katherine.black@otago.ac.nz
This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph +643 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

# Appendix F

## SCORING INSTRUCTIONS FOR THE PITTSBURGH SLEEP QUALITY INDEX:

The Pittsburgh Sleep Quality Index (PSQI) contains 19 self-rated questions and 5 questions rated by the bed partner or roommate (if one is available). Only self-rated questions are included in the scoring. The 19 self-rated items are combined to form seven "component" scores, each of which has a range of 0-3 points. In all cases, a score of "0" indicates no difficulty, while a score of "3" indicates severe difficulty. The seven component scores are then added to yield one "global" score, with a range of 0-21 points, "0" indicating no difficulty and "21 " indicating severe difficulties in all areas.

Scoring proceeds as follows:

### Component 1: Subjective sleep quality

Examine question #6, and assign scores as follows:

| Response | Component 1 score |
|---|---|
| "Very good" | 0 |
| "Fairly good" | 1 |
| "Fairly bad" | 2 |
| "Very bad" | 3 |

*Component 1 score:*________

### Component 2: Sleep latency

1. Examine question #2, and assign scores as follows:

| Respo\nse | Score |
|---|---|
| ≤15 minutes | 0 |
| 16-30 minutes | 1 |
| 31-60 minutes | 2 |
| > 60 minutes | 3 |
| *Question #2 score:* | ________ |

2. Examine question #5a, and assign scores as follows:

| Response | Score |
|---|---|
| Not during the past month | 0 |
| Less than once a week | 1 |
| Once or twice a week | 2 |
| Three or more times a week | 3 |
| *Question #5a score:* | ________ |

3. Add #2 score and #5a score

*Sum of #2 and #5a:* ________

4. Assign component 2 score as follows:

| Sum of #2 and #5a | Component 2 score |
|---|---|
| 0 | 0 |
| 1-2 | 1 |
| 3-4 | 2 |
| 5-6 | 3 |

*Component 2 score:*________

## Component 3: Sleep duration

Examine question #4, and assign scores as follows:

| Response | Component 3 score |
|---|---|
| > 7 hours | 0 |
| 6-7 hours | 1 |
| 5-6 hours | 2 |
| < 5 hours | 3 |

***Component 3 score:*** ________

---

## Component 4: Habitual sleep efficiency

1. Write the number of hours slept (question #4) here: ________
2. Calculate the number of hours spent in bed:

   Getting up time (question #3): ________

   Bedtime (question #1): ________

   ____________________

   *Number of hours spent in bed:* ________

3. Calculate habitual sleep efficiency as follows:

   (Number of hours slept/Number of hours spent in bed) X 100 = Habitual sleep efficiency (%)

   (________ / ________ ) X 100 = %

4. Assign component 4 score as follows:

| Habitual sleep efficiency % | Component 4 score |
|---|---|
| > 85% | 0 |
| 75-84% | 1 |
| 65-74% | 2 |
| < 65% | 3 |

***Component 4 score:*** ________

## Component 5: Step disturbances

1. Examine questions #5b-5j, and assign scores for each question as follows:

| Response | Score |
|---|---|
| Not during the past month | 0 |
| Less than once a week | 1 |
| Once or twice a week | 2 |
| Three or more times a week | 3 |

*5b score:* ________

*5c score:* ________

*5d score:* ________

*5e score:* ________

*5f score:* ________

*5g score:* ________

*5h score:* ________

*5i score:* ________

*5j score:* ________

2. Add the scores for questions #5b-5j:

*Sum of #5b-5j:* ________

3. Assign component 5 score as follows:

| Sum of #5b-5j | Component 5 score |
|---|---|
| 0 | 0 |
| 1-9 | 1 |
| 10-18-4 | 2 |
| 19-27 | 3 |

***Component 5 score:*** ________

## Component 6: Use of sleeping medication

Examine question #7 and assign scores as follows:

| Response | Component 6 score |
|---|---|
| Not during the past month | 0 |
| Less than once a week | 1 |
| Once or twice a week | 2 |
| Three or more times a week | 3 |

***Component 6 score:*** ________

*PSQI Page 5*

## Component 7: Daytime dysfunction

1. Examine question #8, and assign scores as follows:

| Response | Score |
|---|---|
| Never | 0 |
| Once or twice | 1 |
| Once or twice each week | 2 |
| Three or more times each week | 3 |

*Question#8 score:* ________

2. Examine question #9, and assign scores as follows:

| Response | Score |
|---|---|
| No problem at all | 0 |
| Only a very slight problem | 1 |
| Somewhat of a problem | 2 |
| A very big problem | 3 |

*Question #9 score:* ________

3. Add the scores for question #8 and #9:

*Sum of #8 and #9:* ________

4. Assign component 7 score as follows:

| Sum of #8 and #9 | Component 7 score |
|---|---|
| 0 | 0 |
| 1-2 | 1 |
| 3-4 | 2 |
| 5-6 | 3 |

***Component 7 score:*** ________

## Global PSQI Score

Add the seven component scores together:

***Global PSQI Score:*** ________