Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers

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DECLARATION

I, Miss Ashleigh de Freitas declare that

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2. This dissertation has not been submitted for any degree or examination at any other university.

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This dissertation is dedicated to all the female KwaZulu-Natal Swimmers.
Without their support and commitment, this study would not have been a success.

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ABSTRACT

Introduction: The Female Athlete Triad (FAT) is a syndrome that poses a serious threat to the health status of physically active females. It comprises of three components that were adapted to the American Collage of Sport Medicine (ACSM) 2007 Position Stands criteria and consists of three interconnected components namely; low energy availability (with or without disordered eating) that occurs due to insufficient calorie intake in combination with high amounts of physical activity, menstrual dysfunctions defined as exercise induced menstrual dysfunction, and low bone mineral density (BMD) in which the bone mineral density is weakened as a result of prolonged menstrual dysfunction. These components are linked across a continuum of healthy (optimal energy availability, eumenorrhea (a menstrual cycle of twenty eight days), and optimal bone health) to unhealthy.

Aim(s): To determine the risk stratification for the FAT in elite sprint and distance swimmers.

Method(s): Twenty one provincial and national level KwaZulu-Natal sprint (n=11) and distance (n=10) swimmers with a mean age of 18.95 (6.3) years voluntarily participated in this descriptive, cross-sectional study. For descriptive purposes, anthropometric measurements (weight, height, skin folds and Body Mass Index (BMI)) were recorded. Each participant completed three eating disorder questionnaires (Eating Attitude Test (EAT-26), Body shape Questionnaire (BSQ-34) and a Bulimic Investigatory Test, Edinburgh (BITE)), one Menstrual Cycle and Time Spent in Exercise Questionnaire and a Self-Administered Bone Mineral Density questionnaire. A Bioelectrical Impedance Device was used to measure full body composition. The participants were requested to complete an online ASA24 Dietary Recall of the previous day's food and drink intake. The criteria for the risk of the FAT was determined by a positive score for all three FAT components (low energy availability (with or without eating disorders, menstrual dysfunction and low bone mineral density).

Result(s): The comparison between the different sporting disciplines showed that sprint swimmers are more at risk (63.6%) for disordered eating compared to distance swimmers (50%). Low energy availability was significantly evident in sprint swimmers with a result of 9.79 kcal.kg-1FFM.d-1 (SD 9.56). Out of the total sample size, only six (28.57%) swimmers were classified as having a menstrual dysfunction. Sprint swimmers showed to have a 90.9%

risk of low BMD. The overall results signified that out of the total sample group, 9.5% were not at risk, 14.3% showed a low risk, 52.4% had a moderate risk and 23.8% were at a high risk for the whole FAT.

Conclusion: Elite sprint and distance swimmers are not at risk for the FAT, however, elite level sprint and distance swimmers are susceptible for the risk of FAT components.

Key Words: Energy Availability, Amenorrhea, Low Bone Mineral Density, Swimmers, Disordered Eating

CHAPTER ONE

1. INTRODUCTION

The Female Athlete Triad (FAT) is a syndrome that poses a serious threat to the health status of physically active females (Morgenthal, 2002). It was first officially recognised in June 1992 when the American College of Sports Medicine (ACSM) Task Force on Women's Issues assembled to discuss an area of escalating concern (Morgenthal, 2002; Drinkwater et al., 1997). Following this, in 1997 the ACSM published a position stand on the FAT which identified the three components, namely disordered eating, amenorrhea (absence of menstrual periods) and osteoporosis (low bone mineral density) (Drinkwater et al., 1997). These three components are interconnected in aetiology, pathogenesis and consequences (Drinkwater et al., 1997; Morgenthal, 2002).

In 2007, the ACSM published an updated position stand on the FAT, which replaced the 1997 position stand. In this, the three components were adapted and now consist of three interconnected components namely; low energy availability (with or without disordered eating) that occurs due to insufficient calorie intake in combination with high amounts of physical activity, functional hypothalamic amenorrhea (FHA) defined as exercise induced menstrual dysfunction, and osteoporosis in which the bone mineral density (BMD) is weakened as a result of prolonged menstrual dysfunction (Loucks et al., 2007). Gibbs, De Souza, and Williams (2012) explains that these components are linked across a continuum of healthy (optimal energy availability, eumenorrhea (a menstrual cycle of twenty eight days), and optimal bone health) to unhealthy. The FAT spectrum is illustrated in Figure 1.1.

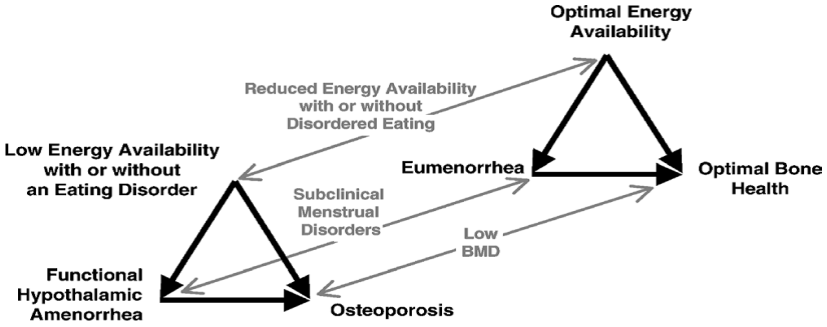

Figure 1.1: The Female Athlete Triad Spectrum (Adapted from Márquez and Molinero, 2013)

Therefore, this study acknowledges the definition of the FAT as characterised by the clinical manifestations of low energy availability (with or without eating disorders), menstrual dysfunction, and low BMD.

Endurance sports like distance-running, cycling, triathlons, swimming, dancing, and skiing include disciplines that are highly competitive and physique conscious. Similarly, Micklesfield et al. (2007, p. 679) stated that the athletes most at risk are those that partake in sports where success is believed to be achieved through leanness and aesthetics. There have been reports of the prevalence within each of the FAT components, although very limited research has been conducted on the risk stratification of the FAT interconnected components in endurance athletes, specifically swimming and cycling. Wolman and Harries (1989, p. 1-12) found that the statistic of female athletes of various sporting disciplines with menstrual irregularity was between 17-100%. Additionally, Micklesfield et al. (2007) reported that the bone mineral density of past amenorrhoeic/oligomenorrhoeic athletes are frequently lower when compared to normal menstruating female runners.

Furthermore, Micklesfield et al. (2007) conducted a study on menstrual dysfunction and bone stress injuries on a population of 613 female runners. Results indicated that 14.7% (n=90) scored positive for an eating disorder, 17% (n=105) reported a previous bone stress injury and 52.7% (n=323) reported currently or previously experienced a menstrual dysfunction. However, only 2.3% were positive for all the components of the FAT. Additionally, a study by Torstveit and Sundgot-Borgen (2005, p. 1449) stated that the prevalence of the FAT is more dominant in elite athletes, with 1-5% of elite female athletes being present with the FAT when compared to recreational athletes. Nevertheless, one out of four or one out of five female athletes are positive with one component of the FAT, which increases the athletes' risk of developing the whole condition (Miller et al., 2012). This in turn clarifies that the prevalence of the FAT is associated with training load. However, research incorporating training load and menstrual dysfunction has shown to have no relation (Torstveit and Sundgot-Borgen, 2005).

1.1 Problem Statement

The FAT is a serious health condition that affects highly active women. As the level of athletic elitism continues to accelerate for female athletes, so do the detrimental health risks. Unfortunately, there are limited studies examining the risk stratification on all three components of the FAT, specifically in aquatic sports like swimming. Nevertheless, the current research stipulates that there is a high concern if athletes continue to be unaware of the FAT and its physiological and psychological negative consequences (Márquez and Molinero, 2013). This syndrome has been identified in multiple sports, however, only one other international study in Brazil has successfully examined elite swimmers for the risk of the FAT.

1.2 Aim

1. The aim of this study was to determine the risk stratification for the FAT among elite female sprint and distance swimmers in KwaZulu-Natal.

1.3 Objectives

The objectives for the study were as follows:

1. To determine the risk stratification for disordered eating in elite sprint and distance swimmers.
2. To determine the risk stratification for low energy availability in elite sprint and distance swimmers.
3. To determine the risk stratification for menstrual dysfunction in elite sprint and distance swimmers.
4. To determine the risk stratification for low bone mineral density in elite sprint and distance swimmers.
5. To compare the risk stratification for the FAT between elite sprint and distance swimmers.

1.4 Hypothesis

1.4.1 Hypothesis:

1. There is a high risk stratification for FAT among elite sprint swimmers.
2. There is a high risk stratification for FAT among elite distance swimmers.

1.4.2 Null Hypothesis:

1. There is a low risk stratification for FAT among elite sprint swimmers.
2. There is a low risk stratification for FAT among elite distance swimmers.

1.5 Significance

Due to the limited studies on the prevalence or risk for the FAT among aquatic athletes, specifically sprint and distance swimming, this study will provide data that will aim to fill the gap in the literature. A comparison of the degree of risk for the FAT between sprint and distance swimmers will be used for descriptive purposes. Results can also be used as part of educational tools. Educators, parents and coaches maybe educated in the screening, treatment, prevention and guidance of athletes with regard to the FAT.

1.6 Glossary

(Medical Dictionary, 2012)

Aetiology:	The set of causes, or manner of causation of a disease or condition.
Allostatic:	The process of achieving stability, or homeostasis, through physiological or behavioural change.
Amenorrhea:	The absence of menstruation by the age of 15 in a girl with secondary sex characteristics.
Anorexia Nervosa:	An emotional disorder characterised by an obsessive desire to lose weight by refusing to eat.

Anthropometry:	The scientific study of the measurements and proportions of the human body.
Aquatic:	Sports played in or on water.
Binge:	Over-indulging in an activity, especially eating, to excess.
Bone Mineral Density:	The amount of mineral matter per square centimetre of bones.
Bulimia Nervosa:	An emotional disorder characterized by a distorted body image and an obsessive desire to lose weight, in which bouts of extreme overeating are followed by fasting or self-induced vomiting or purging.
Compensatory Purging:	Compensatory activities such as fasting or excessive exercise.
Compulsive Training:	It is associated with a subjective sense of being driven or compelled to exercise, giving it priority over other activities and associating its postponement with feelings of guilt and anxiety.
Disordered Eating:	A wide spectrum of harmful and often ineffective eating behaviours used in an attempt to lose weight or achieve a lean appearance.
Eating Disorder:	Any of a range of psychological disorders characterized by abnormal or disturbed eating habits.
Energy Availability:	The amount of dietary energy for all physiological functions after accounting for energy expenditure from exercise.
Eating Disorders Not Otherwise Specified:	These are variants of disordered eating that do not meet the diagnostic criteria for anorexia nervosa or bulimia nervosa.
Elite:	A select group that is superior in terms of ability or qualities to the rest of a group or society.
Endothelial Dysfunction:	A condition in which the endothelium of blood vessels does not function normally.
Energy Availability:	The remaining energy after exercise and dietary intake.
Eumenorrhea:	A menstrual cycle of twenty eight days.

Excessive Training: Training that significantly interferes with important activities, occurs at inappropriate times or in inappropriate settings, or continues despite injury or other medical complication.

Folliculogensis: It is the maturation of the ovarian follicle, a densely packed shell of somatic cells that contains an immature oocyte.

Functional Hypothalamic Amenorrhea: Exercise induced menstrual irregularity**.**

Hypoestrogenism: A lower than normal level of oestrogen.

Hypokalaemia: A deficiency of potassium in the bloodstream.

Oligomenorrhea: Menstrual cycles are greater than 35 days in length or 4-9 menstrual periods per year.

Osteopenia: A medical condition in which the protein and mineral content of bone tissue is reduced, but less severely than in osteoporosis.

Osteoporosis: A disease characterised by low bone mass and microarchitecture deterioration of bone tissue leading to enhanced skeletal fragility and increased risk of fracture.

Ovulation: It is one part of the female menstrual cycle whereby a mature ovarian follicle discharges an egg. It is during this process that the egg travels down the fallopian tube where it may be met by a sperm and become fertilized.

Pathogenesis: The manner of development of a disease.

Physical Activity: Physical exercise is any bodily activity that enhances or maintains physical fitness and overall health and wellness.

Prevalence: The fact or condition of being prevalent; commonness.

Psychogenic: To have a psychological origin or cause rather than a physical one.

Purging: An eating disorder characterized by recurrent purging (self-induced vomiting, abuse of laxatives, diuretics, or enemas) to control weight.

Secondary Amenorrhea: The absence of three or more consecutive menstrual cycles after menarche.

Somatotype: A category to which people are assigned according to the extent to which their bodily physique conforms to a basic type.

1.7 Abbreviations

FAT: Female Athlete Triad

ACSM: American College of Sports Medicine

BITE: Bulimic Investigatory Test, Edinburgh

EAT: Eating Attitude Test

BMD: Bone Mineral Density

EA: Energy Availability

EI: Energy Intake

EE: Energy Expenditure

DSM-IV: The Diagnostic and Statistical Manual of Mental disorders

RDA: Recommended Daily Allowance

QUS: Quantitative Ultrasound

pQCT: Primary Peripheral Quantitative Computerised Tomography

KZNA: KwaZulu-Natal Aquatics

DE: Disordered Eating

PI: Primary Investigator

FHA: Functional Hypothalamic Amenorrhea

PA: Postural Anterior

EPFTB: Euro fit Physical Fitness test battery

HPA: Hypothalamic-Pituitary-Adrenal

TSH: Hydroid-Stimulating Hormone

WB: Weight-Bearing

NWB: Non-Weight-Bearing

GnRH: Gonadotropin-Releasing Hormone

GH: Growth Hormone

LBM:	Lean Body Mass
SD:	Standard Deviation
aBMD:	Areal Bone Mineral Density

CHAPTER TWO

2. LITERATURE REVIEW

This chapter will account for a detailed review of all the current scientific literature based on the Female Athlete Triad (FAT). The chapter is divided into nine different segments to explain the FAT and each of its components, as well as the history of the condition and current treatment procedures.

2.1 Introduction

The FAT is a syndrome that poses a serious threat to the health status of physically active females (Morgenthal, 2002). A unique challenge is placed on the female athlete based on performance and psychological stresses enforced by Western society. The female athlete feels pressured to obtain and maintain the extreme leanness that has been "sold" as the ideal body shape and size for optimal performance (Laframboise, Borody and Stern, 2013). In order to achieve this, athletes turn to unhealthy measures like extreme reductions in calorie intake and excessive exercising. The mental concept of maintaining a low body weight in the name of performance and aesthetic reasons is a popular characteristic among female athletes (Laframboise, Borody and Stern, 2013), yet it has detrimental health implications.

The health implications that are associated with the FAT are generated from low energy availability, caused by the result of an insufficient caloric intake in relation to energy expenditure. In the early stages, some of the health implications that could result include stress fractures, osteopenia, fatigue, infertility, and impaired endothelial function. If the condition is untreated, the long term health implications could result in an increased risk of osteoporosis and cardiovascular disease (Miller et al., 2012).

The National and International elite level of competition within swimming has soared over recent years with only a few split-seconds separating the elite competitors. These athletes must undergo regular physical and biomechanical assessment to achieve and maintain optimal performance. Athletes require absolute precision, as 0.01 seconds is all that could stand

between a win and a loss (Rossi et al., 2013). It is for this reason that both sprint and distance swimmers endure many hours of tedious training sessions in which four times more energy compared to training on land is exerted. A sprint swimmer may compete in events ranging between 50 metres to 1500 metres, where a distance swimmer would compete in a larger water mass (dam, lake, ocean) and cover distances from 3000 metres and greater.

Although the events differ in distance, both the sprint and distance swimmers train an average of five to six hours per day and can utilise up to 11.67 calories per minute depending on the training intensity (Rosenbloom, Jonnalagabba, Skinner, 2002). Rossi et al. (2013) identified that absolute and relative body sizes, somatotype and body composition of elite swimmers differ from non-aquatic individuals. Additionally, physical characteristics differ between gender and swim events (Carter and Ackland, 1994).

Due to the large influence on lean physiques and tight aesthetic clothing that is popular in the aquatic environment, it is widely identified that swimmers can be associated with poor self-image and nutritional deficiencies. For the amount of training that is performed, many female swimmers do not consume enough calories needed for the training sessions. It is suggested that female swimmers should be consuming between 4000 - 5000 calories a day to replenish energy stores. Nutritional deficits increases the athletes' risk of developing the interrelated components of the FAT (Hoogenboom et al., 2009).

To date, there has been no research speculating on the comparison between weight bearing and non-weight bearing exercise in relation to the FAT. This could be highly controversial as non-weight bearing activity has been associated with a risk of osteoporosis. This would perhaps make aquatic athletes more susceptible to the FAT condition. On the contrary, runners have been identified as having a strong relationship with poor calorie intake and eating disorders (Micklesfield et al., 2007). When disordered eating occurs in conjunction with a high training load or overtraining, there is an increased risk of the FAT. Weight bearing athletes are found to have leaner body compositions compared to aquatic athletes. There is limited research conducted on swimmers and the FAT. This study aims to improve the current body of knowledge in the literature on the FAT when tested on sprint and distance swimmers.

2.2 Background

As mentioned, the FAT was first officially recognised in June 1992 by the American College of Sports Medicine (ASCM) (Drinkwater et al., 1997; Morgenthal, 2002). Then with the change in the FAT position stand in 2007, the FAT components became namely; low energy availability (with or without disordered eating) that occurs due to insufficient calorie intake in combination with high amounts of physical activity, functional hypothalamic amenorrhea defined as exercise induced menstrual dysfunction, and osteoporosis in which the bone mineral density (BMD) is weakened as a result of prolonged menstrual dysfunction (Loucks et al., 2007). This new statement replaced the 2007 FAT positon stand. (Drinkwater et al., 1997; Morgenthal, 2002).

Disordered eating was adapted to low energy availability (with or without disordered eating). Energy availability is the remaining energy after exercise and dietary intake. This was adapted as some athletes unknowingly increase energy expenditure without increasing energy intake, while others reduce energy intake without decreasing energy expenditure (Loucks et al., 2007). Detrimental health effects are predominant when energy availability is less than $30kcal.kg^{-1}$ of fat-free mass per day (Loucks et al., 2007).

Amenorrhea was adapted to functional hypothalamic amenorrhea (FHA) which refers to exercise induced amenorrhea (Drinkwater et al., 1997). In this primary amenorrhea was reduced to a menstrual delay of 15 years of age, as menarche is occurring earlier in today's generation and secondary amenorrhea was adapted to a consecutive three months absence of menstrual cycles, as a loss of menstrual cycles lasting ninety days or more is uncommon (De Souza et al., 2013). Oligomenorrhea was adapted to menstrual gaps lasting longer than 35 days (Loucks et al., 2007). Functional hypothalamic amenorrhea is more common in athletes than non-athletes. This is due to the increased physical stress applied by athletes to maintain optimal performance statuses, but without an additional increase in caloric intake, which results in certain health implications such as menstrual irregularities.

Osteoporosis remained the same, however the diagnostic criteria was adapted. The ACSM defined osteoporosis as 'secondary clinical risk factors for fracture with BMD Z-score of $\leq$2.0'

(Loucks et al., 2007, p. 1870). The dual energy x-ray absorptiometry (DEXA) provides Z-scores to compare individual BMD scores of an average person of the same age and sex (Loucks et al, 2007, p. 1869).

Therefore, FAT is now characterised by the clinical manifestations of: 1) low energy availability with or without eating disorders, 2) functional hypothalamic amenorrhea, and 3) osteoporosis.

2.3 Disordered Eating

Disordered eating was defined as "a wide spectrum of harmful and often ineffective eating behaviours used in attempts to lose weight or achieve a lean appearance" (Drinkwater et al., 1997, p. 1). Examples of this include food restriction, fasting, frequently skipped meals, overeating, binge eating followed by purging, ingesting diet pills, laxatives, diuretics or enemas, and abnormal thought patterns such as fear of becoming fat, distorted body image and preoccupation with food. The prevalence of disordered eating within female athletes is 28-62% (Laframboise, Borody and Stern, 2013).

Peters and Rooney (2003, p. 30) identified that high school female athletes had a prevalence of less than 1% of obtaining the complete FAT, but college female athletes showed to have a much higher prevalence as two thirds of the athletes scored positive for one or more components of the FAT (Peters and Rooney, 1994). The psychological and behavioural characteristics of disordered eating can range from dieting to illegal substance abuse (Bonci et al., 2008). There have been multiple studies indicating that female athletes within different sporting codes deliberately limit their caloric intake or partake in other energy restricting behaviours (Zanker and Cooke, 2004). In selected cases, the condition can be fatal (Bonci et al., 2008). However, it was also believed that there are female athletes unaware of the energy deficiency that occurs and the health implications that follow (Zanker and Cooke, 2004).

The Diagnostic and Statistical Manual of Mental disorders (DSM-IV) considered disorders of Anorexia Nervosa and Bulimia Nervosa as being the most extreme points of severity in

disordered eating (Drinkwater et al., 1997; Morgenthal, 2002; Loucks et al., 2007). Disordered eating negatively affects both performance status and health status of the individual. The consequences of disordered eating on the athletes' health depend greatly on different variables such as; the stress of sport-specific training; type, severity, and period of eating disorders; the degree of nutrient deficiency; occurrence of comorbid physical and psychological disorders; and the precision and quality of therapeutic interventions (Bonci et al., 2001).

Performance decreases as restricted caloric intake may steer athletes to overtraining syndrome, increased risk of injury as well as decreased endurance, strength, reaction speed and concentration (Morgenthal, 2002). Health detriments include reduced metabolic rate and growth, and changes in the musculoskeletal, cardiovascular, endocrine, gastrointestinal, and thermoregulatory and central nervous systems which can lead to morbidity, amenorrhea and a six-fold increase in standard mortality rates compared to the general population (Drinkwater et al., 1997; Morgenthal, 2002; Loucks et al., 2007).

Eating disorders are common in adolescence and more specifically in athletic adolescents. Studies that targeted athletes found that a 13.5% of athletes were at risk of developing an eating disorder compared to the general public, and that females were more susceptible to the condition than males (Ghoch et al., 2013; Sundgot-Borgen and Torstveit, 2004). The DSM-IV has identified three clinical conditions that vary in severity: Anorexia Nervosa, Bulimia Nervosa and Eating Disorders Not Otherwise Specified (EDNOS) (Bonci at al., 2008).

Selected harmful eating behaviours that fall under EDNOS are binge eating and purging. This is characterised by consuming large amounts of food with the sensation of a lack of control to stop. These individuals exhibit strict dietary rules and believe an infringement of those rules shows a lack of self-control, which will result in further harmful measures such as a bulimic episode (Ghoch et al., 2013). Binge eating and purging have been known to be used as a break-away tool from undesirable personal events or unendurable emotions states. The most frequently used methods are; self-induced vomiting, laxative abuse, diuretic abuse, and a series of spitting techniques. Purging is used for two purposes; firstly, to replace the bulimic episode (compensatory purging), and secondly, to decrease the calories consumed despite food

already engulfed by means of laxatives or diuretics (non-compensatory purging) (Ghoch et al., 2013).

These methods have been deemed successful strategies to decrease undesired weight by the athletic population. However, this indicates a poor knowledge base as research shows that vomiting is an ineffective means of weight loss; as the minority of consumed food is discarded, laxatives show a poor result, as these only effect the food in the large intestine once the absorption process has already occurred, and diuretics has absolutely no positive effect on weight loss (Ghoch et al., 2013). Eating Disorder Not Otherwise Specified have many negative effects on performance. These eating disorder conditions have a negative effect on athletic performance as it decreases energy availability through the lack of food consumed, it is a cause of dehydration which leads to fatigue, and in some cases hypokalaemia could develop (Eichner, 1992).

The prevalence of these conditions in the non-athletic population is lower than the athletic population with prevalence such as anorexia nervosa (0.6%), bulimia nervosa (1%) and binge eating disorders (3%) over a lifetime (Sundgot-Borgen and Torstveit, 2004). Although there is limited information with regards to EDNOS, 40-70% of individuals suffering from an eating disorder are diagnosed with this condition (Ghoch, et al., 2013). If individuals do not seek professional assistance and treatment, these conditions can have life threatening consequences, even resulting in death. These consequences occur through mediums such as under-eating, purging, and low body weight (Ghoch, et al., 2013; Grave, Calugi, and Marchesini, 2008).

Eating disorders have a negative influence on individuals' psychosocial abilities. Due to the obsession with self-assessment over their body shape, weight and eating behaviours, their ability to be present around others and form close relationships have become skewed (Fairburn, et al., 2008). Eating disorder conditions are associated with clinically low body weight. Many in the athletic industry have the belief that weight loss and excessive leanness aids in performance and this may explain the growth of eating disorders in athletes (Ghoch et al., 2013). With the intense weight loss, athletes can develop what is known as "starvation symptoms", as defined in literature by Keys et al. (1950). These symptoms include preoccupation with thoughts of food and eating, irritability, mood swings, lack of sleep, social

withdrawal, fatigue, gastrointestinal complications, dislike of the cold, poor concentration and boredom (Keys, et al., 1950).

Another condition that accompanies disordered eating is excessive or compulsive training. Training is termed 'excessive' when "it significantly interferes with important activities, occurs at inappropriate times or in inappropriate settings, or continues despite injury or other medical complication", or 'compulsive' when "is it associated with a subjective sense of being driven or compelled to exercise, giving it priority over other activities and associating its postponement with feelings of guilt and anxiety" (Grave, 2009). The prevalence of excessive/compulsive training in individuals suffering from eating disorders is 39-42% and can be an alarming 80% in anorexia nervosa patients (Grave, Calugi, and Marchesini, 2008). These individuals ensure that physical activity is incorporated in their daily living, by walking too much, standing rather than sitting, or other irregular activities such as multiple amounts of callisthenic exercises (sit-ups, push-ups) at home or in strange places (public restrooms). For athletes, another version is training beyond what is required and at much higher intensities (Grave, Calugi and Marchesini, 2008). Unfortunately, this condition is not easy to identify unless the individual complains of fatigue and other related symptoms. There are some eating disorder rehabilitation programmes that combine physical fitness and nutritional education, but minimal information is available (Alberti, et al., 2013).

Alberti et al. (2013) examined whether physical fitness has an effect on the treatment of anorexic patients. Anorexic nervosa patients (n=37) and a healthy control group (n=40) were tested both pre- and post-weight gain (body mass index $\geqq$18.5kg.m). The Euro fit Physical Fitness test battery (EPFTB) and a combination of six fitness tests measuring aerobic fitness, musculoskeletal fitness, flexibility and motor function were selected. Results showed that the anorexia nervosa patients' fitness levels were significantly lower than the control group. However, post-weight gain, there was an improvement in five of the six fitness tests and but still showed a significant drop compared to the healthy control group, except in the muscular endurance test component.

Nutrition is an important factor of bone mass and bone turnover. Zanker and Cooke (2004, p. 1372) explained that "diet plays a dual role in the regulation of bone metabolism, through the

provision of substrate for the synthesis of bone tissue and through an influence on the circulating levels of key hormones that regulate bone metabolism". Diet has shown to have a greater influence on bone density than exercise, as it acts on the whole skeleton via systematic processes.

Over the years, it has been identified that female athletes have insufficient diets. Together with the disturbed psychological thought patterns regarding food and eating, eating disorder patients may enforce a strict daily dietary routine in which they obsess over what they eat, when they eat, and how they eat. Such obsessions could include not dining with others, eating smaller amounts than others present, not consuming food where the calorie content is unknown or that is prepared by others, and eating late in the evening (Ghoch, et al., 2013).

The root cause of insufficient dietary consumption is due to the lack of nutritional knowledge and nutritional false beliefs. Current athletes receive their nutritional information from parents, coaches, magazines, peers, and the internet. However, even with this information available to them, misconceptions are evident (Hoogenboom et al., 2009). This is a cause for concern, as the lack of correct nutritional knowledge could develop into a greater increase of athletes acquiring more than one component of the FAT (Hoogenboom, et al., 2009). It has been stated that calcium and iron are, on average, the most frequent mineral deficiencies in female swimmers with an estimation of 50% of female swimmers not meeting the Recommended Daily Allowance (RDA) (Hoogenboom et al., 2009). This, in combination with the non-impact activity, could heighten the risk of developing osteoporosis and poor bone health.

Vitamin D is another micronutrient that is known to lack in female adolescents **(**Bonci, et al., 2008)**.** It is recommended that an adolescent should spend 10-15 minutes a day in the sunlight. This can produce up to 10 000-20 000 IU of vitamin D. An optimal dose of vitamin D will reduce the risk of stress fractures, infectious diseases, inflammation, and aid in muscle function. It can be found in many food products such as oily fish, dairy products, breakfast cereals and margarine (Ackerman and Mirsa, 2011). In a means of maintaining energy balance, the RDA for female swimmers are as follows: Carbohydrates: 55%-65%; Proteins: 12%-15%; Fats: 25%-30%; Calcium: 1200mg; Iron: 15mg; Vitamin D: 400-1000 IU

(Hoogenboom et al., 2009; Ackerman and Mirsa, 2011). However, many athletes do not follow these recommendations.

Therefore, disordered eating has a negative effect on both performance and health.

2.4 Menstrual Dysfunction

Menstrual dysfunction is associated with a range of reproductive abnormalities, namely; primary amenorrhea, secondary amenorrhea, oligomenorrhea, and luteal phase defects (Morgenthal, 2002). Primary amenorrhea is "the absence of menstruation by the age of 15 in a girl with secondary sex characteristics" (Drinkwater et al., 1997). Secondary amenorrhea is "the absence of three or more consecutive menstrual cycles after menarche" (Drinkwater et al., 1997). Oligomenorrhea occurs when the "menstrual cycles are greater than 35 days in length or 4-9 menstrual periods per year" (Morgenthal, 2002, p. 97-98).

Statistics show that the prevalence of menstrual dysfunction in female athletes over the age of 18 years is estimated to be 12-79%, with non-athletes estimating a prevalence of 2-5% (Laframboise, Borody and Stern, 2013). Studies conducted by Torstveit et al. (2005, p.141-147) on the prevalence of menstrual dysfunction within different sporting disciplines found that 34.5% occur in athletic sports; 30.9% in endurance sports; 23.5% in sports depicting weight categories; 17.6% in non-weight bearing sports; 16.7% in technical sports and 12.8% in ball technique and power sports. If the condition is not rectified, an estimated 2-3% of BMD will be lost per year (De Souza et al., 2013).

The presence of amenorrhea results in many endocrine abnormalities namely, reduced levels of estradiol, progesterone and thyroid hormones and higher levels of cortisol and prolactin (Morgenthal, 2002, p. 97-106). This is thought to be caused by low energy availability (dietary intake minus exercise energy expenditure) which causes a decrease in gonadotrophic releasing hormone (GnRH) pulses secreted by the hypothalamus, which in turn reduces luteinizing hormone (LH) pulses from the pituitary gland resulting in amenorrhea (Drinkwater et al., 1997; Loucks et al., 2007).

Menstrual dysfunction has the following detrimental effects on the health status of the individual; premature loss of BMD due to the inhibition of bone formation and enhancement of bone reabsorption, fourfold greater risk for stress fractures, damage and inadequate repair of soft tissue, inhibition of immune and thyroid function, elevated low-density lipoprotein cholesterol levels, and adverse effects to the cardiovascular and renal system (Loucks et al, 2007). Miller et al. (2006, p. 2932) examined the detrimental effects menstrual dysfunction and low weight mass has on BMD in anorexic individuals. The results showed that resumption in menstrual function had a positive effect on the postural anterior spine but not the hip, without weight improvement. A second result showed that an improvement in weight increased BMD in the hip but not the postural anterior spine. Individuals who did not improve in weight resumption in menses showed a BMD decrease of 2.7% in the postural anterior spine and 2.6% in the hip (Miller et al., 2006). This indicates that resumption of menses is a crucial aspect in improvement of BMD of the lumbar spine, irrespective of weight gain. However, weight gain is a vital factor for hip bone density improvement (Miller et al., 2006).

Functional hypothalamic amenorrhea (FHA) (exercise induced amenorrhea) occurs in female athletes who suffer with irregular or continual energy inequity as a result of insignificant energy availability or excessive exercise (Drinkwater et al., 1997). These female athletes may also experience psychogenic behaviours such as those associated with high competition and balancing of strict training regimes with the demands of daily life. Pauli and Berga (2010, p. 33) have the opinion that "it is important to determine the roles of energy imbalance and psychogenic factors in the pathogenesis of athletic amenorrhea". The physiology of the ovulation process shows that the female menstrual cycle is assisted by the hypothalamic GnRH pulse generator. This GnRH pulse generator responds to central nervous system activities that affect the hypothalamus (Pauli and Berga, 2010, p. 39). When the body is under acute stress, homeostasis occurs by means of hormonal mechanisms. However, chronic stress may results in an adjustment of homeostasis. Thus allostatic occurs. Pauli and Berga (2010, p. 39) explain this process as "allostasis is achieved when hypothalamic function is altered to allow for preservation of the individual at the expense of psychological function". An individual's response to energy inequality or psychogenetic stresses varies drastically from female to female.

An estimated 5% of athletic females of reproductive age are affected with FHA (Kaplan and Manuck, 2004, p. 89). Functional hypothalamic amenorrhea has been identified in female athletes and individuals diagnosed with disordered eating more than any other condition (Laughlin, Domingues, and Yen, 1998). Female that are positive for FHA have decreased their GnRH count resulting in a decrease of FSH and LH hormone levels which are required for folliculogensis and ovulation. Female Hypothalamic Amenorrhea individuals can develop allostatic changes in the metabolic axis (Pauli and Berga, 2010). The hypothalamic-pituitary-adrenal (HPA) is affected in females with FHA and has been identified to increase cortisol levels (Berga et al., 1989).

Females with FHA may develop cognitive dysfunction and psychiatric morbidity such as; depression, inability to deal with high amounts of stress, dysfunctional behaviours or attitudes, and improbable outlooks. The stress of high bouts of exercise is a cause for FHA, although, selected individuals may use exercise as a stress relief. Regrettably, when exercise is used as a coping tool for psychological stressors, it can cause more negative than positive outcomes. The consequences of amenorrhea do not only affect the individual immediately, but on the chances of future pregnancies as well. Pauli and Berga (2010, p. 36) state that "the consequences of alterations to the adrenal and thyroid axciles may be less clinically appreciated in women who are not pregnant. However, adrenal and thyroid dysfunction can have a profound impact, particularly in the setting of pregnancy". With the acknowledgment of the serious health effects that accompany FHA, it is vital that a treatment plan be developed to encourage recovery. One such method is hormone replacement, although, this method is limited (Pauli and Berga, 2010).

In 2009, a study tested over 780 Iranian athletes for menstrual irregularities. As a female athlete in Iran, they must adhere to the strict rules enforced by the Islamic Law. As such there are multiple sporting disciplines that females are prohibited from participating in. Each athlete completed a structured questionnaire pre- and post-training. This included demographic information, athletic history, history of illness and injury, age of menarche and menstrual cycle information, and use of hormonal medication over the previous two years. (LH, thyroid-stimulating hormone (TSH), Prolactin, DHEA and ultrasonography evaluation). From this

population, 9% tested positive for amenorrhea, 4.2% were positive for oligomenorrhea and 4.8% of the population had secondary amenorrhea. Of the positive cases reported, 15.5% were diagnosed with having polycystic ovary disease. This study aids in supporting the current literature that amenorrhea/oligomenorrhea are more prominent in female athletes (Dadgostar et al., 2009).

It is evident that female athletes with amenorrhea have higher blood lipid parameters than athletes with no recorded menstrual irregularities (Korsten-Rech, 2011. p. 156). The menstrual irregularities results increase when there is a drop in energy availability. A study by Lagowska et al. (2014) examined the effect of a dietary intervention has on menstrual dysfunction. Athletes (n=45) with recorded menstrual irregularities participated. Over a time period of three months, each participant completed a medical questionnaire on menstruation and time spent in physical activity. A gynaecological evaluation including pelvic ultrasound, endothelial measurements: LH, follicle stimulating hormone (FSH), progesterone, estradiol, prolactin, thyroid-stimulating hormone (TSH), testosterone (T) and sex-hormone-binding globulin (SHBG) was conducted. Blood samples, anthropometric measurements and resting metabolic rates were taken and recorded as well as a seven-day food diary was recorded, with each participant attending weekly sessions with trained dieticians. The results provided data that supported the theory that menstrual dysfunctions are highly impacted by energy deficiencies in female athletes (Lagowska et al., 2014).

It is important to note that menstrual dysfunction has a detrimental effect on performance as hypoestrogenism impairs arterial vasodilatation therefore reducing perfusion of working muscle and impaired skeletal muscle oxidative metabolism (Drinkwater et al., 1997; Morgenthal, 2002; Loucks et al., 2007).

Menstrual dysfunction is clearly defined and has negative effects that could affect the athlete at an endothelial level, their BMD status, and could hinder performance.

2.5 Low Bone Mineral Density

Low bone mineral density is defined by Drinkwater (1997, p. 2) as "disease characterised by low bone mass and micro architectural deterioration of bone tissue leading to enhanced skeletal fragility and increased risk of fracture". It is taught and practiced that bone health improves with regular physical activity, although, a high amount of exercise has been shown to be detrimental to bone health (Zanker and Cooke, 2004). The diagnostic criteria for BMD, established by the World Health Organisation is categorised according to standard deviation (SD) score (Drinkwater et al., 1997). The World Health Organisation defines osteoporosis as a BMD score greater than -2.0 SD for weight bearing athletes and -2.5 SD for non-weight beating athletes below the mean of young adults. A severe osteoporosis BMD score is defined as more than -2.0 SD for weight bearing athletes and -2.5 SD for non-weight bearing athletes plus one or more fragility fractures (Drinkwater et al., 1997). Bone mineral density is affected by genetics, endocrine function, nutritional status and type of skeletal loading during exercise (Drinkwater et al., 1997). As it is the only condition of the FAT that does not have noticeable symptoms, it can develop unobserved by the athlete, and for this reason is referred to as the 'silent' component (Mallinson and De Souza, 2014).

Although this study will not be able to examine true osteoporosis, it is still critical to identify and illustrate the susceptible skeletal areas in female athletes. However, this study will record any previous fractures that have occurred. The most common site of stress factors has been identified at the tibia in female athletes. This has been estimated at 25-63% of all examined cases. Gibbs, De Souza and Williams (2012) stated in a review that low BMD can be identified at 0-15.4% in female athletes with a Z-score of greater than or equal to -0.2 SD and 0-39.8% in female athletes with Z-scores between -0.1 and -0.2 SD (Mallinson and De Souza, 2014).

The endocrine system has a large effect as estradiol (a form of oestrogen) impacts calcium uptake into the bone and when this hormone level is low it will adversely affect calcium uptake resulting in a lower BMD. Menstrual dysfunction has been known to lead to an increase risk in stress fractures (Zanker and Cooke, 2004, p. 1380). A decrease in energy levels in combination with an oestrogen shortage has been known to cause negative effects on

the formation and restoration processes of bone (Mallinson and De Souza, 2014, p. 451-467). Therefore, female athletes with low energy availability and amenorrhea are more likely to be predisposed to osteoporosis, irreversible bone loss and are more susceptible to stress fractures (Morgenthal, 2002. p, 97-106).

With the heightened concern for female athletes, both elite and recreational, primary research into the FAT has begun to focus on this silent component. However, there has been significant research in low bone density in swimmers but minimal studies results have been conducted. With the increase in today's modern technology and the improvements of screening and imaging methods, research is able to surpass BMD assessment and analyse the geometry and microarchitecture of bone, the consequence of the effects of the different types of sport and the mechanical loading on bone health, the superior factors that contribute to negative bone health and greater evaluation into stress fractures (Mallinson and De Souza, 2014).

The most accurate measurements can be obtained via a two-dimensional imagery technique known as a dual-energy x-ray absorptiometry (DEXA), quantitative ultrasound (QUS) or through the use of a three-dimensional imagery technique, i.e. Primary peripheral quantitative computerised tomography (pQCT). The DEXA technique is currently the most popular quantifiable form of diagnosis for osteoporosis and osteopenia but it is limited due to its two-dimensional measurements, and is not as effective in assessing true BMD (volumetric BMD, bone geometry). Even though, there are multiple benefits to DEXA, it is a non-invasive technique, inexpensive, produces low levels of radiation, has a quick analysis process and is more assessable than the pQCT or gamma-ray techniques (Rossi et al., 2013). The use of the pQCT has shown greater accuracy in identifying weakening trabecular microarchitecture, i.e. identified as having a larger amount of trabecular spacing rather than trabecular quantity (Ackerman and Misra, 2011, p. 135). It is interesting to note that female athletes who are amenorrhic have been known to have osteogenic advantages with regular exercise, as their total bone area at the distal tibia is greater when compared with sedentary factors and alike to eumenorrheic athletes. Bone size is a crucial factor in relation to bone strength (Ackerman and Misra, 2011). This shows that in spite of menstrual irregularities, regular exercise may aid in protecting against a loss in bone strength. However, it must be taken into account that

although amenorrhic athletes have a greater bone area at the distal tibia, the evaluation of total bone area (trabecular and cortical bone) shows that amenorrhic athletes have a larger relative trabecular bone area but a lesser relative cortical bone area at the distal tibia compared with sedentary factors (Ackerman and Misra, 2011; Ackerman et al., 2012).

An activity that applies a loading effect and mechanical strain at a point that encourages modelling and the development of new bone is predicted to improve and maintain bone mass. Nikander et al. (2005, p. 520-528) examined female athletes who participated in high impact (volleyball, hurdling) and odd impact (soccer, squash) sports and found athletes to have greater bone health compared to female athletes that participated in non-impacted sports (swimming, cycling). When areal (a determinant of bone strength (aBMD)) BMD and estimated cross-sectional area of the femoral neck were examined, swimmers and cyclists showed no difference in these components whereas impact, odd impact, high magnitude (weightlifting) and repetitive low impact (cross-country skiing) sports showed a greater aBMD and cross-sectional area difference. Similarly, Nilsson et al. (2007) observed the BMD between an athletic group, swimmers, and a control group. Results showed the athletic groups' BMD to surpass both the other groups, whereas the swimmer and control groups' results did not differ.

Nichols et al. (2007) evaluated the relationship between loading mortality and menstrual dysfunction on bone health in high school female athletes. The participants were classified as eumenorrheic or amenorrheic and were grouped according to sporting disciplines. The eumenorrheic athletes who participated in high/odd impact sports showed to have a greater hip BMD and greater lumbar spine Z-scores compared to the non-impact athletes. These results demonstrates how sport loading modalities impacts on the BMD of athletes. On the other hand, Gomez-Bruton et al. (2013) concluded that swimming does not result in lower BMD. Longitudinal studies indicated that lower BMD increases during a season in this specific sport.

However, for athletes it is essential to monitor a consistent balance between moderate and vigorous intensity exercise and adequate caloric intake. If this is not maintained, an energy deficit will develop (Zankerand Cooke, 2004). Therefore, osteoporosis is diagnosed as a BMD

Z-score of more than -2.0 standard deviation but can be reduced with weight-bearing activity and a resumption in Menes.

2.6 Hormone deficiency

Endothelial dysfunction (Zanker and Cooke, 2004; Laframboise, Borody and Stern, 2013) has shown that the FAT has progressed into a tetrad of interconnected components, with endothelial dysfunction being the primary risk factor of cardiovascular disease for the female athlete. It has been suggested that endothelial dysfunction is the product of a decrease in oestrogen ultimately resulting from low energy availability. The vessels hold oestrogen receptors that permit oestrogen to become a regulatory factor in vascular function. This stimulates endothelial-derived nitric oxide, which ultimately leads to vasodilatation

Laframboise, Borody and Stern, (2013, p. 316) explains the endothelial process as "low energy availability in the female athlete results in changes in physiological and neuroendocrine response including a decrease in leptin, triiodothyronine (T_3), insulin, insulin-like-growth-factor-1 (IGF-1), plasma glucose, and a resultant increase in ghrelin, cortisol and growth hormone (GH). Physiological and neuroendocrine changes within the body will signal the hypothalamus to stop producing GnRH. A decrease in GnRH halts the releases of LH and follicle stimulating hormone (FSH) from the pituitary gland. Furthermore, an overall decrease in LH and FSH suppresses the ovaries from producing oestrogen and progesterone leading to abnormal menses in the female athlete" (Laframboise, Borody and Stern, 2013).

A study that tested endothelial dysfunction with regards to the FAT in 22 professional ballet dancers showed concerning results as only three out of the 22 dancers were negative for the four components (including endothelial dysfunction) of the FAT. This study indicates that professional dancers are highly susceptible to the FAT (Hoch et al., 2011).

Amenorrhea will lead to damaged endothelial cell function and impaired arterial dilation, leading to cardiovascular disease (Laframboise, Borody and Stern, 2013, p. 320). There are essential differences between female athletes with primary ovarian failure and female athletes

with exercise/diet induced amenorrhea. Exercise/diet induced amenorrhea occurs due to ovarian suppression brought on by neuroendocrine disruption (hypothalamic amenorrhea) compared to ovarian failure (Zanker and Cooke, 2004).

It has been found that distance runners with a body mass index of 18kg.m^2 have low nutritional markers IGF-1 and T_3. Insulin-like-growth-factor-1 is a peptide hormone that is utilised by multiple tissues in reaction to GH and is transferred to serum in connection with its rate of synthesis. Triiodothyronine is a thyroid hormone that has an effect on every physiological aspect of the human body such as developmental processes, growth, thermoregulation, and metabolism, to name a few. With a deficiency of IGF-1, this could lead to reduced bone formation. It has been established that oestrogen hold a considerable influence with bone turnover. Zanker and Cooke (2004, p. 1380) stated that "this is exemplified by the deleterious effects of ovarian failure on skeletal integrity". Furthermore, with a decrease in plasma concentration of lepton, due to the effects of energy deficiency, poor bone health could result (Zanker and Cooke, 2004, p. 1382). Lepton is a cytokine-like protein identified by the *ob.* gene and can be located in white adipose tissue (Zanker and Cooke, 2004, p. 1382).

Although the current study will not test for endothelial dysfunction, it is still relevant to take note of the physiological effect that it has on the described interconnected FAT components.

2.7 Female Athlete Triad

Gibbs, De Souza and Williams (2012) evaluated and reviewed 65 studies on the prevalence of the FAT in exercising women. Most of the studies were conducted in the United States of America, Norway and the United Kingdom, with a select few from Germany, Australia, Turkey, Malaysia, Iran, Sweden, Croatia, South Africa (one study), and Brazil. Almost half of these studies (45%) included competitive athletes as their target population of weight conscious sports namely; runners, dancers, endurance athletes, gymnasts, tri-athletes, figure skaters, weight lifters, and one study on swimmers. From the 65 studies, only nine studies evaluated the prevalence of all three triad components. Five of these were conducted using the 1997 position stand and only four used the latest 2007 position stand. Five grouped athletes as

a whole and only four into specific ‘sports’ with only one focusing on swimming. Results showed that a relatively small percentage of athletes (0-15.9%) exhibited all three triad conditions.

An Australian study (Miller, et al., 2012) was conducted to illustrate the lack of knowledge among female athletes towards the triad. In this study 180 female athletes partook, including 11 swimmers, as well as various other sporting disciplines. Only 10% of the participants could identify all three components. Approximately one third of the population believed that menstrual irregularity was normal for active individuals, and one of two international level athletes considered amenorrhea normal for female athletes. Additionally, 54% of the sample accurately acknowledged that poor bone health could be the result of menstrual dysfunction. This study gives a clear indication that educational programmes need to be promoted.

A comparative study on whole body and site-specific BMD in female collage athletes from different sporting codes showed that even with the variety in sporting disciplines (gymnastics, softball, cross country, track, field hockey, soccer, crew, running. and swimming/diving) there was little difference in whole BMD except for running and swimming/diving athletes. The greater difference was established in the site-specific areas such as the lumbar spine, pelvis, and average leg BMD. However, it was the running and swimming/diving athletes that showed the lowest values in all BMD tests. This could lead to further clinical connotations (Mudd, Pivarnik, and Fornetti, 2007).

In August 2009, a study was conducted in the United States of America among female college swimmers to determine their nutritional knowledge and how efficiently they could apply their nutritional knowledge to their daily lives. Swimmers (n=85) from different institutions participated. The participants had to complete a validated nutrition knowledge questionnaire and a 24-hour dietary recall survey. Almost all participants (95.9%) did not reach the RDA for the macronutrients (carbohydrates, protein, and fat), and 80% of the participants failed to meet two out of the three macronutrients. Overall, the study showed that swimmers had a poor nutritional knowledge base, made poor food choices, could not comprehend the components of

a well-balance meal plan and showed no concept of how nutrition impacts performance (Hoogenboom, et al., 2009).

Another study conducted in the United States of America examined the prevalence of the FAT among high school athletes that participated in a variety of sports compared with a sedentary control group. Students (n=160) volunteered to participate (80 athletes, 80 control). From this sample, 17 were swimmers. To be eligible for the study, the participants had to be between the ages of 13-18 years old and be a member of a sports team. Participants who did not participate in a sports team or performed ≤ two hours of physical activity per week, were selected for the control group. The participants had to complete the following; a self-completed questionnaire (sport history, demographic information), an EAT-26 questionnaire, a menstrual cycle questionnaire, a DEXA scan was used to measure BMD, fasting blood samples were obtained on the morning of testing and each participant had to complete a three-day food diary. The athletes demonstrated an average of 8.66hr/wk of exercise compared to 1.02hr/wk from the control group. Only 35% of athletes and 19% of the control group could establish all three inter-connected components of the FAT. Results showed that 36% of the athletes had low energy availability (<45kcal/kg/LBM) compared to the control group (39%). Out of the athletic group, five participants showed to have an energy availability of under 30kcal/kg/LBM. Menstrual dysfunction was evident in 54% of the athletes, with five participants being positive for primary amenorrhea, 24 with secondary amenorrhea, and 14 with oligomenorrhea. As for the control group, 21% reported a menstrual dysfunction. The athletic group showed that 13% had a BMD Z-score between -1.0 and -2.0, and 3% showed a Z-score below -2.0. The combined results identified one participant positive for FAT. It was concluded that the components of FAT are a significant health threat to both active and sedentary females (Hoch, et al., 2009).

Similarly, Rauh, Nichols, and Barrack, (2010) examined the relationships among injury and disordered eating, menstrual dysfunction and low BMD among high school athletes. Female (n=163) athletes from various sporting disciplines (nine swimmers) participated in this study. It was found that 37.4% had sport-related injuries and that musculoskeletal injuries were more frequent in non-weight bearing or endurance athletes than weight-bearing athletes. The results

indicated that athletes that tested positive for disordered eating had a 4.2-fold increase in injury risk; were positive for oligomenorrhea/amenorrhea had a 3-fold increase in injury risk; and athletes with a Z-score of ≤-1.0 SD had a 3.6-fold increase injury risk.

2.8 Treatment for the Female Athlete Triad

In 2014, the FAT Coalition established a statement on Treatment and Return to Play of the FAT (De Souza et al., 2013). This statement is to be used as an addition to the ACSM 2007 position stand. The Coalition panel has identified and acknowledged the negative health elements of the FAT in regards to the severe, subclinical/less severe and minimal conditions. It is for this reason, that a clear return to play statement has been conducted and implemented. The Coalition panel agreed that prevention and early detection is the most critical aspect to avoid the progression of the more severe clinical conditions associated with the FAT (De Souza et al., 2013).

The result for treatment has been identified, and with the provision and supervision of a multi-disciplinary health care team (physician, sports dietician, psychological professional, exercise scientist,athletic trainer and biokinetisist), the athletes have an opportunity to recover (De Souza et al., 2013). There are multiple tools that can be utilised through the pre-participation examination and screening process.

However, there is limited evidence with regards to the efficiency of screening questions and evaluations, although, the Coalition panel recommends that athletes undertake annual screenings via triad-specific self-reported questionnaires, such as the questionnaires utilised in this study. Early detection and screening in adolescent females for the inter-connected components of the FAT is vital as 90% of bone mass is produced by the age of 18 years, thus allowing the chance to optimise their bone health. However, this can only be accomplished with the honesty and compliance required from the athlete (De Souza et al., 2013).

Recovery can be accomplished by means of a reduction in training load or an increase in caloric intake. This can be performed simultaneously. Hormone replacement has been shown

to have evasive effects for treatment of bone loss. For the benefits of treatment to take effect, it would require "a change in behaviour that such individuals could consider undesirable and impractical. This would be particularly true for individuals who are deliberately manipulating their energy balance to sustain a low body mass and body fat content, for example, the female athlete triad" (Zanker and Cooke, 2004, p. 1375). The athletes should focus on rectifying their energy balance (Micklesfield et al., 2007). For active women with low BMD, the Coalition panel recommends an increase in energy availability, an increase in body weight, and a resumption of menses. Additionally, calcium and vitamin D balances should be monitored. Educational programmes will assist and stress the aid of treatment (De Souza et al., 2013).

For an efficient design of the educational programme, an emphasis towards the FAT and the athlete's knowledge, attitudes, and behaviours should be improved (Miller et al., 2012). Due to the lack of concern many female athletes have demonstrated towards menstrual dysfunction, it is critical to educate athletes that osteoporosis is a silent illness (Miller et al., 2012, p. 131-138). There is a greater demand for the establishment of educational initiatives for the South African female athlete. For example, the United States of America incorporate aid of the Female Athlete Triad Coalition. This organisation provides information on the FAT via educational material and online resources (www.femaleathletetriad.org) including videos, slide shows, and brochures (Miller et al., 2012, p. 135).

In 2008, the National Athletic Trainers' Association produced a position statement on preventing, detecting and managing disordered eating in athletes. The purpose of the position statement was to aid in the improvement of the athletic trainer, health care professionals, sporting management, parents and coaches to better understand athletes dealing with disordered eating. The identification and treatment of disordered eating should be incorporated into athletic programmes (Bonci et al., 2008).

As previously mentioned the degree of disordered eating varies along a scale of severity. This includes three clinically diagnosable conditions defined by DSM-IV as anorexia nervosa, bulimia nervosa and eating disorders not otherwise specified (Bonci, et al., 2008). It is crucial that the health care team recognise the signs and symptoms of these conditions in the early

stages. These could include: cardiovascular (bradycardia, hypotension, atrial and ventricular arrhythmias); endocrine (hypoglycaemia, low female sex hormones, delayed onset of puberty); gastrointestinal (constipation, bloating, abdominal pain); fluids and electrolytes (dehydration, electrolyte abnormalities, muscle cramps); Thermoregulation; Hematologic; Dermatological (hair loss, dry skin, lanugo); and others (significant weight loss, extreme weight fluctuations, fatigue, muscle weakness) (Bonci, et al., 2008). Screening methods should be administrated into the programme as self-identification is unlikely due to secrecy, shame, denial, or fear of punishment (Bonci, et al., 2008).

Nowadays, there are multiple behaviour and attitude questionnaires (Eating Disorder Inventory (EDI), Eating Disorder Examination (EDE-Q), Eating Attitudes Test (EAT)) that are used in the screening process. If concerning results develops from the questionnaires, then an in-depth interview conducted by a trusted health care professional should be enforced.

2.9 Summary

The FAT has progressed over the years into three interconnected components that have been illustrated by the ACSM as a condition of escalating concern, as the syndrome could hinder athletic performance and health status if not identified and treated. The three components of the FAT (low energy availability (with or without eating disorders), functional hypothalamic amenorrhea and osteoporosis) are interconnected in aetiology, pathogenesis, and consequences. All three components impair the athlete from her optimal potential and reveal harmful aesthetics traits.

As there has been limited literature in elite aquatic athletes and the FAT, the results from this study will aid in the understanding of the FAT and the effect of training and nutrition on non-weight bearing athletes.

CHAPTER THREE

3. METHODOLOGY

This chapter will account for a detailed explanation of the research methods and materials used to conduct the data collection and analysis.

3.1 Study Design

This study was a descriptive cross-sectional study. The study utilised a cross-sectional study as it was a form of an observational study that includes the examination of data collected from a certain population at a precise time (Levin, 2015). As this study will have a short data collection term, it is imperative that the study remain cross- sectional as the competitive months of this sport are short and the environment cannot be manipulated. The chosen study period was during the sports peak season as the training is at its highest intensity.

3.2 Population and Sample

The target population was elite KwaZulu-Natal Sprint and Distance Swimmers who competed at the 2014 and 2015 South African National Aquatic Championships. The population consisted of approximately 39 elite female swimmers. This population was chosen due to the lack of research on female swimmers and the Female Athlete Triad (FAT). Currently, there is a single International study that examines aquatic female athletes and this condition. Additionally, there is no South African literature of this kind. This is an area that would greatly benefit this sport and its athletes. As competitive swimming in South Africa is quickly becoming one of our more dominant sports, this type of study is vital to the athletes. Educating athletes on health issues and providing further information to the Swimming South Africa Federation for future generations is very relevant. Swimmers are not stereotypically been thought to be prone to unhealthy behaviours such eating disorders or to have poor body image. However, they are classified as endurance athletes and should be tested for FAT.

The sample consisted of 21 participants who adhered to the following criteria:

3.2.1 Inclusion criteria

- Female Athletes
- Athletes that were affiliated with KwaZulu-Natal Aquatics (KZNA)
- Athletes that competed at the 2014/2015 South African Nationals

3.2.2 Exclusion criteria:

- Male Athletes
- Non-aquatic athletes
- Athletes not affiliated to KZNA
- Athletes who did not compete at South African Nationals 2014/2015
- Athletes who were pregnant
- Athletes who had been diagnosed with a thyroid dysfunction
- Athletes who took supplementation for bone growth, example: aid in bone mineral density

3.3 Procedures and protocol

3.3.1 Procedures

Gate-keeper permission from the KwaZulu-Natal Health Department (Appendix A) was requested. Gate-keeper permission from KZNA (Appendix B) was requested to grant permission for KZNA swimmers to participate in the research study. Once Gate-Keeper permission from KZNA was granted (Appendix C), the Convenor of the sporting discipline (Appendix D) was requested to grant athlete participation and for their support in the research study. The study received a verbal response from the Convenor of the sporting discipline.

Once permission to conduct the study had been granted by the Gate-keepers and the University's Biomedical Research Ethics Committee (BE284/14), a research information package (Appendix E, F) as well as informed consent forms (Appendix G) and assent forms, where applicable, were sent out to participants. Once participants had provided informed consent or assent to participate in the study, and adhered to the inclusion/exclusion criteria, data collection dates were determined.

3.3.2. Protocol

Participants were recruited from the various KwaZulu-Natal clubs and the aquatic federations. All female 2014 and 2015 South African National competitors were informed of the study by a FAT flyer (Appendix H) and their various coaches and associations as per the agreement between the researcher and the sporting federation (Appendix B). A presentation (Appendix I) was performed by the researcher at club meetings to further explain and respond to any questions.

The testing protocol consisted of one session and was divided into three phases, namely;

Phase One

- Participants handed in signed consent or assent forms and entered their names on the Confidential Subject Classification Sheet (Appendix J) and were assigned a number. This strengthened participant confidentiality throughout the study. Numbers were assigned in chronological order and were recorded on all data pages.

Phase Two

- A private room at the King's Park Medical Centre was allocated for data collection.
- Each participant was allocated an individual testing time. Each participant was requested to complete five questionnaires, namely, Eating Attitudes Test (EAT-26), Body Shape Questionnaire (BSQ-34), Bulimic Investigatory Test, Edinburgh (BITE), Menstrual Cycle and Time spent in Exercise Questionnaire, and a Self-Administered Bone Mineral Density Questionnaire. This process was approximately 45 minutes.

- Each participant was then seated at a private table to ensure confidentiality in her answers, as well as for personal security, as the participant was requested to complete the questionnaires with absolute honesty.
- The researcher remained in the room at all times supervising and ensuring that all questions were understood and that questionnaires were completed.
- Each participant also completed a Demographic Information sheet (Appendix K) with questions pertaining to supplementation and secondary risk factors.
- Anthropometric measurements (height, weight, and skin folds) and body composition (Bioelectrical Impedance Device) were then measured by the researcher in another private cubicle. Confidentiality of the participant's results were maintained and aided by the assurance of the participant's privacy. This process was approximately 10 minutes.

Phase Three

- Once all administrative forms (Appendix G, J, and K) were completed, the participants were then chaperoned to another private room on the same premises where the online ASA24 Dietary Recall was completed on the researcher's private software programme. This process was approximately 45 minutes.

The total testing time consisted of a two-hour testing session.

All participants who agreed to volunteer to participate in the study were compensated with travel expenses to and from the testing venue.

3.4 Instrumentation

3.4.1 Questionnaires

With the cross-sectional study design, questionnaires were the chosen tool to compile confidential information on eating disorders, body shape belief, and female menstrual cycle

awareness and bone mineral density information. Every questionnaire utilised was previously used and accredited in past eating behaviour and FAT research (Drinkwater, 1990).
All participants were required to complete the following validated questionnaires:

- Eating Attitudes Test (EAT-26) (Appendix L) (Garner et al., 1982) determined the participant's attitude and beliefs towards food.

Eating Attitude Test (EAT24) (Appendix L): calculation of results via scoring procedure (Appendix M). This questionnaire enabled the researcher to identify the severity of the participants' attitude to food and any harmful psychological patterns. There were three criteria for a positive test;

  - a score of≥20 out of 30
  - the answer 'yes' to behavioural questions
  - A BMI of <18

- Body Shape Questionnaire (BSQ-34) (Appendix N) (PSYCTC.org, nod) examined the participant's personal view of their body.

Body Shape Questionnaire (Appendix N): calculation of results via scoring procedure (Appendix O). Criteria for a positive test;

  - A score of >140 of the possible 204. This showed a marked concern of Body Shape which was a score in the top third percentile.

- Bulimic Investigatory Test, Edinburgh (BITE) (Appendix P) (BITE- Bulimic Investigatory test, Edingburgh, n.d.) identified the severity of disordered eating.

Bulimic Investigatory Test, Edinburgh (BITE) (Appendix P): calculations of results via scoring procedure (Appendix Q). Criteria for a positive test; both the Symptom and Severity Scale were taken into consideration.

  - A System Scale of >20 out of the possible 30 was defined as Bulimic or Binge Eater.
  - A Severity Scale of >5

In order to test positive for disordered eating the participants needed to have scored positive for one out of the three questionnaires (Schtscherbyna, et al., 2009).

- Menstrual Cycle and Time spent in Exercise Questionnaire (Appendix R) (Southwick, 2008.p. 1-177) to identify menstrual irregularity and contributed to determine energy expenditure.

Menstrual Cycle and Time spent in Exercise Questionnaire (Appendix R): Positive results for menstrual dysfunction were based on positive classification to set definitions applicable to FAT. Responses to time spent in exercise were related to the possible risk of functional hypothalamic amenorrhea (Drinkwater, et al., 1997). The ASA24 online dietary recall aided in calculating the daily calories to help provide a conclusion if calorie restriction contributed to any menstrual dysfunctions.

- Self-Administered Bone-Mineral-Density Questionnaire (Appendix S) (Hackettstown Diagnostic Imagining, 2014) identified any previous bone fractures or injury.

A Self-Administered bone-mineral-density questionnaire (Appendix S) positive score was a high report classification for BMD risk factors revealing a risk of having low BMD.

Secondary clinical risk factors for fractures were determined by a positive result in at least one of the following subcategories: (Loucks, et al, 2007).

- Under-nutrition: low energy availability
- Eating Disorder: scoring for disordered eating
- Prior fractures: answered 'yes' to any fractures experienced, asked in the Demographic Information Sheet
- Hypoestrogenism: positive for menstrual dysfunctions

3.4.2 ASA24 Dietary Recall

All participants were required to complete the online ASA24 dietary recall. This tool was chosen for its accurate account of daily consumables and easy accessibility for both the participant and the researcher. Participants registered online and followed the instructions where they were required to provide a detailed description of their food and drink intake of the previous day over 24 hours. The results were then sent via email to the researcher (ASA24 Automated Self-administered 24hour Recall, 2013).

The results from the ASA24 Dietary Recall and body composition from the bioelectrical impedance device (fat-free mass) were used as descriptive data of athletes relating to low energy availability (Female Athlete Triad Coalition., 2002). The time spent in exercise questionnaire aided towards calculating the amount of energy used during exercise per day in combination to the total daily calories consumed. This amount affects the energy availability post exercise. Which in turn, could affect the athletes' athletic performance and hinder optimal daily physiological functions.

3.4.3 Anthropometrical Measurements

Height and Weight (Schtscherbyna, et al., 2009)

The anthropometric measurements were used to calculate the body composition of the participants. This added to the results of the Eating Attitude Questionnaire and give an indication of atheistic or lean appearance. A greater body fat percentage of a participant will not be an indication of a low risk of the FAT components. The researcher conducted all of the anthropometric measurements to maintain consistency of results and validation of procedures. Height (Metres) and weight (Kilograms) were measured via a calibrated scale and recorded to the nearest 0.1 mm and 0.1g. Privacy was provided by only allowing the researcher into the private and closed room at the acknowledgment and permission of the participants. The participants wore light, loose garments and remained bare footed. They stood erect on the scale until the measurements were calculated. The researcher recorded the measurements on the Demographic Information Sheet (Appendix K). Body Mass Index (BMI) was calculated using the BMI formula (Clark, et al., 1998).

$$BMI = \frac{Mass_{(kg)}}{Height^{2}_{(m)}} = kg/m^2$$

This formula is the participants body mass (kg) divided by their height (m) measurement squared. The normative data for a healthy young female athlete is between the range of 18.5 – 25 kg/m^2 (Sundgot-Borgen and Torstveit, 2004).

Skinfolds (Wheatley, et al., 2010)

Skinfolds were measured and recorded for descriptive purposes and to reinforce the results from the Bioelectrical Impendance Machine. The skinfold measurements were measured with calibrated callipers. The measurements were measured on the right-hand side of each participant. Participants wore loose fitting garments and the skin was wiped dry of any moisture. The measurement sites were: triceps, biceps, suprascapular, Suprailiac, abdominal and quadriceps These sites are significant to the anatomy of swimmers (Wheatley, et al., 2010). Figures 3.1 to 3.6 provide a further understanding of the different skinfold sites:

1. Triceps

   Landmark: At the mid-point between the acromial and the radial. On the mid-line of the posterior surface of the arm.

Figure 3.1: Triceps Skinfold Site

2. Biceps

   Landmark: At the level of the mid-point between the acromial and the radial. On the mid-line of the anterior surface of the arm.

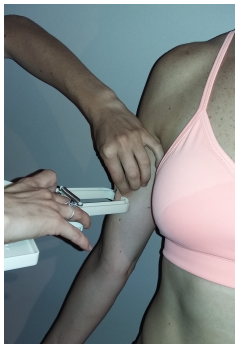

Figure 3.2: Biceps Skinfold Site

3. Subscapular

Landmark: The lower angle of the scapula (bottom point of shoulder blade.

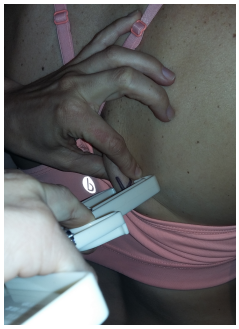

Figure 3.3: Subscapular Skinfold Site

4. Suprailiac

   Landmark: Immediately above the iliac crest. On the most lateral aspect.

Figure 3.4: Suprailiac Skinfold Site

5. Abdominal

   Landmark: a mark is made 5 cm adjacent to the belly-button on the right side.

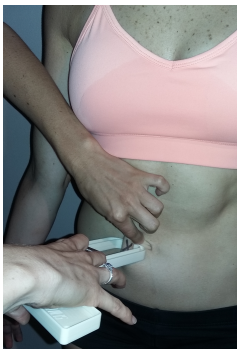

Figure 3.5: Abdominal Skinfold Site

6. Quadriceps.

   Landmark: The mid-point of the anterior surface of the quadriceps, midway between the patella and the inguinal fold.

Figure 3.6: Quadriceps Skinfold Site

Skinfold measurements were analysed using the Jackson Pollock six-site calculation (de Mendonça, et al., 2014).

Bioelectrical Impedance Device

This device estimated full body composition. The selection for this tool was due to its many attributes, but mainly due to it been one of the most accurate portable body composition measurement devices. The participant was informed not to eat or drink 30 minutes before testing. The participant was in a supine position. The researcher placed non-invasive electrodes onto the participants' right hand and right foot (Figure 3.8). Each participant entered their anatomical information into the bioelectrical impedance software. This device calculates body composition via a very low electrical current (Esco et al., 2014). The researcher recorded all measurements (body fat percentage, fat weight, lean weight, basal metabolic weight) on the Demographic Information Sheet (Appendix K).

Figure 3.7 Bioelectrical Impedance Procedure Position

Figure 3.8 Bioelectrical Impedance Device

Body Mass Index was recorded and calculated via the BMI formula. This information was used to provide an indication whether the participant had a healthy height to weight ratio. Skinfold measurements aided in calculating the body fat percentage and used as a marker for the bioelectrical impedance device. The bioelectrical impedance device provided information that was used to calculate energy availability (EA) with the following formula:

EA= (Energy Intake (EI) – Energy Expenditure (EE)) / Fat Free Mass (FFM).

Overall, participants classified as at risk for the FAT were those who presented with a low energy availability count, a positive score for disordered eating, any type of menstrual dysfunction (primary amenorrhea, secondary amenorrhea or oligomenorrhea), and a positive result for low BMD (Schtscherbyna, et al, 2009).

3.5 Data Collection

Data was collected and filed in chronological order by the researcher. All collected data was kept in a locked office with only the researcher having access to it. All data was stored on a password protected computer and in password protected electronic files. Table 3.1 will provide a summary of all the testing procedures used in this study for each Fat component.

Table 3.1 Summary of Testing Procedures

Test Component	Author Reference Date	Purpose	Possible Outcome
Demographic Information Sheet	2015 (Compiled by the researcher)	To record all data. Identified stress fractures	Favourable results
Eating Attitudes Test	Garner et al. (1982)	Identifies severity of behaviour towards food	Positive or poor results
Body Shape Questionnaire	PSYCTC.org (n.d)	Identifies positive/poor self body image	Favourable or poor self body image
Bulimic Investigatory Test, Edinburgh	BITE- Bulimic Investigatory test, Edingburgh (n.d)	Identifies harmful eating behaviours	Positive harmful results or a healthy result
Menstrual Cycle and Time Spent in Exercise Questionnaire	Southwick (2008. p. 1-177)	Identifies menstrual dysfunctions and training load	Euromenorrhea Polymenorrhea Amenorrhea Secondary Amenorrhea. Oligomenorrhea.
Self-Administered Bone Mineral Density Questionnaire	Hackettstown Diagnostic Imagining (2014)	Identifies low bone mineral density risk	Normal bone mineral density Abnormal bone mineral density
Skinfolds	Wheatley, et al. (2010)	Calculates and confirms body fat percentage	High body fat percentage Low body fat percentage
Anthropomentric Measurments	Schtscherbyna, et al. (2009)	Calculates height (m) and weight (kg). Calculates BMI	Aids towards Eating Attitude questionnaire results
Bioelectrical Impedence Device		Calculates total body composition and basal metabolic rate	Normal mucle mass for age group Low muscle mass for age group
ASA24 Dietray Recall	ASA24 Automated Self-administered 24hour Recall (2013)	Identifies total daily calorie intake	Normal energy availabilty. Low energy availablity

3.6 Statistical Analysis

A positive risk stratification of the FAT was calculated as a positive score for all components (disordered eating, low energy availability, menstrual dysfunction and low BMD). The t-test was used to compare means within and between the two aquatic disciplines (Trochim, 2006). Binomial tests were used when the response was a dichotomous categorical; and the Chi-Square test was used to evaluate the association among categorical variables (Vincent, 2005).

Non-parametric tests were used in this study due to the small population group. Significance was set at a $p \leq 0.05$.

3.7 Ethical Considerations

Before the study began, the KZN Heath Department granted ethical concent. The KZNA was contacted and provided their consent to contact and interact with all swimmers under their jurisdiction. Once permission from KZNA was granted, the Convenor of the sporting discipline was requested to grant athlete participation and for their support in the research study. The study received a verbal response from the Convenor of the sporting discipline. Permission to conduct the study had been granted by the University's Biomedical Research Ethics Committee (BE284/14). All participation was voluntary and the anonymity of each participant was maintained by the use of coding.

Confidentiality was maintained at all times. The data collected was securely stored in such a way that only the researcher was able to gain access to it. At the end of the project any personal information was destroyed immediately except that, as in accordance with the University's research policy, raw data on which the results of the project depend were retained in a secure storage place for the next five years, after which it will be destroyed by incineration.

CHAPTER FOUR

4. RESULTS

This chapter will account for a detailed assessment of the scientific results from the study. Each objective within the study will be addressed.

4.1 Introduction

This chapter presents the results obtained from the testing protocol in this study. The data represents the measurements and evaluation of the anthropometrical tests. Responses from the questionnaires and subsequent analyses are also presented.

4.2 Descriptive Data

This section summarises the descriptive information of the sample.

From a population of 39 elite female distance and sprint swimmers, 21 swimmers adhered to the inclusion and exclusion criteria and volunteered to participate in the study. The participants were tested for low energy availability (with or without disordered eating); menstrual dysfunction; and low bone mineral density (BMD). Therefore, 21 participants tested for a risk of a component of the Female Athlete Triad (FAT) and the FAT as a whole.

All participants were in the accurate age group (≧15 years) for menstrual dysfunctions (functional hypothalamic amenorrhea) to occur (Drinkwater, et al., 1997). The mean age of the sample was 18.95 (SD 6.2years). Eleven participants (52.4%) were sprint swimmers and ten (47.6 %) were distance swimmers.

4.3 Anthropometrical Data

The anthropometrical data of the sample is presented in Table 4.1

Table 4.1: Demographic Information of the Sample (n=21)

Measure	Age	Body Mass Index (kg/m^2)	Weight (kg)	Height (m)	Body Fat (%)	Fat Weight (kg)	Lean Weight (kg)	Basal Metabolic Rate (kcal)
Mean (SD)	18.95 (6.29)	21.31 (1.67)	60.71 (8.20)	1.71 (9.51)	22.86 (5.54)	14.04 (3.67)	45.63 (11.15)	1574.47 (146.07)
Minimum	14	18.20	32.50	1.56	9.40	6.70	4.50	1367
Maximum	45	24.91	71.90	1.86	33.50	22.90	64.50	1985

The mean height and weight of participants was 1.71m and 60.71kg respectively. The mean body mass index (BMI) was 21.31$kg.m^2$. The mean body fat percentage was 22.86%. Additionally, the maximum fat weight of 22.90kg was relatively high for a national level athlete, while on the other hand a relatively very low minimum lean weight of 4.50kg .was demonstrated. The mean basal metabolic rate was 1574.47kcal for the sample.

4.4 Training Frequency and Load

Participant training frequency and training load will be presented in Table 4.2.

Table 4.2. Training Frequency of the Sample (n=21)

	Mean Time spent in exercise per day (minutes)	Mean Time spent in exercise per week (minutes)	Mean Daily calorie expenditure (Kcal)	Mean Energy availability (kcal/kg)
Total Sample (n=21)	131.66	784.86	2706.42	22.95kcal/kg
Sprint Swimmers (n=11)	136.8	868.2	2846.18	19.8kcal/kg
Distance Swimmers (n=10)	126	780	2624.7	26.4kcal/kg

Majority of participants where categorised as senior competitive swimmers with the exception of two. This would not alter the results. The average time (minutes) spent training per week was 784.86. With an average daily training frequency of 131.66 minutes/day. The training load between the two disciplines did not vary. The participants were recorded as swimming between 6-8km/day. Training intensity and frequency were very similar and thus this study will be examining these two elements.

4.5. Female Athlete Triad Components

This section summarises each component of the FAT, i.e. Component 1: Low Energy Availability (with or without disordered eating); Component 2: Menstrual Dysfunction and Component 3: Low Bone Mineral Density (BMD).

Table 4.3: Components of the Female Athlete Triad

Category	Elite Swimmers (n=21)	Elite Sprint Swimmers (n=11)		Elite Distance Swimmers (n=10)
Disordered Eating N (%)	12 (57.1)	7 (63.6)		5 (50.0)
Mean Low Energy Availability n (%)	21 (100) 22.95kcal/kg	11 (100) 19.8kcal/kg		10 (100) 26.4kcal/kg
Menstrual Dysfunction n (%)	6 (28.5)	3 (27.3)		3(30.0)
Low Bone Mineral Density n (%)	16 (76.1)	10 (90.9)		6 (60.0)

Table 4.3 represents the risk stratification for the FAT among the swimmers per discipline. Seven (63.6%) sprint swimmers were at risk for disordered eating, while the remaining four sprint swimmers (36.4%) were not. The distance swimmers results indicated that half of the sample (n=5) were at risk for disordered eating. However, there was no statistical significant difference in the proportion that do, and do not suffer from disordered eating.

Furthermore, more than half of the sample (57.14%) were at risk for disordered eating and the whole sample group were at risk for low energy availability. Menstrual dysfunction revealed to be low in the sample group, however, if combined with low energy availability there will be a greater risk of low bone mineral density developing. Low bone mineral density showed to be a high risk (76.1%) component.

Component 1: Low Energy Availability (with or without disordered eating)

The risk stratification for disordered eating was tested via a series of questionnaires. A risk for disordered eating required the participant to have a positive score for one or more of the eating disorder questionnaires. The results from the questionnaires are as follows: ten positive Eating Attitudes Tests (EAT-26); eight positive Body Shape Questionnaires (BSQ-34) and two positive Bulimic Investigatory Test, Edinburgh (BITE).

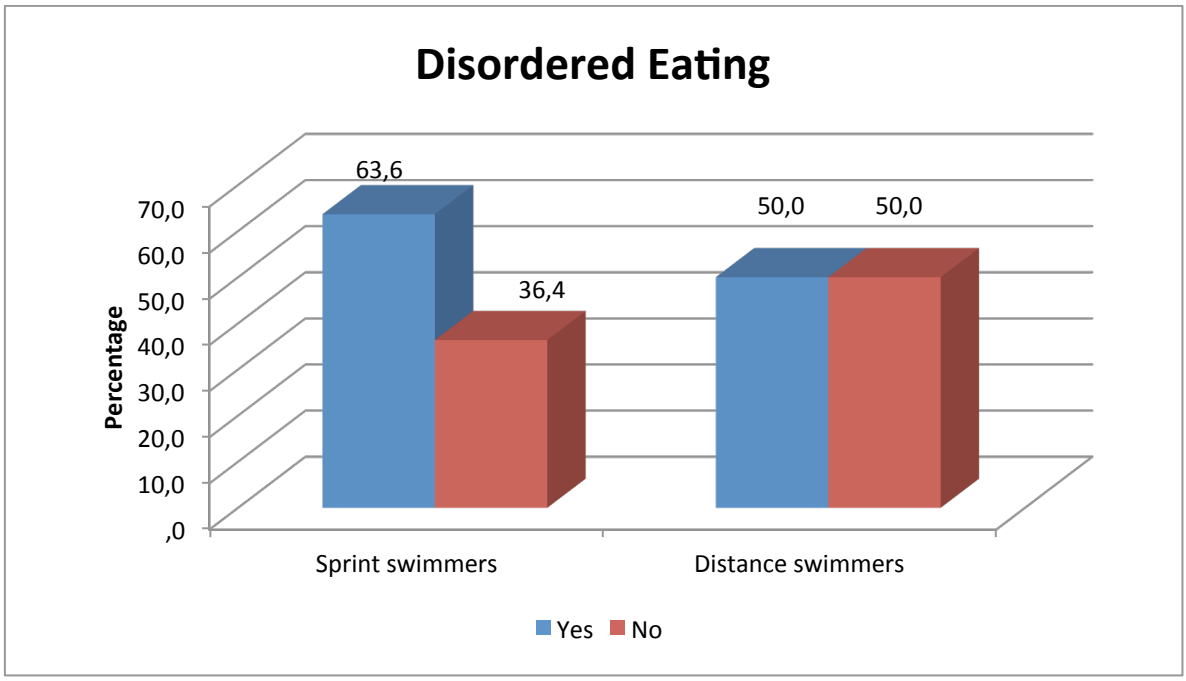

Figure 4.1: Risk Stratification for Disordered Eating in Elite Sprint and Distance Swimmers

Optimal energy availability for athletic females is regarded as having a value of ≥45 kcal/kg. Reduced energy availability is a value of ≤45 kcal/kg and anything below 30 kcal/kg is considered low energy availability.

With the statistical analysis of a one-sample t-test, the mean energy availability for the distance swimmers was 26.41 kcal/kg (SD 19.97). Although this is not a favourable result, it was not statistically significant. The mean energy availability for the sprint swimmers was 19.79 kcal/kg (SD 9.56). This is significantly lower than 30kcal/kg ($t(10) = -3.542$, $p=0.005$).

Furthermore, the Time Spent in Exercise questionnaire showed a mean training time of 131.6min/day. Majority (76.2%) of the participants trained for longer than 120min/day.

Component 2: Menstrual Dysfunction

Menstrual dysfunction was measured via a Menstrual Cycle questionnaire. The mean age of menaces of the sample was 13.3 years. The results were classified according to the definitions of menstrual irregularities, namely; primary amenorrhea (the absence of menstruation by the age of 15 years in a girl with secondary sex characteristics), secondary amenorrhea (the absence of three or more consecutive menstrual cycles after menarche) and oligomenorrhea (menstrual cycles are greater than 35 days in length or 4-9 menstrual periods per year). Polygomenorrhea was recorded as a menstrual dysfunction but will not be stated in this study as it is not a relevant FAT menstrual condition (Korsten-Rech, 2011).

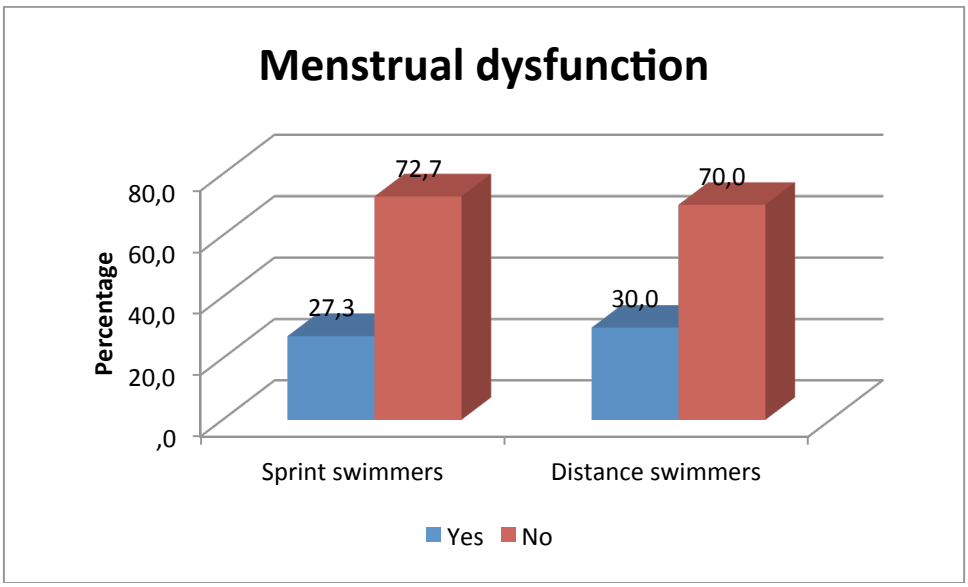

Figure 4.2 Risk Stratification for Menstrual Dysfunction in Elite Sprint and Distance Swimmers

Out of the total sample, only six (28.57%) participants were classified as having a menstrual dysfunction. From those six, three (27.3%) were sprint swimmers and three (30%) were distance swimmers. The menstrual irregularities from those six conclusive results showed two primary amenorrhea and one secondary amenorrhea case. This is illustrated in Figure 4.2.

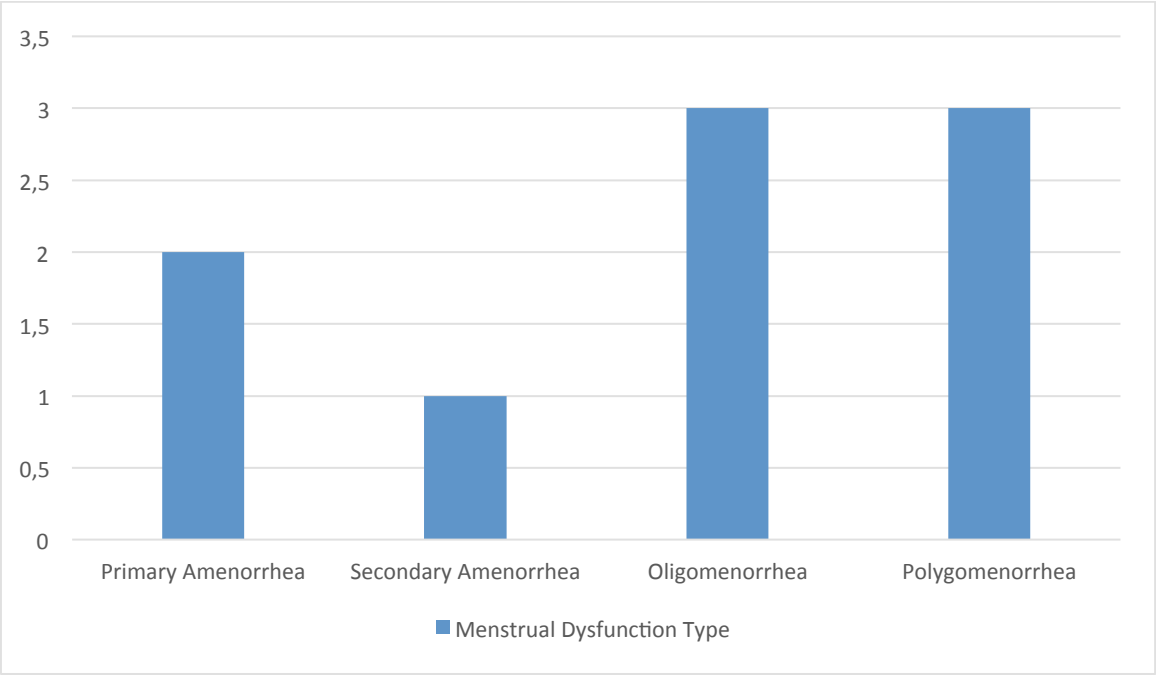

Figure 4.3: Types of Menstrual Dysfunction (n=9)

Participants with positive menstrual dysfunction, demonstrate an associated positive result with low energy availability. This will be further discussed in Chapter Five.

The statistical analysis used to calculate menstrual dysfunction in both sprint and distance swimmers was the binomial test. The results showed that there was no significant difference in the proportion that do and do not suffer from menstrual dysfunction.

Component 3: Low Bone Mineral Density

Low Bone Mineral Density was measured via a Self-Administered Bone Mineral Density Questionnaire in combination with a positive score for one or more secondary risk factors. A secondary risk factor includes: under nutrition (low energy availability); an eating disorder; prior fractures and/or a hypoestrogenism.

The binomial test was applied to each of the sporting disciplines to test the proportions. Results showed that 60% of the distance swimmers were at risk for low BMD. Sprint

swimmers showed to have a 90.9% risk of low BMD. The analysis showed that significantly (p=.012) more of the sprint swimmers suffer from low BMD than distance swimmers.

4.6 Risk Stratification for the Female Athlete Triad

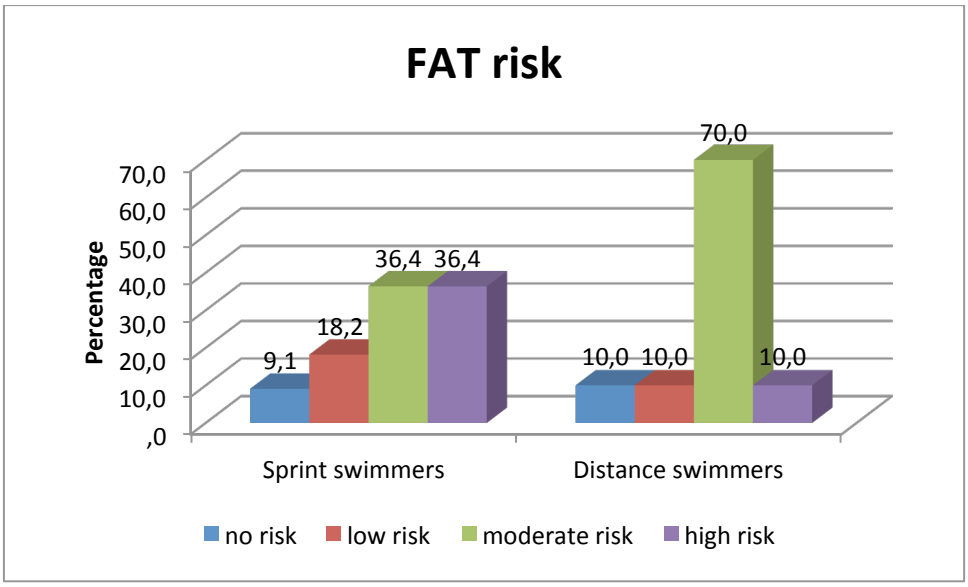

Figure 4.4: Elite Sprint and Distance Swimmers FAT risk Stratification

For a participant to be at risk for the FAT, a combined report for all of the FAT components (low energy availability (with or without an eating disorder, menstrual dysfunction, and low BMD) must be demonstrated.

The results were classified as the following: no risk (no positive FAT components), low risk (one positive FAT component), moderate risk (two positive FAT components), and high risk (three positive FAT components).

Table 4.4 presents the FAT risk classification of the sample.

Table 4.4: Frequencies of FAT in Sample Group

Category	Total Sample n	Sprint swimmers n	Distance Swimmers n
No risk	2	1	1
Low Risk	3	2	1
Moderate Risk	11	4	7
High Risk	5	4	1
Total	**21**	**11**	**10**

One participant from each group presented with no risk of FAT, while majority (n=7) of the participants were classified as moderate risk from the distance swimmers group. Five swimmers were classified as high for the FAT.

The Chi-square goodness of fit test was applied to ascertain whether any of the classifications were significantly more prevalent than the others. Analysis shows that significantly more of the distance swimmers have a moderate FAT risk (χ^2 (3, N=11) = 10.800, p=.013).

To deduce if there was a relationship between the sporting disciplines and the FAT, an independent chi-square test was used. Results showed that 9.5% of elite swimmers were not at risk, 14.3% showed a low risk, 52.4% had a moderate risk and lastly, 23.8% were at high risk for the FAT.

4.7 Conclusion

The results of this study shows that elite swimmers have a varied degree of risk for the FAT. Sprint swimmers were at a higher risk of developing low BMD. The overall results indicate that distance swimmers present with a greater chance of developing two or more components of the FAT. Possible reasons for this phenomenon will be further discussed in the following chapter.

CHAPTER FIVE

5 DISCUSSION

This chapter will address the greater significance of the results and further explain the implications of the study objectives.

5.1 Introduction

This chapter discusses the objectives and the results of the findings that were obtained in this study. Of particular interest are the results of the individual components for the Female Athlete Triad (FAT) in comparison between the different sample groups. Where possible, the results are related to the available literature specific to female adolescent athletes, the components for FAT and the precautions for FAT. This promotes the relevance and position of this study in a wider research context.

5.2 Anthropometrical Data

The overall anthropometric measurements in this study were within acceptable ranges. The mean body mass index (BMI) was 21.31kg.m^2. This is within the recommended category (20-25kg.m^2) for female individuals (El Ghoch, et al., 2013). The mean body fat percentage of 22.86% is considered acceptable by the American College of Sports Medicine (ACSM) (Female Athlete Triad Coalition, 2014). One would assume that this percentage is relatively high for National level athletes, however, this result would seem to be acceptable for elite female swimmers as indicated in other studies. Tuuri, Loftin, and Oescher (2002) found the average female swimmer to have a body fat percentage of 23% irrespective of age. Similarly, elite female swimmers in Rio de Janeiro, Brazil, presented with a body fat percentage of 24% (SD 6.2) (Schtscherbyna, et al., 2009). Thus the outcomes of this study coincide and are supported by the literature.

5.3 Low Energy Availability (With or Without Disordered Eating)

Energy availability was defined by Márquez and Molineroas (2013, p. 1012) as "the amount of dietary energy for all physiological functions after accounting for energy expenditure from exercise, that is, the amount of remaining energy available for other body functions after exercise training".

It has been previously established that a swimmer training at a moderate to high intensity will burn approximately 11.67 calories/minute (Rosenbloom, 2002). With elite athletes accomplishing between five-six hours of training daily, their energy availability will be greatly depleted unless correct nutritional guidelines are followed. As seen in the results from this study, majority of the total sample group were categorised as having "reduced energy availability"(<45kcal/kg). Hence, this will in turn have a negative effect on performance and as that has shown to be the case in this study, the study is in agreement with the literature.

Results significantly (p=0.005) show that the sprint participants do not consume the sufficient amount of kilocalories to achieve optimal daily living. The recommended kilocalorie intake that an elite swimmer should be consuming per day is an average of 4000-5000 kilocalories (Hossgenboom, 2009). Majority of the participants in this study were under consuming, with the total sample consuming an average of only 2746.42 kilocalories per day. A greater kilocalorie amount ensures optimal energy availability (>45kcal/kg) for prime physiological functioning as well as replenishing depleted energy balance due to excessive exercise. Concerning, sprint swimmers showed an energy availability mean of 19.79 kcal/kg, categorising their result as low energy availability (<30kcal/kg). In selected cases, low energy availability may be mistaken in athletes as disordered eating due to uncharacteristic eating traits, such as; a fear of weight gain, or incorrect views about food that may have occurred (Márquez and Molineroas, 2013). At this level of severity, the body' s menstrual function and bone formation are suspended as the body conserves energy, resulting in detrimental consequences to the reproductive and skeletal systems. This must be rectified immediately when identified.

When disordered eating is in conjunction with a high training load or over-training, there is a greater risk that the FAT will develop (Grave, 2009). This study established that even with a lower calorie intake, the participants with a high training load were the ones more at risk of the FAT components or the full FAT. As such, this study is supported by the literature. Eating disorders have negative emotional, psychological and psychosocial effects (Nazem and Ackerman, 2012). Disordered eating is defined in this study as a wide spectrum of harmful and often ineffective eating behaviours used in attempts to lose weight or achieve a lean appearance (Drinkwater, et al., 1997). The examples of disordered eating identified in this study included food restriction, frequently skipped meals, overeating, binge eating followed by purging, abuse of laxatives, and abnormal thought patterns such as fear of becoming fat and distorted body image. Within the total sample, a high majority (85%) of the participants were identified with suffering from distorted body image, while other participants turned to more severe forms of disordered eating. This distorted body image mentality could be stemmed from a series of negative self-talk, poor self-confidence, personal mental and physical break down, peer pressure or chastisement on her physique by parents or coaches. Young adolescents have been known to experience depression if physical goals are not reached (Pauli and Berga, 2010). This study is in agreement with the literature.

The Coach is the Senior Trainer and takes complete control of a swimmers annual training schedual. Coaches have been know to be trusted with giving out their athletes' daily diet plans, recovery workouts and even in charge of bed time curfuse. Parents nowadays have given complete and total control of their child over to a coach in the hope that the coach is knowlegeable on training regimens. This is very dangerous as the treatment and care of an athlete is a team responsibly and should not be the sole responsibility of a single individual. As previously stated the Team should include the parents, coach, assistant coach, sports scientist, doctors, physiotheripist and/or biokineticist. The Team needs to ensure that the athletes are not over training and are maintaining a healthy balance between athletic performance and physical health. Adequate calorie and water inatke must be monitored, as well as to ensure that there is sufficient time to fully recover between training sessions and to maintain a good and secure training environment.

The primary concern that was identified in this section was the increased dependency each participant expressed towards physical exercise as a form of maintaining a favourable physique. This was due to the old belief that a lean physique will aid their performance (Alberti, et al., 2013). It is this concept or belief that leads athletes to over-train or develop an unhealthy attachment to training. The repercussions of calorie restriction to maintain or develop a "lean" physic can cause physiological changes in the body's attempt to maintain an optimal core temperature. Some of these changes include hair loss, unwanted and excessive hair growth on the face and limbs, tooth and gum disease, and fainting. Trying to maintain a low BMI or body fat percentage by over training will cause revere harm to the body and eventually even the innteral vital organs such as the lungs, kidney's and heart (Alberti, et al. 2013).

Results show that both sporting disciplines have a moderate to high risk for developing an eating disorder. Almost two-thirds (63.6%) of the sprint swimmers were positive for an eating disorder. These results are of concern, as the risk of developing further FAT components are amplified when low energy availability is combined. On the other hand, the distance swimmers showed a 50% risk for developing disordered eating. These results are also of some concern, however, correct management and dietary supervision needs to be implemented by both the swimmer and support systems, as disordered eating can quickly change in severity.

Disordered eating has shown to have serious negative effects on athletic performance. These effects can be divided into various categories, namely, the stress of sport-specific training; type, severity, and period of eating disorders; the degree of nutrient deficiency; occurrence of co-morbid physical and psychological disorders; and the precision and quality of therapeutic interventions. The negative effects of disordered eating identified in this study were reported primarily from sport-specific training and period of disordered eating. Pre-season and in-season training were the highest reported disordered eating periods. It should be stated that no reports of anorexia nervosa or bulimia nervosa were identified in this study.

5.4 Menstrual Dysfunction

Previous research has theorised that menstrual dysfunction in female athletes is caused by an onset of menarche when the critical threshold of body fat (17% of body weight) is not reached (Berga, et al., 1989). As a result of a negative body fat threshold, the metabolic rate decreases and the sensitivity of the hypothalamus to gonadal steroids would be altered (Roupas and Georgopoulos, 2011).

Six swimmers were positive for a spectrum of menstrual dysfunction; primary amenorrhea (n=2), secondary amenorrhea (n=1) and oligmenhorria (n=3). Additionally, only one swimmer had a body fat percentage of less than 17%, while the others had an optimal or high body fat percentage. It should be taken into consideration that a higher body fat content is favourable in aquatic sporting codes due to the buoyancy effect (Schtscherbyna, et al., 2009). This study reveals results that supports the literature.

Korsten-Rech (2011, p. 156-159) explains that "in addition to regulating appetite and energy availability, leptin is known to centrally act to influence reproduction, exerting its effect over a narrow range of concentrations. Leptin concentration responds to a negative energy balance, and it seems that menstruation is not possible if leptin levels drop under a critical level." Five of the positive six swimmers for menstrual dysfunction had a combined report with low energy availability, and three swimmers reported as having a positive component combination of menstrual dysfunction, low energy availability, and disordered eating. Thus, menstrual dysfunction is not caused by stress or a low proportion of body fat, but results from the disruption of the Gonadotropin-Releasing Hormone (GnRH) pulse generator as a consequence of low energy availability. With high component amalgamations such as these, swimmers must be aware of developing cognitive dysfunction and psychiatric morbidity (depression) (Roupas and, Georgopoulos, 2011). This negative condition will limit or hinder the athletes' athletic performance and finally, their health.

Drug or hormone supplementation is a method of treatment for menstrual dysfunction. This could help restore irregular menstruation and improve bone mineral density (BMD). For example, oral contraceptives containing oestrogen and progestin, transdermal oestrogen, or

lepton, could aid as a remedy (Laughlin, Domingues, and Yen, 1998). However, further research needs to be conducted to confirm whether these supplements could be utilised as part treatment for athletes presenting with or at risk for the FAT.

5.5 Low Bone Mineral Density

The last component of the FAT is low BMD. This condition when identified in female athletes, warrants concern, as damaging skeletal effects may take place; such as premature bone loss and bone formation decline, microarchitecture deterioration, increased skeletal fragility, and increased risk of stress fractures (Gibbs, De Souza and Williams, 2012). It has been reported that physical exercise has a positive effect on bone build up and architecture, and athletic individuals may have a higher BMD than non-athletic individuals (Mallinson and De Souza, 2014). As swimmers participate primarily in non-weight bearing activity, in theory, swimmers should be more susceptible to low BMD. The findings in this study show that the risk for low BMD is more prevalent in sprint swimmers compared to distance swimmers. Collectively, the sprint sample (90.9%) showed to have a high risk for low BMD. These athletes have a strict and regimented training programme and do all of their training in the water. This would greatly influence their skeletal structure, as aquatic training holds zero resistive (weight-bearing) force on the athletes' skeletal systems. However, if the athlete has been reported with suffering from a previous menstrual dysfunction or low energy availability, there is a higher risk that low BMD will develop (Gibbs, De Souza and Williams, 2012).

Amenorrheic athletes have been reported as having a lower BMD than their eumenorrheic equivalents (Márquez and Molinero, 2013). This study identified that from the six swimmers that were positive for a menstrual dysfunction risk, all those swimmers were identified with a low BMD risk as well. Therefore, elements contributing to menstrual dysfunction can predispose swimmers at risk for compromised bone health and for the development of abnormally low BMD (osteopenia) and osteoporosis.

In addition to a lower quantity of hormone concentration, the other components of FAT will either reduce or sustain the lower bone mass. For example, the result of low energy

availability will cause inadequate intake of micronutrients (amino acids, fatty acids, minerals and vitamins), an impairment of bone formation and have a negative effect on other hormones such as cortisol and leptin (Nazem and Ackerman, 2012). Only one swimmer in this study reported a stress fracture in the last three months, however, it is noted that swimmers suffering from menstrual dysfunctions are particularly at risk for stress fractures.

Swimmers should be informed that even when treatment for menstrual dysfunction is underwent, there has been no confirmed study stating that lost BMD can be fully regained (De Souza, et al., 2013). Adolescent swimmers are especially at risk as peak bone mass is reached by the third decade of life (Sundgot-Borgen and Torstveit, 2004).

5.6 Female Athlete Triad Risk

The FAT had been identified in a wide spectrum of sporting codes. Research suggests that 1-3% of female athletes meet the three criteria for FAT, and sports in which body contour-revealing clothing is worn for competition (swimming, diving, gymnastics, jockeys, ballet), are some of the most prone (Gomez-Bruton, et al., 2013). A study among Brazilian swimmers reported that 44% of the swimmers met the FAT criteria for disordered eating, and had an overall FAT report of 1.34% of all three components (Schtscherbyna, et al., 2009).

Although one of the components of the FAT may be identified in a significant number of female athletes, only a few actually suffer from all three components of the FAT (Korsten-Rech, 2011). However, within the FAT, all the components are inter-connected and have an effect on the other. When more than one component is identified in a female athlete, the athlete has a greater risk for developing the complete FAT (Drinkwater, et al., 1997). In this study, the aim was to assess from these three interrelated components whether the FAT is a risk in elite sprint and distance swimmers. The total FAT was correlated by risk severity.

This study identified that the sprint swimmers presented with a wide spectrum of the FAT with four swimmers (34.6%) positive for the risk for the FAT. These results suggest that elite sprint swimmers do not have a high risk for the FAT, however, they are at risk for the

individual FAT components. This is concerning, as majority of this sample were adolescents. The distance swimmers reported a 70% moderate risk for the FAT, with only one swimmer at for risk for the FAT. Even though the sporting disciplines marginally differ in training load, frequency, and intensities, results show that distance swimmers are more at risk to the FAT as compared to sprint swimmers**.**

The total evaluation for the FAT suggests that elite sprint and distance swimmers have a risk for the individual interconnected components of the FAT. However, no significant relationship between sprint and distance swimming was found with being at the risk for the FAT.

Treatment and preventive aspects for the FAT are crucial, and must incorporate the entire support team (De Souza, et al., 2013). Athletes, parents and coaches should be educated about what FAT is, how to recognize signs, steps for prevention, before this condition causes irreversible health problems (Miller, et al., 2012). Health team members must pinpoint conditions that may have contributed to the symptoms, and try to address these issues. The ACSM recommends that screening of the athletes for low energy availability, disordered eating, amenorrhea and other forms of menstrual dysfunction, history of stress fractures, training intensity, and lifestyle behaviours, are essential for prevention of the FAT (Morgenthal, 2002). The screening process must begin with a detailed history report, including aspects regarding diet and eating behaviours, menstrual history, physical activity, and injuries. Athletes with a history suggesting one or more components of the FAT should have a physical examination, being aware for signs and symptoms or an eating disorder. All swimmers in this study who tested positive for a FAT component risk were referred to the correct physician corresponding to their individual reports.

CHAPTER SIX

6 CONCLUSION

This final chapter will provide information on the conclusion based on this study's results and thus this research study as a whole.

6.1 Introduction

The aim of this study was to determine the risk stratification of each Female Athlete Triad (FAT) component (low energy availability, with or without eating disorders; menstrual dysfunction and low bone mineral density); and the complete FAT in elite sprint and distance swimmers.
5. To compare the risk stratification for the FAT between elite sprint and distance swimmers.

The results of this study showed that there was a significant difference (p=0.005) in energy availability, with majority of the sprint swimmers being at risk for reduced energy availability. However, there was no significant differences in the risk for disordered eating among either sprint or distance swimmers. Additionally, no significant risk for menstrual dysfunction for either discipline was found.

Furthermore, sprint swimmers were more at risk (p=0.012) for low bone mineral density than distance swimmers. To explain the reasoning for this occurance further research in this specific area would need to be conducted. With the correct educational programmes and awareness campaigns, young KwaZulu-Natal female athletes will be able to make the educated decisions, have the positive aesthetic outlook, and acquire physiological health knowledge of that expected of elite athletes.

This study succeeded in identifying problem areas in KwaZulu-Natal female swimmers. These included the insufficient daily dietary consumption that majority of the participants revealed. This will result in detrimental effects to the physical and psychological manners of the

swimmers, as well as their athletic performances in their sport and in competition. With the high training load that the participants were undertaking during the peak season of the sport and the pressure for victory, the participants' revealed unhealthy psychological behaviours and beliefs towards their bodies. With that false mind set, harmful actions such a practising purge and binging of food or total restriction of calories in the hopes to lose weight and decrease resistance in the water was identified. This study also succeeded as an educational tool for FAT awareness and treatment. This benefited the participants, as well as parents, coaches and the KwaZulu-Natal Swimming Federation.

The researcher would recommend that additional research should be conducted on the FAT and aquatic athletes as this is a relevant topic that needs constant research. Furthermore, educational programmes should be put into place to educate athletes of all ages and of all aquatic sports, parents, coaching personal and federations on the cause and treatment of the FAT.

Based on the study results, the hypothesis is rejected and the null hypothesis is accepted; there is a low risk stratification of FAT among sprint swimmers and there is a low risk stratification for the FAT among distance swimmers.

In conclusion, elite swimmers are not at risk for the FAT, however, there is a moderate risk for distance swimmers to obtain one or more of the interconnected components of FAT.

6.2 Conflict of Interest

The Author declares no conflict of interest.

6.3 Limitations and Strengths

The major limitation to this study was the limited sample size. The sample size was relatively small and these results will need confirmation in a larger sample. Even though swimming is one of KwaZulu-Natal's most popular competitive sports, it is male dominant. An added limitation was the stringent inclusion/exclusion criteria, specifically that swimmers must be categorised as an elite athlete. This limited the sample size further.

Due to the hormonal nature of the contraceptive pill, participants that reported positive use for hormonal supplementation were allocated a negative report for menstrual dysfunction, however, were still eligible to complete the testing procedures for the other individual FAT components.

As most of the participants were 18 years old and under, the study was limited by time constraints as the participants' academic responsibilities were their priority.

A strength of this study was that testing was conducted during the peak competition season, thus the participants were in their most intense training sessions.

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APPENDICES

Appendix A: Gate-Keeper: KwaZulu-Natal Health Department

GATE KEEPER LETTER

Address:

Discipline of Biokinetics, Exercise
And Leisure Sciences
Westville Campus
Durban

Project Title:

Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers

Dear Sir/Madam.

I am a Post Graduate student studying Exercise Science at the University of KwaZulu-Natal and as part of my studies I am required to conduct a research project. I have identified a need for research into **Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers.** I am writing to request permission to allow ethical clearance to conduct research at King Edward VIII Hospital. I have prepared a full description of the study and what is involved in it for potential participants. I would like to begin DEXA Scan data collection by August 2014 as this is post competition season in the Provincial and National Aquatic calendar.

I wish to have the research conducted on the King Edward VIII Hospital and Nelson Mandela Medical School's premises as this would be more convenient for all parties. I anticipate that we would require two sessions that will not take more than three hours in total to collect the necessary information. The participants would need to: complete five valid questionnaires and a demographic information sheet that will provide information on their current female physiological health status (Energy availability,

Eating Habits, Body Image, Menstrual Function and Bone Mineral Density); anthropometric measurements will be taken and recorded (height and weight). Participants will also be required to complete an online dietary recall of the previous day's intake, a urinary pregnancy test and a DEXA scan analysis of the spinal region or femoral hip joint for osteoporosis risk. This will be used to determine bone mineral density and the total percentage of muscle mass and fat mass. This will be conducted at King Edward Hospital in Durban.

The results will remain confidential at all times.

Results of the project will be circulated to KwaZulu-Natal Aquatics, Convenor of each Sporting Discipline affiliated to KwaZulu-Natal Aquatics and each Participant on completion of the project. The Participants names will be kept confidential.

I hope that you find the project of interest and will be interested in working with us on it.

Please feel free to contact us if you have any queries. Alternatively, you may wish to contact my supervisors, if you would like a reference or other information.

Many thanks for taking the time to read this and we hope to hear from you soon.

Yours faithfully

Ashleigh De Freitas (researcher)
Telephone Number- 0846579137
Email: ash_defreitas@yahoo.com

Dr Rowena Naidoo (Supervisor)
Email: naidoor3@ukzn.ac.za

Appendix B: Gate-Keeper: KwaZulu-Natal Aquati

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

GATE KEEPER LETTER

Address:
Office 24-Kings Park Pool Complex
MasabalalaYengwa Ave
Durban
4025

Discipline of Biokinetics, Exercise and Leisure Sciences
Westville Campus
Durban

Project Title:

Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers

Dear Mr. Peter Thomson

I am a Post Graduate student studying Exercise Science at the University of KwaZulu-Natal and as part of my studies I am required to conduct a research project. I have identified a need for research into **Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers.** I am writing to request permission from KwaZulu-Natal Aquatics to allow the KZN swimmers to participate in this study.

I have prepared a full description of the study and what is involved in it for potential participants. Attached is a copy of the proposed study. I would like to begin data collection by August 2014 as this is post competition season in the Provincial and National Aquatic calendar but I am very happy to be guided by you on this.

I would be conducting the study at the Kings Edward VIII Hospital and Nelson Mandela Medical School's premises as this would be more convenient for all parties. I anticipate that it would require at least one session that will not take more than three hours in total to collect the necessary information.

The participants would need to: complete five valid questionnaires and a demographic information sheet that will provide information on their current female physiological health status (Energy

availability, Eating Habits, Body Image, Menstrual Function and Bone Mineral Density); anthropometric measurements will be taken and recorded (height and weight). Participants will also be required to complete an online dietary recall of the previous days dietary intake, perform a urinary pregnancy test and undergo a DEXA scan analysis of the spinal region or femoral for osteoporosis risk. This will be conducted at King Edward VIII Hospital in Durban.

There has yet to be a completed study on the FAT in South Africa and very few conducted worldwide. There is only one other published study, which was conducted in Brazil, that looks at FAT in swimmers. This study will aim to fill the gap in the literature and aid in educating the athletes, coaches, parents and aquatic federations to the detection, treatment and prevention of the female athlete triad.

The results will remain confidential at all times. Additionally, results of the project will be circulated to KwaZulu-Natal Aquatics, the Convenor of the Sporting Discipline affiliated to the respective KwaZulu-Natal Affiliations and each Participant on completion of the project. The Participants names will be kept confidential.

I hope that you find the attached project of interest and will be interested in working with me on it. Please feel free to contact me if you have any queries. Alternatively, you may wish to contact my supervisors, if you would like a reference or other information.

Many thanks for taking the time to read this and I hope to hear from you soon.

Yours faithfully

Ashleigh de Freitas (researcher)
Telephone Number- 0846579137
Email: ash_defreitas@yahoo.com

Dr Rowena Naidoo (Supervisor)
Email: naidoor3@ukzn.ac.za

Appendix C: Gate-Keeper Reply: KwaZulu-Natal Aquatics (KZNA)

Dear Ms. De Freitas,

KZN Aquatics have reviewed your proposal, and we are happy for you to approach the swimmers who are registered with our Association. Please note, that all due ethical guidelines must be adhered to. Individuals must provide you with written, informed consent prior to your commencement of the study, and should they wish to withdraw from the study after providing consent, they must be at liberty to do so. All medical or clinical assessments conducted on these athletes must be made available in a confidential manner to these athletes, and should you detect any abnormalities arising from these assessments, they will need to be provided with guidelines on how to address these with the health practitioner of their choice

We wish you everything of the best with your study, and should you require any further assistance, please do not hesitate to contact us. We look forward to receiving a report on your study on its completion

Yours sincerely

Prof Rajen Naidoo
KZN Aquatics
General Secretary

Appendix D: Convener of each Sporting Discipline

GATE KEEPER LETTER

Address:
Office 24-Kings Park Pool Complex
MasabalalaYengwa Ave
Durban
4025

Discipline of Biokinetics, Exercise and Leisure Sciences
Westville Campus
Durban

Project Title:

Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers

Dear Sir / Madam

I am a Post Graduate student studying Exercise Science at the University of KwaZulu-Natal and as part of my studies I am required to conduct a research project. I have identified a need for research into **Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers.** I am writing to request your support in allowing your athletes to participate in the study. I have prepared a full description of the study and what is involved in it for potential participants. Attached is a copy of the proposed study. I would like to begin data collection by earliest August 2014 as this is post competition season in the Provincial and National Aquatic calendar. Thus this will aid greatly to the results.

I will be conducting the study the Kings Edward VIII Hospital and Nelson Mandela Medical School's premises as this would be more convenient for all parties. I anticipate that it would require at least one session that will not take more than three hours in total to collect the necessary information.

The participants would need to: complete five valid questionnaires and a demographic information sheet that will provide information on their current female physiological health status (Energy availability, Eating Habits, Body Image, Menstrual Function and Bone Mineral Density);

anthropometric measurements will be taken and recorded (height and weight). Participants will also be required to complete an online dietary recall of the previous days dietary intake, a urinary pregnancy test and a DEXA scan analysis of the spinal region or femoral for osteoporosis risk. This will be conducted at King Edward VIII Hospital in Durban. I will endeavour to keep the disruption to your working day to an absolute minimum.

The results will remain confidential at all times, additionally, the results of the project will be circulated to KwaZulu-Natal Aquatics, the Convenor of the Sporting Discipline affiliated to the respective KwaZulu-Natal Affiliations and each Participant on completion of the project. The Participants names will be kept confidential.

There has yet to be a completed study on the FAT in South Africa and very few conducted worldwide. There is only one other published study, which was conducted in Brazil, that looks at FAT in swimmers. This study will aim to fill the gap in the literature and aid in educating the athletes, coaches, parents and aquatic federations to the detection, treatment and prevention of the female athlete triad. This study will be the first of its kind in South Africa. All the participants that volunteer will remain anonymous through-out the study. The participants will receive all the physical testing at no expense to them. The benefits of the study include free physical and behavioural tests that will be covered by the researcher and King Edward VIII Hospital and the results will be returned to each participant and coach after completion of the study as well as compensation for travel expenses to and from King Edward VIII Hospital.

I hope that you find the attached project of interest and will be interested in working with me on it. Please feel free to contact me if you have any queries. Alternatively, you may wish to contact my supervisors, if you would like a reference or other information.

Many thanks for taking the time to read this and I hope to hear from you soon.

Yours faithfully

Ashleigh de Freitas (researcher)
Telephone Number- 0846579137
Email: ash_defreitas@yahoo.com

Dr Rowena Naidoo (Supervisor)
Email: naidoor3@ukzn.ac.za

Appendix E: FAT Information Pamphlet

The Female Athlete Triad

Sport is a great way for girls and women to build strong, healthy bodies, self-esteem and a life-long love of physical activity. However, some female athletes participate in sport in a way that is Less than optimal for their health and well-being. The Female Athlete Triad is a serious health concern that has been identified among athletes, particularly girls and women in competitive sport.

THE FEMALE ATHLETE TRIAD COALITION

What is the Female Athlete Triad?

The Female Athlete Triad (Triad) refers to three health problems that are linked to each other: Low energy availability or energy deficiency ("under-fueling"), menstrual problems, and weak bones. Menstrual problems include irregular or missed periods. Bone problems can include stress fractures and reduced bone density for your age. These health problems, especially when they occur at the same time, require prompt medical attention. Having just one part of the Triad is enough, however, for any girl or woman who wants to stay active to seek help. Luckily, the key to avoiding menstrual problems and building strong bones is simple – eat enough calories to fuel your body during exercise and at rest.

Under-fueling (low energy availability)

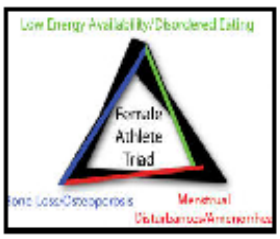
Energy availability is defined as the amount of energy from food (calories eaten) that is available for your body *after* exercise (calories expended). Active girls and women who routinely expend more calories than they take in will end up in an energy (caloric) deficit. If this energy deficit is too large, your body will have too few calories or too little energy left over to maintain other normal functions, like having a menstrual period every month or developing healthy bones.

Sometimes, female athletes slip into this under-fueled state. They simply don't realize how much energy they expend during workouts and they don't eat enough to maintain a healthy weight. In other cases, athletes and physically active girls and women try to lose too much weight or lose it too quickly in order to look or perform better. They under-eat by skipping meals, avoiding all foods that contain fat or they eliminate lots of foods without making healthy substitutions. Some athletes use too much exercise relative to their caloric intake in order to lose weight quickly which can create an excessive energy deficit.

In the short-term, low energy availability or energy deficiency makes it hard to perform at your best. When you are dehydrated and low on fuel, this means you have less power, muscle strength and stamina. You will not get the benefit of improved performance from your workouts, and in fact, your performance may even get worse. You'll tire more quickly, get sick more easily and you'll recover less quickly. Girls and women who try one diet after another or who lose too much weight (or lose it too quickly) can also be slowed down by other serious problems, like iron-deficiency anemia, menstrual problems and stress fractures.

Irregular or missed periods

Low energy availability or energy deficiency disrupts the reproductive system in otherwise healthy active girls and women. The result is irregular or less frequent menstrual cycles (oligomenorrhea). Even more worrisome is when three (or more) menstrual cycles in a row are missed (amenorrhea). Eating too few calories can also delay the onset of menstruation, so that a young woman does not begin having periods by age 15. When periods are less frequent or missed, the body makes less estrogen. Estrogen is a hormone that is absolutely necessary for building strong bones. Any menstrual irregularities must be diagnosed by a physician in order for proper care to be provided.



Stress fractures and other bone problems

Because of changes in hormones that are associated with decreased energy availability or energy deficiency, your body is not able to replace old bone cells with new healthy cells. During this time, you are at risk for poor bone health. The situation is even more alarming for physically active girls with irregular periods during their peak bone-building years (puberty to age 20). Despite the positive bone-building effects of exercise, these girls actually fail to build all the bone that is expected. It remains unclear whether this "lower-than-expected" or overall decrease in bone mass is permanent or if full "catch-up" is possible once menstruation begins.

Losing bone mass or bone density faster than you should sets the stage for stress fractures and the early onset of osteoporosis (weak bones that break easily). Bone loss is made worse by energy deficiency and under-fueling and getting too little of important nutrients like calcium and vitamin D.

Appendix F: ASA24 dietary Recall Information

ASA24™
ASA24 Automated Self-administered 24-hour Recall

What is ASA24?

The Automated Self-administered 24-hour Recall (ASA24) is a free internet tool that allows for 24 hour diet recalls. It consists of a Respondent Web site that is used to collect diet recall information. This allows for a report of the previous days dietary intake from midnight to midnight (24 hours) and a Researcher Web site that is used to control the study logistics and store data analyses. There are two Respondent Web sites available: ASA24-2011(available in English and Spanish) andASA24-Kids-2012 (English).

Why choose ASA24?

ASA24 has a renowned reputation as being one of the most appropriate forms of research methodology to measure food intake for dietary examination, nutritional epidemiology, clinical research and intervention research as it supplies the highest quality and none prejudiced dietary data over a 24 hour period. With this methodology it is a simple system of collecting dietary intake and portion sizes and due to the collection phase occurring the following day, it does not hold any influence over the participant's dietary choices.
Due to the recall being a direct follow up this minimized memory and cognitive loss.
The design of ASA24is based on an adapted version of the interviewer-administered Automated Multiple Pass Method (AMPM) developed by the U.S. Department of Agriculture (USDA).

The Participants Application:

The participant's application provides the following:

- An animated guide with instructions to participants
- Requires participants to report their eating event and time of Consumption
- Includes modules with questions on where meals were eaten, who the Participant ate with, television or computer use during meals, etc.
- Requires participants to provide a meal-based "quick list" and drinks consumed the previous day
- Participants are able to find food and drink items by browsing the different food groups or by searching from a list of food terms

- Instructions guide the participants through a list of thorough questions on food preparations and additions to assign food codes from USDA's Food and Nutrient Database for Dietary Studies (FNDDS)
- Provides images to help respondents in reporting portion size
- Participants can add or change food and drink choices several times during the interview
- Includes a final review of the day's dietary intake

- Provides a module to questions on dietary supplement consumption based on supplements reported in the 2007 -2008 National Health and Nutrition Examination Survey (NHANES)
- Available in English and Spanish
- Accessible to individuals with speech and hearing impairments

Interview Process Steps:

1. Meal-based quick list;
2. Meal gap review;
3. Detail pass;
4. Forgotten foods;
5. Final review;
6. Question about whether the day's intake was usual or not; and
7. Supplement module (if selected by the researcher).

http://riskfactor.cancer.gov/tools/instruments/asa24/

Please see the above web site for further information,

ASA24 Automated Self-administered 24hourrecall (2013). *Risk Factor Monitoring and Methods.* [Online] Available from: http://riskfactor.cancer.gov/tools/instruments/asa24/ [21/03/

Appendix G: Parent/Guardian & Participant Information Sheet & Consent Forms

Parent/Guardian and Participant Information Sheet and Consent Form

Project Title:

Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers

RE: Permission to test the female participants for the risk stratification of the Female Athlete Triad.

Dear Participant / Parent / Guardian

Thank you for showing an interest in this project. Please read this information sheet before you and your child decide whether or not to participate. If you decide to participate I thank you. If you decide not to take part there will be no disadvantage to you or your child of any kind and I thank you for considering my request.

The project is being undertaken as the requirement for a Master's degree in the discipline of Biokinetics, Exercise and Leisure Sciences at the University of KwaZulu-Natal.

The purpose of the study is to identify the risk stratification of the Female Athlete Triad (FAT) in elite swimmers, which participated at the 2014 and 2015 South African National Competitions.

You are invited to attend a power point presentation that I, the researcher, will present for all those interested in participating to better inform you and your child on the female athlete triad and the benefits of the study as well as provide an opportunity to answer any questions you

may have. Attached is an information package on the FAT and the equipment that will be used in the study for your reading pleasure.

Elite female swimmers will take part in this study.

Should you agree or should you allow your child to take part in this project, you will be asked to participate in a one day testing period that will be conducted by the researcher, thus you will be in safe hands.

Participants will enter their name on the Confidential Subject Classification Sheet and be assigned a subject number. Numbers will be assigned in chronological order and will be recorded on all data pages. Each participant will be asked to complete a series of valid questionnaires to provide information on energy availability, eating habits, body image perception, menstrual status and time spent in exercise and low bone mineral density. The procedure will take place at The Medical Centre at King's Park. They will be seated and asked to complete five questionnaires; Eating Attitudes Test (EAT-26), Body Shape Questionnaire, Bulimic Investigatory Test, Edinburgh (BITE), a Menstrual Cycle and Time spent in Exercise Questionnaire and a Self-Administered Bone Mineral Density questionnaire. Then participants will fill out a demographic information sheet and record anthropometric measurements taken by the researcher. These include height and weight measurements, skin folds and a bioelectrical impedance analysis. Once all information is completed data will be collected by the researcher and filed in chronological order. The participants will then complete an online dietary recall.

The testing day should take approximately two hours in total.

There are no risks in this study. The researcher will be present during all physical testing sessions.

The benefits of this study include a greater knowledge base gained by participants, parents, coaches and management about the risks, treatments and prevention for symptoms of the female athlete triad.

You and your child may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

Your child will be allocated a number in chronological order to ensure that confidentiality and anonymity is maintained throughout the study.

Results of this project may be published but any data included will in no way be linked to your child. The data collected will be securely stored in such a way that only the researcher will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as in accordance with the University's research policy. Raw data on which the results of the project depend will be retained in a secure storage place for five years, after which will be destroyed by incineration.
All participants that agree to volunteer to participate in the study will be compensated with travel expenses to and from the testing venue at The Medical Centre at King's Park. This study has been ethically reviewed and approved by the UKZN Biomedical research Ethics Committee (approval number BE284/14).

In the event of any problems or concerns/questions you may contact the researcher or the UKZN Biomedical Research Ethics Committee, contact details as follows:

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus
Govan Mbeki Building
PrivateBagX54001
Durban
4000

KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za

If you have any questions about the project, either now or in the future, please feel free to contact the researcher or the supervisor.

Ashleigh De Freitas (Researcher)
Telephone Number- 0846579137
Email: ash_defreitas@yahoo.com

Dr Rowena Naidoo (Supervisor)
Email: naidoor3@ukzn.ac.za

CONSENT FORM:

I, have been informed about the study entitled "Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers"
By Ashleigh de Freitas.

I understand the purpose and procedures of the study and that my participation in the project is entirely voluntary;

- I am free to withdraw from the project at any time without any disadvantage; the data will be kept in a safe place then destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed.
- I will be informed if results show that my health is at serious risk and will be asked to see my physician.
    - I am aware that there is a no risk
    - If I agree to participate in this study, I will be compensated with travel expenses to and from the testing venue at the Medical Centre at King's Park.
    - The results of the project may be published but my anonymity will be preserved

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I have been informed about any available compensation or medical treatment if injury occurs to me as a result of study-related procedures.

If I have any questions or concerns about my rights as a study participant or if I am concerned about an aspect of the study or the researchers or in the event of any problems or concerns/questions you may contact the researcher or the UKZN Biomedical Research Ethics Committee, contact details as follows

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
PrivateBagX54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za

Ashleigh De Freitas (researcher)
Telephone Number- 0846579137
Email: ash_defreitas@yahoo.com

Dr Rowena Naidoo (Supervisor)
Email: naidoor3@ukzn.ac.za

_____ _____

Signature of Participant **Date**

_____ _____

Signature of Witness **Date**

_____ _____

Signature of Parent / Guardian **Date**

Appendix H: FAT Flyer

FEMALE SWIMMERS NEEDED!!!

Recruiting: Female KZN swimmers to participate in UKZN 2015 Masters Research Project.

Criteria:

- Female Sprint and Distance Swimmers
- Swimmers that are affiliated with KwaZulu-Natal Aquatics (KZNA)
- Swimmers that competed at the 2014\2015 South African Nationals

Research Topic:

Female Athlete Triad Risk Stratification in KwaZulu-Natal Elite Sprint and Distance Swimmers

Background

The Female Athlete Triad (FAT) is a syndrome that poses a serious threat to the health status of physically active females. The three components are disordered eating, amenorrhea (absence of menstrual periods) and osteoporosis (low bone mineral density)
The purpose of this study is to examine the prevalence of the FAT among elite female swimmers in KwaZulu-Natal.

This will be the first study that tests **swimmers** for the Female Athlete Triad in South Africa!

BENEFITS:

- **Only requires 2 hours of your time!**
- Free physical screening
- Petrol compensation to and from the testing grounds
- Results will be given back to each swimmer, parent, coach and sporting federation
- Results may aid performance

Join us at Prime Human Performance Centre on the 26Th July at 9am for a presentation to explain the study and answer any questions!

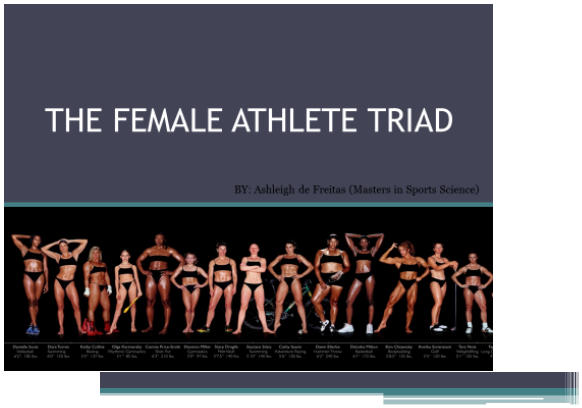
Please contact us if you are interested in attending.

Be a part of ground breaking research for South African Swimmers!

Contact details:
Ashleigh De Freitas (Researcher)
Cell Number- 0846579137
Email: ash_defreitas@yahoo.com

Dr Rowena Naidoo (Supervisor)
Email: naidoor3@ukzn.ac.za

Appendix I: FAT Presentation



WELCOME
Swimmers, Parents, Coaches and Friends!!!

History of FAT

1992
First identified

1997
The ACSM established the first **FAT** Position Stand:
Eating Disorders, Amenorrhea & Osteoporosis

2007
ACSM updated the **FAT** position stand:
Low Energy Availability(with or without disordered eating),
Functional hypothalamic Amenorrhea and Osteoporosis

What is The FAT?????

Three interconnected health problems:

- Low energy availability (not eating enough)
- Menstrual problems (irregular or missed periods)
- Weak bones (Stress fractures or low bone density)

https://www.youtube.com/watch?v=a7erGI_weAE

Low Energy Availability

- Definition: the amount of energy from food (calories eaten) that is available for your body after exercise (calories expended)

Active girls and women who routinely expend more calories than they take in will end up in an energy (caloric) deficit

Disordered Eating

- Definition: A wide spectrum of harmful and often ineffective eating behaviours used in attempts to lose weight or achieve a lean appearance
- Examples:

Food restriction
Fasting
Frequently skipped meals
Overeating
Binge eating followed by purging
Ingesting diet pills
Laxatives
Diuretic or enemas
Abnormal thought patterns such as fear of becoming fat, distorted body image and preoccupation with food

Disordered Eating

Types:

- Anorexia Nervosa (refusing to eat)
- Bulimia Nervosa (extreme overeating followed by self-induced vomiting or purging)
- Eating Disorders Not Otherwise Specified (binge eating and purging)

Menstrual Problems

- Low energy availability or energy deficiency disrupts the reproductive system in otherwise healthy active girls and women. The result is irregular or less frequent menstrual cycles
- Types:
  - **Primary Amenorrhea**: Absence of menstruation by age15 in a girl with secondary sex characteristics
  - **Secondary Amenorrhea:** absence of three or more consecutive menstrual cycles
  - **Oligomenorrhea:** menstrual cycles are greater than 35days in length or 4 to 9 menstrual periods per year

Menstrual Problems

Menstrual problems can result in:

- Endocrine abnormalities (reduces estrogens, progesterone and thyroid hormones)
- Premature loss of Bone mineral density
- Greater risk for stress fractures
- Damage to soft tissue
- Inhibition of immune function

Bone Problems

- Definition: a disease characterized by low bone mass leading to enhanced skeletal fragility and increased risk of fracture

Despite the positive bone-building effects of exercise, these girls actually fail to build all the bone that is necessary

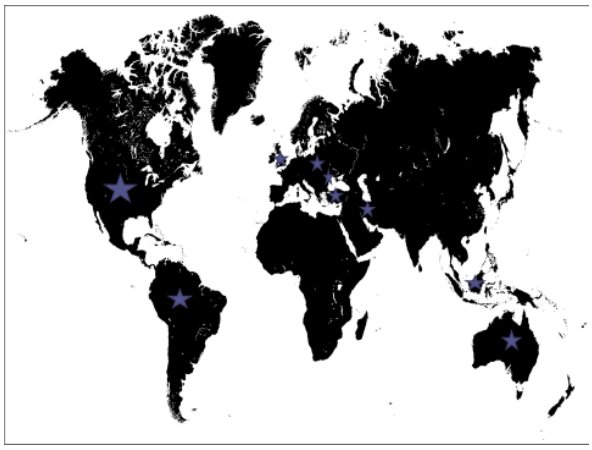
Losing bone mass or bone density faster than you should sets the stage for stress fractures and the early onset of osteoporosis (weak bones that break easily)

Bone loss is made worse by energy deficiency and under-fueling and getting too little of the important nutrients like calcium and vitamin D

FAT Signs....

Any thoughts, beliefs or behaviours that lead to low energy availability or energy deficiency might be considered a risk factor for developing FAT

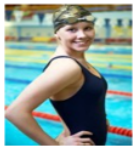
- Signs:



The Research Study

Title:

The Risk Stratification of the Female Athlete Triad in KwaZulu-Natal Elite Sprint and Distance Swimmers


Participants

Target Population:

Elite KZN swimmers that competed at the 2014 and/or 2015 South African Nationals.

approx. 39 athletes

Inclusion Criteria:

- Female Athletes.
- Athletes that are affiliated with KwaZulu-Natal Aquatics (KZNA)
- Athletes that competed at the 2014 South African Nationals

Exclusion Criteria:

- Male Athletes
- Non aquatic athletes
- Athletes not affiliated to KZNA
- Athletes who are pregnant
- Athletes who did not compete at South African Nationals 2014
- Athletes who have been diagnosed with a thyroid dysfunction
- Athletes that take bone growth Supplementation

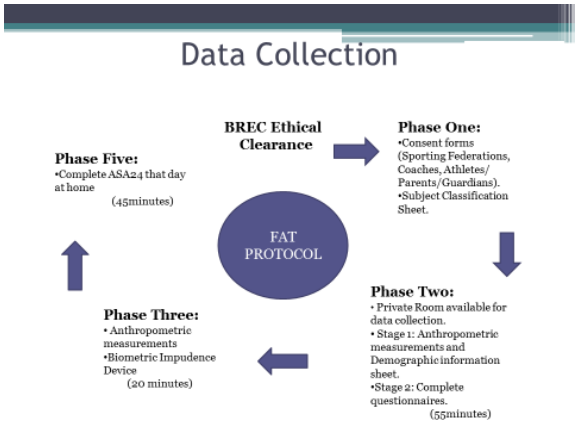
Research Objectives

- To examine the risk stratification of disordered eating in eite sprint swimmers
- To examine the risk stratification of low energy availability in elite sprint swimmers
- To examine the risk stratification of menstrual dysfunction in elite sprint swimmers
- To examine the risk stratification of osteoporosis in elite swimmers
- To deduce from these four objectives whether the risk stratification FAT is evident in elite sprint swimmers

Research Objectives

- To examine the risk stratification of disordered eating in elite distance swimmers
- To examine the risk stratification of low energy availability in elite distance swimmers
- To examine the risk stratification of menstrual dysfunction in elite distance swimmers
- To examine the risk stratification of osteoporosis in distance elite swimmers
- To deduce from these four objectives whether the risk stratification of FAT is evident in elite distance swimmers
- To compare the degree of risk stratification of the FAT between elite sprint and elite distance swimmers


Equipment
Demographic information sheet
Skinfold Callipers
1. Eating Attitudes Test (EAT26)
2. Body Shape Questionnaire (BSQ-34)
3. Bulimic Investigatory Test, Edinburgh (BITE)
4. Menstrual Cycle and Time spent in Exercise Questionnaire
5. Dual Energy X-ray Absorptiometry (DEXA) Scan Questionnaire
ASA24 Dietary Recall
Self Administered Bone Mineral Density Questionnaire
Biometric Impudence Device


Data Collection
BREC Ethical Clearance
Phase One:
•Consent forms (Sporting Federations, Coaches, Athletes/ Parents/Guardians).
•Subject Classification Sheet.
Phase Two:
• Private Room available for data collection.
• Stage 1: Anthropometric measurements and Demographic information sheet.
•Stage 2: Complete questionnaires.
(55minutes)
Phase Three:
• Anthropometric measurements
•Biometric Impudence Device
(20 minutes)
Phase Five:
•Complete ASA24 that day at home
(45minutes)
FAT PROTOCOL

Risks and Benefits

- Risks:

No risks in this study!!

- Benefits:
  - Free physical screening
  - Petrol compensation to and from the testing venue
  - Individual results will be given back to each participant, parent, coach and sporting federation.
  - Results may aid in performance

Ethics

- Each participant will have full anonymity through-out the study
- You are free to pull out of the study at any time with no disadvantage to you
- The data will be kept in a secure place and then destroyed on completion of study
- The results of the study may be published but your anonymity will be preserved

Appendix J: Confidential Subject Classification Sheet

Confidential Subject Classification Sheet

Allocated Subject Number	Name, Surname	Contact Number	Email Address	Sprint/ Distance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Demographic Information Sheet

Participant Information:

Participant Number: _____
Gender: _____
Date of Birth: _____
Please tick the appropriate Box:

- Have you had any previous broken/fractured bones? Yes No
- Have you been diagnosed with a thyroid dysfunction? Yes No
- Are you pregnant? Yes No
- Do you take any form of hormone replacements (contraceptive pill, hormone replacement)? Yes No
- Do you take any form of supplementation? Yes No

  If yes, please state them:
  _____
  _____
  ____

Sport Discipline Information:

My Sport is: _____

- I Competed at South African Nationals 2014/2015 representing KwaZulu-Natal

  Yes

  No

(Official Use Only)

Anthropometric Measurements:

- Height: m BMI: $Kg.m^2$
- Weight: kg
- Skin Fold Sites:

Triceps	mm
Biceps	mm
Subscapular	mm
Suprailiac	mm
Abdominal	mm
Quadriceps	mm

Sum of Skinfolds:
mm

- Bioelectrical Impedance Analysis:

Fat Free Mass: mm

Fat Mass: mm

Appendix L: Eating Attitudes test (EAT-26) Questionnaire

Eating Attitudes Test (EAT-26)

Age: _____ Current Weight: _____ Highest weight (excluding pregnancy): _____
Sex: _____
Height: _____ Lowest Adult Weight: _____ Ideal Weight: _____

✓	Please choose one response by marking a check to the right for each of the following statements:	Always	Usually	Often	Some times	Rarely	Never	Score
1.	Am terrified about being overweight.							
2.	Avoid eating when I am hungry.							
3.	Find myself preoccupied with food.							
4.	Have gone on eating binges where I feel that I may not be able to stop.							
5.	Cut my food into small pieces.							
6.	Aware of the calorie content of foods that I eat.							
7.	Particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.)							
8.	Feel that others would prefer if I ate more.							
9.	Vomit after I have eaten.							
10.	Feel extremely guilty after eating.							
11.	Am preoccupied with a desire to be thinner.							
12.	Think about burning up calories when I exercise.							
13.	Other people think that I am too thin.							
14.	Am preoccupied with the thought of having fat on my body.							
15.	Take longer than others to eat my meals.							
16.	Avoid foods with sugar in them.							
17.	Eat diet foods.							
18.	Feel that food controls my life.							
19.	Display self-control around food.							
20.	Feel that others pressure me to eat.							
21.	Give too much time and thought to food.							
22.	Feel uncomfortable after eating sweets.							
23.	Engage in dieting behavior.							
24.	Like my stomach to be empty.							
25.	Have the impulse to vomit after meals.							
26.	Enjoy trying new rich foods.							
						Total Score =		

Behavioral Questions:			
In the past 6 months have you:		**Yes**	**No**
A.	Gone on eating binges where you feel that you may not be able to stop? (Eating much more than most people would eat under the same circumstances) If you answered yes, how often during the worst week:		
B.	Ever made yourself sick (vomited) to control your weight or shape? If you answered yes, how often during the worst week: _____		
C.	Ever used laxatives, diet pills or diuretics (water pills) to control your weight or shape? If you answered yes, how often during the worst week?		
D.	Ever been treated for an eating disorder? When: _____		

EAT-26 From: Garner et al. 1982, *Psychological Medicine, 12*, 871-878); adapted by D. Garner with permission.

Appendix M: EAT-26 Scoring Sheet

Item Scoring			
Item 1-25		**Item 26 only**	
Always	3	Always	0
Usually	2	Usually	0
Often	1	Often	0
Sometimes	0	Sometimes	1
Rarely	0	Rarely	2
Never	0	never	3
Total:			

Behavioural Questions	
Any **'Yes'** Score on A, B, C or D	

Body Mass Index Score		
calculated BMI		
<18	Underweight	
> 18	Not Underweight	

Result of Questionnaire		
Item Score	<20	>20
Behavioural score	Yes	NO
BMI score	<18	>18
	Positive	Negative

Overall Result	
Positive	
Negative	

Appendix N: Body Shape Questionnaire (BSQ-34)

BSQ-34

We should like to know how you have been feeling about your appearance over the **PAST FOUR WEEKS**. Please read each question and circle the appropriate number to the right. Please answer all the questions.

OVER THE PAST FOUR WEEKS:

		Never	Rarely	Sometimes	Often	Very often	Always
1.	Has feeling bored made you brood about your shape?.....	1	2	3	4	5	6
2.	Have you been so worried about your shape that you have been feeling you ought to diet?.....	1	2	3	4	5	6
3.	Have you thought that your thighs, hips or bottom are too large for the rest of you?.....	1	2	3	4	5	6
4.	Have you been afraid that you might become fat (or fatter)?.....	1	2	3	4	5	6
5.	Have you worried about your flesh being not firm enough?.....	1	2	3	4	5	6
6.	Has feeling full (e.g. after eating a large meal) made you feel fat?.....	1	2	3	4	5	6
7.	Have you felt so bad about your shape that you have cried?.....	1	2	3	4	5	6
8.	Have you avoided running because your flesh might wobble?.....	1	2	3	4	5	6
9.	Has being with thin women made you feel self-conscious about your shape?.....	1	2	3	4	5	6
10.	Have you worried about your thighs spreading out when sitting down?	1	2	3	4	5	6
11.	Has eating even a small amount of food made you feel fat?.....	1	2	3	4	5	6
12.	Have you noticed the shape of other women and felt that your own shape compared unfavourably?.....	1	2	3	4	5	6
13.	Has thinking about your shape interfered with your ability to concentrate (e.g. while watching television, reading, listening to conversations)?.....	1	2	3	4	5	6
14.	Has being naked, such as when taking a bath, made you feel fat?.....	1	2	3	4	5	6
15.	Have you avoided wearing clothes which make you particularly aware of the shape of your body?.....	1	2	3	4	5	6
16.	Have you imagined cutting off fleshy areas of your body?.....	1	2	3	4	5	6

		Never	Rarely	Sometimes	Often	Very often	Always
17.	Has eating sweets, cakes, or other high calorie food made you feel fat?	1	2	3	4	5	6
18.	Have you not gone out to social occasions (e.g. parties) because you have felt bad about your shape?.....	1	2	3	4	5	6
19.	Have you felt excessively large and rounded?.....	1	2	3	4	5	6
20.	Have you felt ashamed of your body?.....	1	2	3	4	5	6
21.	Has worry about your shape made you diet?.....	1	2	3	4	5	6
22.	Have you felt happiest about your shape when your stomach has been empty (e.g. in the morning)?.....	1	2	3	4	5	6
23.	Have you thought that you are in the shape you are because you lack self-control?.....	1	2	3	4	5	6
24.	Have you worried about other people seeing rolls of fat around your waist or stomach?.....	1	2	3	4	5	6
25.	Have you felt that it is not fair that other women are thinner than you?.	1	2	3	4	5	6
26.	Have you vomited in order to feel thinner?.....	1	2	3	4	5	6
27.	When in company have your worried about taking up too much room (e.g. sitting on a sofa, or a bus seat)?.....	1	2	3	4	5	6
28.	Have you worried about your flesh being dimply?.....	1	2	3	4	5	6
29.	Has seeing your reflection (e.g. in a mirror or shop window) made you feel bad about your shape?.....	1	2	3	4	5	6
30.	Have you pinched areas of your body to see how much fat there is?.....	1	2	3	4	5	6
31.	Have you avoided situations where people could see your body (e.g. communal changing rooms or swimming baths)?.....	1	2	3	4	5	6
32.	Have you taken laxatives in order to feel thinner?.....	1	2	3	4	5	6
33.	Have you been particularly self-conscious about your shape when in the company of other people?.....	1	2	3	4	5	6
34.	Has worry about your shape made you feel you ought to exercise?.....	1	2	3	4	5	6

Appendix O: BSQ-34 Scoring Sheet

BSQ-34 Scoring Sheet

Subject No: _____

Question	Score		
1	11	21	31
2	12	22	32
3	13	23	33
4	14	24	34
5	15	25	
6	16	26	
7	17	27	
8	18	28	
9	19	29	
10	20	30	TOTAL

Scoring Scale		
<80	No Concern with shape	
80-110	Mild Concern with shape	
111-140	Moderate Concern with shape	
>140	Marked Concern with shape	

Result of Questionnaire	
<136	Negative
≥136	Positive

Appendix P: Bulimic Investigatory test, Edinburgh (BITE)

SUBJECT NUMBER:

DATE:

BULIMIC INVESTIGATORY TEST, EDINBURGH (BITE)

1	Do you have a regular day to day eating pattern?	YES/NO
2	Are you a strict dieter?	YES/NO
3	Do you feel a failure if you break your diet once?	YES/NO
4	Do you count the calories of everything you eat, even when not on a diet? YES/NO	
5	Do you ever fast for a whole day?	YES/NO

6 If yes, how often is this?

EVERY SECOND DAY - 5 2-3 TIMES A WEEK - 4

ONCE A WEEK - 3 NOW AND THEN - 2 HAVE ONCE - 1

7 Do you do any of the following to help you lose weight? (Circle number)

	NEVER	OCCASION-ALLY	ONCE A WEEK	2-3 TIMES WEEK	DAILY	2-3 TIMES A DAY	5+TIMES A DAY
TAKE PILLS	0	2	3	4	5	6	7
TAKE DIURETICS	0	2	3	4	5	6	7
TAKE LAXATIVES	0	2	3	4	5	6	7

MAKE YOURSELF VOMIT	**0**	**2**	**3**	**4**	**5**	**6**	**7**

8	**Does your pattern of eating severely disrupt your life?**	**YES/NO**
9	**Would you say that food dominated your life?**	**YES/NO**
10	**Do you ever eat and eat until you are stopped by physical discomfort?**	**YES/NO**
11	**Are there times when all you can think about is food?**	**YES/NO**
12	**Do you eat sensibly in front of others and make up in private?**	**YES/NO**
13	**Can you always stop eating when you want to?**	**YES/NO**
14	**Do you ever experience overpowering urges to eat and eat and eat?**	**YES/NO**
15	**When you are feeling anxious do you tend to eat a lot?**	**YES/NO**
16	**Does the thought of becoming fat terrify you?**	**YES/NO**
17	**Do you ever eat large amounts of food rapidly? (not a meal)**	**YES/NO**
18	**Are you ashamed of your eating habits?**	**YES/NO**
19	**Do you worry that you have no control over how much you eat?**	**YES/NO**
20	**Do you turn to food for comfort?**	**YES/NO**
21	**Are you able to leave food on the plate at the end of A meal?**	**YES/NO**
22	**Do you deceive other people about how much you eat?**	**YES/NO**
23	**Does how hungry you feel determine how much you eat?**	**YES/NO**

24	**Do you ever binge on large amounts of food?**	**YES/NO**
25	**If yes, do such binges leave you feeling miserable**	**YES/NO**
26	**If you do binge, is this only when you are alone?**	**YES/NO**

27 If you do binge, how often is this?

HARDLY EVER	**1**	**ONCE A MONTH**	**2**
ONCE A WEEK	**3**	**2-3 TIMES A WEEK**	**4**
DAILY	**5**	**2-3 TIMES A DAY**	**6**

28	**Would you go to great lengths to satisfy an urge to binge?**	**YES/NO**
29	**If you overeat do you feel <u>very</u> guilty?** **YES/NO**	
30	**Do you ever eat in secret?**	**YES/NO**
31	**Are your eating habits what you would consider to be normal?**	**YES/NO**
32	**Would you consider yourself to be a compulsive eater?**	**YES/NO**
33	**Does your weight fluctuate by more than 5 lbs in a week?**	**YES/NO**

Appendix Q: BITE Scoring Sheet

BITE Scoring Sheet

Subject No: _____

Symptom Scale

Question	Yes	NO	Score		Yes	No	Score		Yes	No	Score
1	0	1		**13**	0	1		**25**	1	0	
2	1	0		**14**	1	0		**26**	1	0	
3	1	0		**15**	1	0		**27**			
4	1	0		**16**	1	0		**28**	1	0	
5	1	0		**17**	1	0		**29**	1	0	
6				**18**	1	0		**30**	1	0	
7				**19**	1	0		**31**	0	1	
8	1	0		**20**	1	0		**32**	1	0	
9	1	0		**21**	0	1		**33**	1	0	
10	1	0		**22**	1	0					
11	1	0		**23**	0	1					
12	**1**	**0**		**24**	**1**	**0**		**TOTAL**			**/30**

Severity Scale

Question	Corresponding score	
6		
7	**Pills**	
	Diuretics	
	Laxatives	
	Vomit	
27		
Total	**/38**	

Result of Symptom

<20	Negative	
>20	Positive	

Result of Severity

<5	Negative	
>5	Positive	

Scoring Scale

Symptom Score	**≥20**	High- highly disordered eating pattern	
	10-19.	medium- Unusual eating pattern	
	<10	Low- Normal limits	
Severity Scale	**<5**	Not Clinically Significant	
	≥5	Clinically Significant	

Appendix R: Menstrual Cycle and Time Spent in Exercise Questionnaire

Menstrual Cycle Questionnaire & Time Spent in Exercise

Menstrual Cycle

Age (in years) at onset of first menstrual cycle _____

History of prior year menstrual cycle (mark one).

0 cycles in past year

1-3 cycles in past year

4-6 cycles in past year

7-9 cycles in past year

10-12 cycles in past year

>12 cycles in past year

Has your period been absent for the past 3 months/cycles (>90days)?

YES	NO

Have you taken oral medications or hormonal replacements to regulate your menstrual cycle?
(Contraceptive pill, thyroid hormone replacement, progesterone injections etc.)

YES	NO

Have you been diagnosed with a thyroid dysfunction?

YES	NO

Exercise

Number of days per week that you exercise to a point where you break a sweat or Increase breathing:_____.

Intensity of training sessions: (tick the most accurate box)

- Easy to moderate exercise ☐
- Hard to vigorous exercise ☐

Amount of time in minutes per exercise session: _____.

Distance in kilometres performed per week:_____

Appendix S: Self-Administrated Bone Mineral Density Questionnaire

BONE MINERAL DENSITY QUESTIONNAIR E

Name:_____

DOB:_____ Date:_____ Age:_____

Sex: M/F

Age of Menopause Onset:_____ Are you pregnant? Yes or No

LMP? _____ Height: _____ Weight:

Have you had any Diagnostic tests within the last 8 days requiring
Contrast media? Yes or No

Do you have a history of malabsorption disease (eating disorders)? Yes or No

Have you ever had surgery on your spine? Yes or No

Have you ever had surgery on your hips? Yes or No

Risk Factor Assessment

1. Are you Caucasian or Asian female? Yes or No
2. Do you have a family history of osteoporosis? Yes or No
3. Do you have a personal history of fracture as an adult? Yes or No
4. Did you have natural or surgically-induced menopause or both ovaries removed? Yes or No
5. Do you suffer from irregular or stopped menstrual periods (1 year or more) Yes or No
6. Do you smoke cigarettes? Yes or No
7. Do you have low body weight (less than 127 lbs) Yes or No
8. Have you had a lifelong low calcium intake? Yes or No
9. Do you consume more than 2 servings of alcohol daily? Yes or No
10. Are you getting little or no weightbearing exercise? Yes or No

Who Should be Tested for Bone Mineral Density (BMD)?

1. Are you a woman 65 years of age or older? Yes or No
2. Are you a postmenopausal woman under age 65 who has one or More additional risk factors (from above section) for osteoporosis? Yes or No
3. Have you been on hormone replacement therapy for prolonged Periods (more than 3 months)? Yes or No
4. Have you taken steroids or glucocorticoid medication (prednisone, Cortisone) to treat asthma, arthritis, lupus or other chronic disease (3 consecutive months or more)? Yes or No
5. Are you diabetic? Yes or No
   If yes, for how long? _____

Appendix T: Ethics Certificate

Zertifikat

Certificado

Certificat

Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Ashleigh De Freitas

a complété avec succès - has successfully completed

Module 2

du programme de formation TRREE en évaluation éthique de la recherche of theTRREE training programme in research ethics evaluation

Febuary 7, 2014

Professeur Dominique Sprumont
Coordenatue TREE Coordinator

Appendix U: 2007 Position Stand Data Capturing Sheet

Subject No:

Energy Availability Result	
Daily Energy Intake (EI)	kcal/d
Daily Energy Expenditure (EE)	kcal/d
Fat Free Mass (FFM)	kg
Energy Availability (EA): **EA= (EI-EE)/FFM**	kcal.kg-1FFM.d-1

Result	>45 kcal.kg-1FFM.d-1	≤45 kcal.kg-1FFM.d-1	< 30 kcal.kg-1FFM.d-1
	Optimal	**Reduced EA**	**Low EA**

Disordered Eating Result		
	Positive	**Negative**
BSQ-34		
EAT-26		
BITE		
	Positive:	**Negative:**

Menstrual Result			
	Presence:		**Result**
Normal Menstrual Function		**Eumenorrhea**	
Primary Amenorrhea (menarche ≥15y)		**Subclinical Menstrual Disorder**	
Secondary Amenorrhea (≥3 missed consecutive cycles)			
Oligomenorrhea (cycle intervals ≥35 days/<10 cycles per year)			
Polygomenorrhea (>12 cycle per year)			
Reduced EA + 1 of the following subclinical menstrual disorders: Primary or secondary amenorrhea or oligomenorrhea		**Functional Hypothalamic Amenorrhea (FHA)**	

Bone Mineral Density (BMD)			
Secondary Clinical Risk Factors (SCRF)	**Under Nutrition**	Low/reduced EA	Optimal
	Eating Disorder	Yes	No
	Prior Fractures	Yes	No
	Hypoestrogenism	Menstrual Dysfunction	Eumenorrhea
		1 presence= Positive	**4 presence= Negative**

Bone Mineral Density z-score	**(>0)- (-0.9)**	**(-1) - (-1.9)**	**(≥-2)**
	Optimal Bone health	**Low BMD**	**Osteoporosis**

Result	**Optimal Bone health**	Positive	correlating z-score
	Low BMD	Positive	correlating z-score
	Osteoporosis	Positive	correlating z-score
			Positive SCRF
		Negative	no Correlating z-score
			SCRF

2007 Position Stand- Female Athlete Triad Results		
Positive	**Positive low EA**	
	Positive FHA	
	Positive Osteoporosis	
Negative	**≥ 1 Negative result**	

2007 Position Stand- Spectrum Female Athlete Triad Results		
Positive	**Positive Reduced EA**	
	Positive Subclinical Menstrual Dysfunction	
	Positive Low BMD	
Negative	**≥1 Negative Result**	