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Examination of Energy Needs in Male and Female Physically Active Individuals

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EXAMINATION OF ENERGY NEEDS IN MALE AND FEMALE PHYSICALLY ACTIVE INDIVIDUALS

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ABSTRACT

Content: The Female Athlete Triad refers to three interrelated components: 1) low energy availability (LEA), with or without an eating disorder (ED); 2) harmful and physiologically impactful hormonal changes; and 3) alterations in bone mineral density, which are often experienced by individuals engaged in organized sports or other intense physical activities. This phenomenon is called the Female Athlete Triad because the relationship of components has thus far been observed primarily in females. A new term, the Male Athlete Triad, has been recently developed to describe the same phenomenon in males. LEA occurs when dietary energy intake (EI) is inadequate to support the energy expenditure required for daily activities and organ function after exercise energy expenditure (EEE) needs are met. **Objective:** To examine the prevalence of LEA with or without an ED in physically active individuals. A secondary purpose is to determine if physically active individuals are meeting the recommended macronutrient intake guidelines. **Design:** A cross-sectional study in a free-living environment. **Participants:** A sample of 58 physically active individuals (35 males and 23 females) who engage in exercise 3 times per week for at least one hour. **Interventions:** Independent variables in this study are sex (male, female) and energy availability (adequate EA, LEA) and dependent variables are ED risk (at risk or not at risk) and macronutrients (proteins, carbohydrates, fats). **Main outcome measures:** Participants completed a 7-day food intake diary to estimate EI and used a SenseWear heart rate monitor during physical activity to estimate EEE. ED risk was examined using the Eating Disorder Inventory 3 (EDI-3) and the EDI-3 Symptom Checklist. Macronutrient intake was calculated and compared using ACSM Nutrition Recommendations to determine if participants are below, within, or over recommendations. **Anticipated Results:** We expected to find that LEA was present in the majority of physically active individuals and that most of these individuals would display LEA with ED risk. Additionally, we expected that physically active individuals, regardless of activity type, would present with low carbohydrate intake, males would have higher protein intakes, and there would be no differences among fat intake. **Conclusions:** We found LEA risk and ED risk to be prevalent in males and females, although there were significant differences across sex. We also found a significant relationship between LEA and ED risk, and most participants who had LEA also had ED risk. Macronutrient intake was significantly different across sex, although carbohydrate intakes were low across all participants with 94.8% having inadequate intake. ED risk varied across sex with several significant differences in scales, composites and pathogenic behaviors across sex.

TABLE OF CONTENTS

CHAPTER I: LITERATURE REVIEW

Introduction

Over the past few decades, the Female Athlete Triad and its components have been studied extensively and our understanding of the symptoms and prevalence has grown significantly. The role of low energy availability in producing the other Triad symptoms is now better understood, and prevalence in athletes and physically active individuals, especially those involved in endurance, aesthetic and weight class sports, is high. While the Triad symptoms in females are well-studied and understood, recent studies have shown Triad-like symptoms in males as well, warranting further study of the phenomenon in males.[4] Although males can withstand a greater energy deficit than females before experiencing alterations in skeletal and reproductive health, it is important to understand energy needs in both males and females to ensure adequate energy is consumed. Low energy availability can occur with or without disordered eating or a clinically diagnosed eating disorder,[7] so screening for symptoms is important. The purpose of this study is to investigate the symptoms and prevalence of low energy availability and assess eating disorder risk in male and female physically active individuals.

Female and Male Athlete Triad

The Female Athlete Triad (Triad) refers to the relationship between three components present in many individuals who participate in organized sports or other intense physical activities: 1) low energy availability (LEA), with or without an eating disorder (ED); 2) harmful and physiologically impactful hormonal changes; and 3) alterations in bone mineral density (BMD).[1] Although the prevalence of the Triad is low with a range of 0% - 1.2% among US high school and college athletes, the individual components of the Triad are common among athletes at all ages and competitive levels with 23.5% of female athletes experiencing menstrual dysfunction, 18.2% showing disordered eating (DE) patterns with or without a diagnosed eating disorder, and 4.1% having low bone mineral density.[2] A recent analysis which examined the prevalence of the Triad and its components among athletes across all activity levels showed a small percentage of athletes with all three components at 0% - 15.9%, but larger percentages exhibited two components (2.7% - 27%) or one component (16% - 60%).[2] Additionally, the prevalence of the Triad in sports which emphasize aesthetics or weight classes ("lean" sports such as ballet, gymnastics, and running) was observed to be 2 – 3 times higher than in non-lean sports.[2]

While the Triad has been extensively researched and studied, there is a need to study the same phenomenon in males. Male athletes participating in lean sports who have bone stress injuries may also show nutritional, endocrine, and/or bone mineral density problems, very similar to the components of the Female Athlete Triad. The Female and Male Athlete Triad Coalition recently defined the Male Athlete Triad as "a syndrome of 3 interrelated conditions, including energy deficiency/low EA, impaired bone health, and suppression of the hypothalamic–pituitary–gonadal (HPG) axis."[4] Currently, the outcomes of the Triad in males are less clearly defined than in females, and the degree of LEA associated with alterations in the HPG axis as well as increased risk of bone stress injury is not clear. Identification of one or more of these components is crucial as early identification can help prevent serious health risks.[5]

Components and their Relationship

As mentioned previously, the three components of the Triad are LEA, with or without an ED; harmful hormonal changes; and changes in BMD. While each of these can be present on its own, low EA can play a causal role in menstrual cycle disturbances as well as in deteriorating skeletal health.[6] Energy availability (EA) is defined as calories consumed, or energy intake (EI), minus the caloric expenditure of exercise, or exercise energy expenditure (EEE), normalized for fat free mass (FFM). LEA occurs when EI is inadequate to support energy expenditure for daily activities and organ function after EEE needs are met. A healthy EA for young adults is 45 kcal/kg FFM.[7] When EA drops below 30 kcal/kg FFM, the risk of menstrual cycle disturbances increases above 50% due to decreases in the release of luteinizing hormone (LH), although more research is needed to determine the precise level of energy deficiency at which menstrual disturbances begin.[6]

Severe undernutrition impairs skeletal health as well as reproductive health, and hormonal changes as a result of LEA may themselves contribute to low BMD.[1] One study found that bone formation was impaired within only 5 days of the onset of LEA.[2] Caloric restrictions and weight loss are associated with bone loss, with a 1% - 2% decrease in BMD resulting from a 10% decrease in weight. Further, amenorrhea causes decline in BMD and even negates the benefits of exercise on skeletal health. Demanding workouts combined with amenorrhea leads to increased likelihood of stress fractures, although the impact loading of the sport is also important to consider. For example, gymnasts are likely to have higher BMD than dancers due to the impact loading associated with gymnastics.[2] Additionally, adolescence is a crucial time for bone development as 26% of adult bone mineral content is acquired during the 2 years when peak height growth velocity occurs. During this time, if adolescents experience LEA, they may lose 2% - 6% of bone mass rather than accruing it, leading to a much higher risk of stress fractures. If this happens, these individuals may never reach peak bone mass, even if normal menstrual cycles are restored.[2] Prolonged LEA and its detrimental impact on hormonal health/menstruation and BMD to impaired performance in sports and physical activities.[8]

Parallels between Females and Males

The concept of adequate EA has thus far been understudied in male athletes, although one study of elite female and male Dutch athletes established that both males and females participating in lean sports exhibited dieting and undereating. Undereating may contribute to both nutrient deficits and physiological problems in both sexes. While adequate EA for females has been established to be about 45 kcal/kg FFM and EA below 30 kcal/kg FFM is considered LEA, the threshold for males is not quite as clear. Some studies suggest that a more severe energy deficit is needed to see deteriorations in skeletal and reproductive health in males than in females. In 2021, the Male Athlete Triad Consensus Statement set the threshold for LEA in males at 15 kcal/kg FFM.[4] Studies of adolescent males in ball or team sports found the range of adequate EA for male athletes to be between 40 – 60 kcal/kg FFM.[3] Another study of adolescent male cyclists found that the athletes' energy intake fell below recommended levels and did not significantly exceed intake levels of the control group, despite fivefold more hours per week spent exercising. Additionally, and similarly to female athletes, males participating in lean sports carry an increased risk of nutritional deficits. Regarding EDs and their prevalence among female and male athletes, a study of elite female and male Norwegian athletes found an 8% prevalence of EDs among the athletes, compared to 0.5% among non-athlete controls. Additionally, 12.9% of males participating in lean sports were found to exhibit EDs, compared with 4.6% prevalence in non-lean sports. Based on this study, males participating in lean sports are 25 times more likely to exhibit an ED than their non-athlete counterparts, which is similar to that of female athletes.[3]

Along with these parallels in LEA among female and male athletes come similarities in terms of harmful hormonal changes and changes in BMD as well. As previously discussed, females may experience hormonal changes and menstrual cycle disturbances when EA drops below 30 kcal/kg FFM.[6] When males experience LEA, the HPG axis may be disturbed and serum testosterone levels may decline, leading to exercise hypogonadal male condition (EHMC). As males experience LEA, EHMC affects reproductive function, similar to the impact LEA has on females.[9] Low BMD is a symptom of hypogonadism, just as low BMD results from amenorrhea in females.[6] In both female and male athletes alike, the altered endocrine profile which comes as a result of LEA is harmful to reproductive function and bone health.[9] Overall, although more research is needed to study the Triad symptoms in males, it is evident that LEA leads to similar problems in both female and male athletes.

Low Energy Availability with or without ED

As mentioned previously, healthy EA for a young adult is approximately 45 kcal/kg FFM; clinical LEA occurs when EA drops below 30 kcal/kg FFM.[7] The American College of Sports Medicine (ACSM) has identified three origins of energy deficiency in athletes. The first of these three origins are obsessive eating disorders which are diagnosed as mental illness. The second is intentional and rational but misguided attempts to manipulate body size for the sake of succeeding in athletic competitions, which may or may not include disordered eating behaviors such as fasting, diet pills, laxatives, diuretics, enemas, and vomiting. The third is unintentionally failing to have adequate EI to compensate for EEE, thereby resulting in LEA.[7] In endurance sports, LEA is prevalent because these athletes engage in prolonged physical activity which drastically reduces EA, often to the point of LEA unless EI is increased to compensate for it. In sports without an emphasis on endurance, LEA may be prevalent as well because dietary restriction may be a prominent part of the strategy to reduce body size or change composition in order to succeed. For example, in sports involving strength and power, such as weightlifting, many athletes aim to have lower body fat percentages in order to optimize power-to-weight ratios. Rather than focusing on absolute strength or power, these athletes often aim to maximize performance at the lowest attainable bodyweight category.[10]

Macronutrient and Micronutrient Needs of Physically Active Individuals

Many athletes, especially those participating in endurance or aesthetic sports and sports which involve weight classes, are chronically energy deficient. As a result, performance, growth, and health are impacted negatively. Energy deficiency in athletes is perhaps more specifically due to insufficient carbohydrate intake. In order to achieve their objectives, athletes must strike the right balance between carbohydrate, protein and fat intake, as well as micronutrient intake.[10,11] These needs will change from athlete to athlete and depend on the training and competition cycle, type of training, volume and intensity of training, as well as other factors such as exposure to cold or heat, fear, stress, injuries, etc.[10] One study which observed changes in EA of division I female soccer players across the season found that 26.3%, 33.3%, and 11.8% had LEA during the pre-, mid-, and post-season, respectively, indicating changing energy expenditure and energy needs throughout the season.[12] Another study of male endurance athletes found that highly trained athletes do not increase EI to compensate for increased training volume as EEE changes in times of high- and low-volume training.[13] Female athletes reportedly consume approximately 30% less energy and carbohydrates per kilogram of bodyweight than their male counterparts in most sports; however, females may tend to under-report their energy intake, which might explain some of that discrepancy.[14] Overall, intake of macronutrients in an athlete's diet should depend on the training-nutrient interactions and how they affect energy systems and training adaptations.[10]

Carbohydrate

Carbohydrate is an important macronutrient in sports nutrition due to its role in the performance of and adaptation to training. Carbohydrates are a key source of energy used by the brain and central nervous system, and they are important to support muscular work because of utilization by anaerobic and oxidative pathways—they improve exercise efficiency by providing more adenosine triphosphate per volume of oxygen delivered to the mitochondria, giving an advantage over other substrates such as fat in terms of exercise efficiency. There is evidence that high carbohydrate availability helps sustain intense exercise, while low carbohydrate availability is associated with fatigue, impaired skill and concentration, and increased perception of effort. The size of carbohydrate stores can be quickly manipulated by dietary intake or by even a single session of exercise.[10]

Individual needs for carbohydrate intake vary from person to person based on the training or competition cycle as well as balancing high-quality exercise and performance with enhancing the training stimulus or adaptation. Generally, suggested carbohydrate intake can be determined based on the athlete's body size and type/characteristics of training. The general categories are as follows: for low intensity or skills-based activities, 3 – 5g/kg bodyweight is recommended per day; for a moderate exercise program, defined as approximately 1 hour per day, 5 – 7g/kg/day is recommended; for an endurance program, defined as 1 – 3 hours of moderate- to high-intensity exercise per day, 6 – 10g/kg/day is recommended; for extreme commitment, defined as over 4 – 5 hours of moderate- to -high-intensity exercise per day, 8 – 12g/kg/day is recommended.[15]

In addition to the amount of carbohydrate intake, the timing of intake is important to performance as well. An important strategy in achieving optimal performance in competitions or key workouts is matching carbohydrate stores with the fuel demands of that particular session. In the 1 – 4 hours pre-session, carbohydrates consumed may continue to increase glycogen stores of the muscles, likely enhancing performance. During that time pre-session, carbohydrate intakes of 1 – 4g/kg bodyweight have been shown to enhance performance in prolonged exercise. It is important to consume low-fiber, low-fat, and low- to moderate-protein snacks or meals prior to exercise in order to avoid gastrointestinal problems during the session. There is also evidence that carbohydrate intake during exercise may also provide benefits to performance. Finally, carbohydrate intake post-exercise is important for glycogen restoration. Because the rate of glycogen restoration is only about 5% per hour, carbohydrate intake of about 1 – 1.2g/kg bodyweight in the 4 – 6 hour period post-exercise is helpful in maximizing refueling time.[10] Importantly, in the absence of carbohydrate intake, refueling after a workout is ineffective.[15] In periods of recovery lasting over 24 hours, as long as adequate energy and carbohydrates are consumed, the type, pattern and timing of carbohydrate-heavy meals can be left up to the athlete to choose what is enjoyable and practical for them.[10,15]

Protein

Protein needs vary from athlete to athlete based on how much aerobic- versus resistance-based training they engage in. When an athlete aims to increase muscle mass and strength, they will likely consume higher amounts of protein than their endurance-training counterparts. Strength- and muscle mass-focused athletes consume more protein because of the macronutrient's ability to facilitate muscle protein generation. The recommended dietary allowance (RDA) for protein is 0.8g/kg bodyweight, which is adequate for most sedentary persons; however, the ACSM recommends, based on its most recent stand, 1.2 – 2.0g/kg/day for endurance- and resistance-trained athletes. Protein intakes as high as 1.8 – 2.0g/kg/day may be advantageous in preventing lean mass loss in times of energy restriction to promote fat loss.[16]

Additionally, while the quantity of protein consumed is important, the quality of protein is important as well in the maintenance, repair and synthesis of muscle protein.[10,16] One indicator of protein quality is the protein digestibility corrected amino acid score (PDCAAS), where a score of 1.0 or very close to 1.0 indicates a high-quality protein source. Animal-based protein sources such as milk, eggs, and meat typically fall under this score.[16] Studies have shown milk-based protein consumption after resistance exercise is effective in increasing muscle mass and facilitating favorable changes in body composition. Whole milk, lean meats, and dietary supplements which include whey, casein, soy, and egg isolated proteins reportedly increase muscle protein synthesis as well. Currently, dairy proteins seem to have the greatest impact on muscle protein synthesis; other high-quality protein sources like lean meat and eggs are effective as well, although more research is needed. When these kinds of high-quality protein sources are not convenient or readily available, athletes can use third-party tested dietary supplements with high-quality ingredients as a practical alternative to meet protein intake goals.[10]

As is the case with carbohydrate intake, the timing of protein intake is important for an athlete's adaptive response to training.[16] After a session of resistance training, upregulation of muscle protein synthesis may occur for up to 24 hours, during which there is increased sensitivity to protein intake. When an athlete incorporates feedings with protein after exercise and throughout the day, skeletal muscle protein accretion improves for both resistance- and endurance-trained athletes.[10] While pre-exercise protein consumption is unlikely to increase muscle protein synthesis, there is overwhelming evidence that post-exercise consumption is beneficial. There is currently no exact window of anabolic opportunity for protein consumption post-exercise, but because protein aids in muscle protein synthesis, the notion that the sooner and athlete can consume protein after exercise, the better, is plausible.[16]

Fat

Fat is an essential macronutrient in a balanced diet as it provides energy and essential elements of cell membranes, and it helps with absorption of fat-soluble vitamins. According to the Dietary Guidelines for Americans, saturated fats should make up no more than 10% of calories per day, and saturated fats should be replaced with unsaturated fats and polyunsaturated fats. Some foods, such as high-fat meat, inherently contain some saturated fats, so it is important to limit them otherwise where possible.[17] Athletes should remain in accordance with public health guidelines and make individual changes where necessary based on performance goals. Athletes should avoid reducing fat intake below 20% of total energy intake as this can reduce intake of important nutrients such as fat-soluble vitamins and fatty acids; however, fats should not make up >30% of daily EI.[10]

While fat is important in a balanced diet, it cannot be relied upon as a primary source of energy in moderate- to high-intensity exercise. Studies have failed to find evidence of enhanced performance in moderate exercise where athletes consume a high fat low carbohydrate diet, and there is evidence that high fat low carb diets impair performance in high-intensity exercise.[18] Limiting carbohydrate availability and reducing capacity to use it as an exercise substrate, as high fat low carb diets do, reduces metabolic flexibility, thereby impairing performance. On the other hand, excessive reduction of fat intake can have a negative effect on overall health and should be limited to acute reduction, such as increased intake of preferred macronutrients (carbohydrates) before a competition or prioritizing gastrointestinal comfort during a competition.[10]

Alcohol

Alcohol can be a part of a balanced diet and social interactions, but excessive alcohol consumption can impair performance and be dangerous to overall health.[10] Alcohol consumption is a prominent part of Western culture, and athletes are not exempt from this. In fact, one study of US college students found that athletes drank more frequently and became drunk more frequently than students not involved in sports. Excessive alcohol consumption by athletes often occurs during the post-competition period. Low doses of alcohol around 0.5g/kg bodyweight consumed post-exercise are unlikely to impair many aspects of recovery and therefore may be acceptable in moderation.[19] However, binge drinking patterns consistent with those of some athletes, particularly team sport athletes, can be concerning and interfere with performance goals. Alcohol contains 7kcal/g, so excessive consumption may put an athlete into a calorie surplus, thereby potentially altering body composition. Overall, athletes are recommended to remain within public health guidelines regarding alcohol, and consumption should be minimized or avoided in cases where injury recovery and general recovery from exercise are a priority.[10]

Micronutrients

Many athletes who restrict energy intake and/or have LEA are at risk of having insufficient levels of micronutrient intake, particularly iron, vitamin D, calcium, and some antioxidants.[10] Iron deficiency is more prevalent among athletes, especially young female athletes, than the general population, likely because of the density of iron in the American diet as a whole as well as the tendency for female athletes to consume inadequate levels of energy. Consequences of iron deficiency include anemia and altered metabolic processes like protein synthesis, among other morphologic, physiologic, and biochemical changes. Because hemoglobin iron facilitates oxygen transport to the muscles, reduced iron content can have a negative impact on exercise performance; individuals who exercise regularly have lower levels of iron. Three groups of people who are particularly vulnerable to iron deficiency are female athletes, distance runners, and vegetarians, all of whom are advised to pay extra attention to iron consumption.[20] Recommended daily iron intake for all men and postmenopausal women is 8mg/day, while the recommendation for premenopausal women is 18mg/day.[21]

Vitamin D plays an important role in bone and skeletal muscle health, and its role in metabolic muscle function indicates its importance to athletic performance.[10] Recent studies have found that vitamin D also reduces risk of stress fractures, inflammation, infectious illness, and impaired muscle function. By enhancing intestinal calcium absorption, vitamin D promotes bone health and prevention of bone injury in physically active individuals. Musculoskeletal weakness and pain are known symptoms of vitamin D deficiency; further, one study found that vitamin D levels were correlated with jump height, velocity, and power of 12-14 year old postmenarchal females. The autocrine function of vitamin D, which facilitates muscle growth, could explain the effect it has on exercise performance—that is, suboptimal levels may explain poor performance, although elevated levels did not necessarily explain excellent performance.[22] Recommended vitamin D intake for adults is 15mcg/day up to age 70 and 20mcg/day for adults over 70,[23] although supplementation above this recommendation may be necessary for athletes.[10]

Calcium is critical to skeletal muscle and bone health as well as nerve conduction and normal blood clotting.[10] Calcium is a major bone-forming mineral as 99% of the body's calcium is stored in the bone. It also plays an important role in many cellular processes which occur during exercise, so the body works to defend serum calcium concentrations, primarily by demineralizing bone. Therefore, individuals who engage in prolonged physical activity may benefit from calcium supplementation. One study found that pre-exercise supplementation helped prevent bone resorption during exercise.[24] Low calcium intake is associated with LEA, disordered eating, and intentional avoidance of dairy products which are high in calcium; insufficient intake may also exacerbate menstrual dysfunction.[10] Recommended daily calcium intake for adults is 1,000mg/day up to age 70 and 1,200mg/day for adults over age 70.[25]

Eating Disorders and Exercise Addiction

As mentioned before, LEA comes about in one of three ways: diagnosed eating disorders which constitute mental illness; intentional and rational but poorly executed efforts to reduce body size or modify body composition for the sake of succeeding in sports; and inadvertently consuming inadequate amounts of energy to compensate for EEE.[7] This means that LEA is the result of overexercising, undereating, or a combination of the two. While regular exercise is an important part of a healthy lifestyle and has beneficial effects on both physical and mental health, excessive exercise can result in physical and psychological damage. Abnormally high volumes of exercise carried out in an uncontrolled way may constitute exercise addiction; this type of behavior is found among both athletes and the general population, although studies suggest that prevalence is much higher among athletes. One study even found a prevalence of exercise addiction in athletes to be as high as 40%, although others have found prevalence to be as low as 2.7%. While there is a large range for what the true prevalence may be, there are several correlates of exercise addiction in athletes which are consistent among most studies. These include significant pressure from coaches and teammates, societal pressure, and level of competition.[26] Recent research has found that compulsive exercise behavior is associated with symptoms of disordered eating behavior and perfectionism as well as obsessive-compulsive tendencies in athletes. Individuals who exhibit compulsive exercise behavior may be at risk of health consequences associated with LEA.[8] One way to assess the prevalence and intensity of psychological traits and symptoms in individuals with EDs is through the Eating Disorder Inventory-3 (EDI-3).[27]

Eating Disorder Inventory-3 (EDI-3)

The EDI-3 provides information on various ED-specific problems as well as psychological issues and includes the following diagnostic groups: Anorexia Nervosa-Restricting type; Anorexia Nervosa-Binge-Eating/Purging type; Bulimia Nervosa; and Eating Disorders Not Otherwise Specified.[27] There are several EDI-3 scales and composites, each of which is accompanied by descriptive scale interpretations as well as interpretive guide tables listing the clinical ranges. The reference group for the interpretive guide tables is the U.S. Adult Combined Clinical sample, and the following clinical ranges are based on percentile ranges for the sample: Elevated Clinical for 67th to 99th percentile; Typical Clinical for 25th to 66th percentile; and Low Clinical for 1st to 24th percentile. The EDI-3 is broken into two broad assessment areas: Eating Disorder Risk Scales and Composite, and Psychological Scales and Composites. The former has been used both in conjunction with and independent of the latter to assess high-risk groups for EDs or to examine significant eating concerns.[27]

The first ED risk scale is the Drive for Thinness scale. This “drive for thinness” is found to be one of the most prominent factors in the onset of many EDs or DE symptoms. This scale assesses preoccupation with restrictive eating and dieting as well as fears of weight gain. For this scale, a raw score between 25 and 28 is considered the elevated clinical range of 67th to 99th percentile. Elevated clinical range indicates that the respondent is very scared of gaining weight, spends a lot of time thinking about dieting, and is preoccupied with the desire to be thinner. A high score in this scale is common among those with diagnosed EDs, therefore a high score on this scale should raise concerns about presence of ED or DE symptoms. A raw score of 17 to 24 indicates typical clinical range, within which individuals have a desire to be thinner as well as preoccupation with dieting and fear of weight gain. A typical clinical score is particularly concerning if the individual is of normal or low bodyweight as this scale is positively correlated with bodyweight. A raw score less than or equal to 16 is considered low clinical, indicating that the individual does not have significant problems with desire for thinness, preoccupation with dieting or fear of weight gain. A high raw score in this scale is associated with a poor prognosis as many recovered individuals still struggle with it, so individuals with high scores may need careful follow-up after initial treatment.

The Bulimia scale assesses the tendency to think about and engage in binge eating, or uncontrollable bouts of eating. One item on this scale also assesses thinking about vomiting to lose weight. Not all individuals who engage in binge eating meet all the criteria to be diagnosed with an ED, but in most cases binge eating is associated with psychological distress. Elevated clinical range, with a raw score of 19 to 32, indicates that the respondent very frequently thinks about binge eating and exhibits behaviors consistent with it, including secrecy, emotional distress, and thoughts of vomiting. Individuals scoring in this range should be evaluated by a specialist familiar with EDs. Typical clinical range includes raw scores from 5 and 18 and indicates that the respondent often thinks and behaves in a manner consistent with binge eating. A score in this range should raise concerns about the presence of harmful overeating tendencies. Low clinical range is a raw score less than or equal to 4 and indicates that the respondent does not exhibit concerning behavior regarding binge eating, or perhaps it could reflect denial on part of the respondent.[27]

The Body Dissatisfaction scale assesses discontent with parts of the body most often associated with EDs, such as the stomach, hips, thighs and buttocks. While this is a common phenomenon among many women in Western culture and does not necessarily indicate the presence of an ED, it is still a risk factor that can lead to DE behaviors if left unchecked. A raw score of 36 to 40 is considered to be the elevated clinical range, indicating that the respondent has a very high level of dissatisfaction with body shape, size, and/or weight of the entire body and/or specific regions of it. A score this high is uncommon among individuals without a clinically diagnosed ED. Typical clinical range includes raw scores from 22 to 35 and indicates that the respondent has significant dissatisfaction with shape, size and/or weight of the body and/or individual body parts. Because of the tendency of Western culture to cause most women to feel some level of dissatisfaction with their bodies, respondents in this range do not need to be evaluated by a specialist unless there are concerns shown in the other ED scales. Low clinical range includes raw scores less than or equal to 21 and indicate that the respondent does not show significant dissatisfaction with shape, size and/or weight of the body and/or individual parts. The association between body dissatisfaction and ED symptoms is higher with body surveillance, neuroticism, or having a family member or friend with an ED. Additionally, depression may be a significant factor in the presence of body dissatisfaction.[27]

The Eating Disorder Risk Composite sums the T scores of the previous three scales in order to assess overall concern with eating and weight, providing equal weight to each scale. Elevated clinical range indicates that the respondent has extreme eating and weight concerns such as fear of weight gain, desire to be thinner, tendency to binge eat, and body dissatisfaction. A score in this range should raise significant concerns over the presence of an ED and/or serious eating concerns, and respondents should be evaluated by a specialist. Typical clinical range indicates that the respondent has concerns overeating and weight; a score in this range is common among those with clinically diagnosed EDs but uncommon among nonclinical samples.

Low clinical range indicates that the respondent does not have significant concerns with eating and weight relative to those with clinical EDs, although it could also reflect denial or response bias on the part of the patient.[27]

The first of the psychological scales and composites is the Low Self-Esteem scale. This scale assesses an individual's negative self-evaluation and feelings of insecurity, inadequacy, ineffectiveness, and lack of self-worth, as well as inability to reach personal goals and standards. Low self-esteem is believed to underlie the development of many EDs. Elevated clinical range for this scale is raw scores from 17 to 24 and indicates that the respondent has extreme feelings of insecurity, inadequacy, ineffectiveness, and low self-worth. Scores in this range warrant evaluation by an expert, and it would also be wise to further evaluate the respondent to rule out depression and suicidal thoughts. Low self-esteem in patients with an ED is often tied to bodyweight. Typical clinical range is raw scores from 9 to 16 and indicates that the respondent has significant feelings of insecurity, inadequacy, ineffectiveness, and low self-worth; scoring in this range is common among those with clinical EDs and overall indicates concerns regarding self-esteem. Low clinical range is raw scores less than or equal to 8, indicating that the respondent does not have significant feelings of low self-esteem relative to those with EDs.[27]

The Personal Alienation scale assesses similar criteria to the Low Self-Esteem scale, but it is broader in that it focuses on emotional emptiness and poor understanding of oneself. It includes things like loneliness, feeling separated, and not receiving credit from others. Raw scores of 17 to 28 constitute elevated clinical range, indicating that the respondent has extreme feelings of emptiness, loneliness and poor self-understanding. The respondent may also feel as if things are always out of control as well as wish to be someone else. Scores in this range are not common among those with EDs and rare among those without EDs. Raw scores of 9 to 16 fall in the typical clinical range and indicate significant feelings of emptiness, loneliness, and poor sense of self. These scores are common among those with EDs but uncommon among those without EDs. Low clinical range includes scores less than or equal to 8 and indicate that the respondent does not have significant feelings of personal alienation.[27]

The Ineffectiveness Composite sums the T scores from the Low Self-Esteem and Personal Alienation scales which are highly correlated in both clinical and nonclinical samples. A high score on this composite indicates low self-evaluation and strong feelings of emptiness, combining to form a lack of understanding of self-identity. Respondents in the elevated clinical range have extreme deficit of self-identity, and they should also be evaluated to rule out depression and suicidal thinking. Scores this high are uncommon among those with clinical EDs and rare among those without EDs. Individuals scoring in the typical clinical range show a significant deficit of self-identity; this score is common among those with clinical EDs but less common among those without EDs. Respondents scoring in the low clinical range do not show significant deficit of self-identity, or at least it is not debilitating. High-scoring individuals are prone to developing EDs, especially as self-esteem is often tied to body size, shape or weight.[27]

The Interpersonal Insecurity scale examines discomfort, apprehension, and reticence regarding social situations and focuses on difficulty with self-expression and tendency to isolate oneself from others. Raw scores of 15 to 28 indicate elevated clinical range, within which respondents experience extreme discomfort in social situations as well as problems with self-expression to others, leading to self-isolation. High scores indicate problems with interpersonal communication. Typical clinical range includes scores from 7 to 14 and indicates that the respondent has significant feelings of discomfort and apprehension in social situations as well as difficulty with self-expression. Scoring in this range is common among those with clinical EDs, and it is not uncommon among those without diagnosed EDs. Low clinical range includes raw scores less than or equal to 6 and indicates minimal discomfort in social situations.[27]

The Interpersonal Alienation scale assesses disappointment, estrangement, distance and lack of trust in relationships as well as a tendency to feel trapped in relationships and inability to experience love from others. Raw scores from 13 to 28 indicate elevated clinical range, meaning that respondents have a very high level of disappointment, distance and distrust in relationships. High scores are uncommon clinical and nonclinical samples and indicate serious issues with interpersonal relationships. Typical clinical range includes raw scores from 6 to 12 and indicates significant feelings of disappointment, distance and distrust in relationships. Scores in this range are common among clinical samples and not uncommon among nonclinical samples. Low clinical range includes scores less than or equal to 5 and indicates no significant problems with trust, distance and disappointment.[27]

The Interpersonal Problems Composite combines the T scores from the previous two scales, which are moderately correlated. This composite measures respondents' degree of insecurity and discomfort in social relationships. Those with clinical EDs often have self-doubt and insecurity in relationships. Elevated clinical range reflects severe interpersonal problems and potential issues regarding psychotherapy that could impede recovery. Scores in this range are uncommon among clinical samples. Typical clinical range indicates significant distress in social situations and potentially significant problems with interpersonal relationships. Low clinical range indicates a lack of interpersonal problems and relationships are generally of good quality.[27]

The Interoceptive Deficits scale measures the ability to recognize and react to emotional states. There are two clusters for this scale: the Affective Fear item cluster indicates stress when emotions are too strong or out of control; the Affective Confusion cluster indicates difficulty in recognizing emotional states. Lack of interoceptive awareness is critical to understanding eating disorders. Raw scores from 21 to 36 fall in the elevated clinical range and indicate that the respondent has extreme difficulty in recognizing emotional states as well as intense fear of emotions when they are too strong. Individuals in this range tend to evaluate emotions to determine their validity rather than just accepting them as they come. High scores are uncommon among clinical and nonclinical samples; scores in this range indicate a high degree of psychopathology. Typical clinical range includes scores from 11 to 20 and indicates significant confusion in recognizing emotional states as well as fear of strong emotions. These scores are common among those with EDs but uncommon among those without. Low clinical range includes scores less than or equal to 10 and indicate a low degree of difficulty in responding to emotional states.[27]

The Emotional Dysregulation scale assesses mood instability, impulsivity, recklessness, anger, and self-destructiveness; it includes two items for substance abuse, one for alcohol and one for drugs. Poor impulse regulation is often associated with a poor prognosis when it comes to evaluating ED risk. Elevated clinical range includes raw scores from 10 to 32 and indicates extreme tendencies toward impulsivity, instability, recklessness, anger and self-destructiveness. This may include tendencies to abuse alcohol, drugs or both. Scores in this range are uncommon among both clinical and nonclinical samples; high scores may indicate a high degree of psychopathology in this area. Typical clinical range includes scores from 4 to 9 and indicates significant tendencies toward impulsivity, instability, recklessness and self-destructiveness. Scores in this range as well as elevated clinical indicate tendencies of mood intolerance, poor impulse regulation, and self-harm, all of which are poor prognostic signs when assessing ED risk. While these behaviors may be present in individuals with EDs, they are also common among psychiatric patients with other diagnoses. Low clinical range includes scores less than or equal to 3 and suggests no serious problems with impulse control, recklessness and self-destructiveness. Patients with Bulimia Nervosa tend to have very high impulsivity scores.[27]

The Affective Problems Composite combines the T scores for the previous two scales to assess the ability to identify, understand and respond to emotional states. The issues examined in this composite are often linked to the persistence of EDs as well as substance abuse. Elevated clinical range scores indicate severe difficulty in understanding and responding to emotional states as well as tendencies toward impulsivity and recklessness which could present serious problems in recovery. Typical clinical range indicates significant problems in understanding emotional states as well as tendencies of impulsivity and recklessness. Low clinical range suggests no serious issues responding to emotional states.[27]

The Perfectionism scale assesses one’s tendency to overachieve and set very high goals for themselves; perfectionism can be self-oriented, socially described, or both. Self-oriented perfectionism refers to one’s desire to achieve the highest standards not due to any outside pressure, while socially described perfectionism stems from seeking the approval of one’s family, friends, or others. Perfectionism may be a key driver of weight control habits and therefore an important part of developing EDs. Elevated clinical range includes raw scores from 17 to 24 and indicates unrelenting demand to meet the highest possible standards for oneself; failing to meet those goals leads to self-criticism. Scores in this range reflect the need to be the best at things and avoid disappointing others such as parents and teachers. These scores are uncommon among clinical and nonclinical samples. Typical clinical range includes raw scores from 10 to 16 and indicates significant need to achieve the highest possible goals, and failure to do so leads to self-criticism. Scores in this range are common among those with EDs, although psychiatric patients with different diagnoses also experience this. Low clinical range includes scores less than or equal to 9 and indicate no significant need to achieve unrealistic standards, but rather reflects more realistic standards of achievement.[27]

The Asceticism scale examines the tendency to seek virtue through ideals such as self-discipline, self-denial, self-restraint, self-sacrifice, and control of bodily urges. It assesses the degree to which respondents feel guilt upon experiencing pleasure. Elevated clinical range includes raw scores from 16 to 28. Scores in this range indicate extreme tendency to exercise self-restraint and self-sacrifice as well as considerable guilt around experiencing pleasure. These scores are uncommon among those with clinical EDs and rare among those without EDs; high scores indicate very serious problems with self-restraint and self-sacrifice and could cause issues in recovery if it is seen as support rather than treatment. Typical clinical range includes scores from 9 to 15, indicating significant tendency to seek virtue through self-restraint. There is some guilt around experiencing pleasure. Scores in this range are common among those with EDs, although it is common among other psychiatric patients as well. Low clinical range includes scores less than or equal to 8, indicating no serious issues regarding self-restraint and self-sacrifice. There is not significant guilt or shame surrounding pleasure. Asceticism can be expressed in different ways, including dieting to “purify” oneself or thinness as a virtue. General renunciation of physical gratification may include purposeful sleep deprivation, self-harm or injury, or exercising for atonement. Two clusters in this scale include “disgust for weakness” and “self-denial and suffering.”[27]

The Overcontrol Composite sums the T scores from the previous two scales to yield an indicator of extremely high standards and refusal to experience pleasure. High scores may indicate that the respondent feels they do not deserve care or love from others. Elevated clinical range indicate extreme demand for high achievement but also self-denial and sacrifice; these scores are uncommon among clinical samples and rare among nonclinical samples. Typical clinical range indicates some demand to meet high standards while engaging in self-denial and self-sacrifice. Low clinical range indicates no serious problems with unrealistic standards of self-restraint.[27]

The Maturity Fears scale examines the desire to return to the security of childhood. The psychopathology of Anorexia Nervosa and Bulimia Nervosa may relate to the fears of attaining an adult weight. Raw scores of 13 to 32 constitute elevated clinical range which indicates extreme desire to return to the security of childhood; adulthood's demands are too much to handle and the happiness of childhood cannot return in adulthood. Scores in this range are uncommon among clinical and nonclinical samples. Typical clinical range includes scores from 6 to 12 and indicates a significant desire to return to the security of childhood. Scores in this range are common among both clinical and nonclinical samples. Low clinical range includes scores less than or equal to 5 and indicate no significant desire to return to the security of childhood. Many individuals with EDs have a certain body weight that they are most scared of, which is often associated with the return of menses and normal hypothalamic pituitary function.[27]

The General Psychological Maladjustment composite sums the T scores of all the psychological scales to assess general psychological well-being. This composite may have value in predicting treatment outcomes in patients. Elevated clinical range indicates a very high level of distress across many different psychological constructs; scores in this range suggest serious problems in personal and interpersonal psychological domains. Poor psychological function tends to be associated with poor treatment outcomes. Typical clinical range indicates significant distress across many psychological areas; the respondent may have significant dysfunction in personal and interpersonal psychological domains. Scores in this range are common for those with EDs but uncommon among those without EDs. Low clinical range indicates no significant psychological distress. Scores in this range are very common among nonclinical samples.[27]

In addition to the EDI-3, the EDI-3 Symptom Checklist (EDI-3 SC) can be used to assess specific symptoms and provide additional information where necessary. This tool consists of 4 pages with 9 sections of questions, each of which relates to various symptoms.[27] The sections in the EDI-3 SC include Dieting, Exercise, Binge Eating, Purging, Laxatives, Diet Pills, Diuretics, and Menstrual History, as well as information on the respondent's current medications. Each section asks if the respondent has engaged in any behaviors relating to that section, and if so, when it started, the current frequency, and other questions relevant to that section such as, "What percentage of your exercise is aimed at controlling your weight?"[27]

The EDI-3 materials can be useful in both clinical and nonclinical settings. The original intent of developing this tool was to assess patients with clinically diagnosed eating disorders and provide information to understand the patient, plan their treatment, and monitor their progress. In the case of nonclinical individuals, the EDI-3 is helpful in assessing the risk of developing an ED. Because the EDI-3 and EDI-3 SC are self-report measures, the person administering them should scan them upon completion to ensure that the respondent has not omitted any questions. Any scale with one or more questions omitted should not be computed, and any composites with missing scales should also not be computed. Multiple missing components may invalidate the patient's protocol.[27] Finally, the EDI-3 scoring includes 3 Response Style Indicators to evaluate response patterns: the Inconsistency Scale, Infrequency Scale, and Negative Impression Scale. The Inconsistency Scale contains a few items with opposite content to determine if similar responses reflect inconsistent responding, as well as items with very similar content to determine if different responses reflect inconsistent responding. The Infrequency Scale contains items with a very low endorsement rate. The Negative Impressions Scale assesses whether responses trend in the negative or pathologically-keyed direction.[27]

Prevalence of LEA in Physically Active Individuals

The prevalence of LEA in males and females is difficult to accurately determine because of the varying methods used to determine it, although recent studies have estimated prevalence to be between 22% and 58%. Regardless of what the true percentage is, LEA is not uncommon among both males and females;[8] however, it may be more prevalent in females as they are more likely to undereat for reasons unrelated to sport as well. Research on this topic has found that about twice as many women as men consider themselves to be overweight, therefore more women than men may be actively trying to lose weight, regardless of performance goals.[7] LEA risk among various athlete populations and physically active individuals ranges from 14% to 63%.[8] While athletes across many different sports may be susceptible to LEA, individuals who participate in endurance sports, aesthetic sports, anti-gravitational sports and sports with weight classes are particularly prone to chronic energy deficiency due to the nature of those sports to focus on weight and/or body composition.[11]

While an individual's eating habits and diet choices are heavily influenced by body image, their environment, including coaches, teammates, and even social media, plays a big role as well. Coaches have a particularly prominent influence as they play a crucial role in the athlete's physical and mental health. While some coaches acknowledge the importance of nutrition in an athlete's performance, others coerce their athletes into achieving a certain physique/leanness or body weight. Comments regarding weight gain or potential benefits of being at a lighter bodyweight can profoundly impact an athlete's mental health and even physical health and even increase risk of developing DE/ED, especially if they act on those comments out of shame. Additionally, relationships with teammates can impact an athlete's self-image. While these relationships may be based on friendship, they also may have a competitive component to them as they strive to be "better" than the other. This can become psychologically damaging as well. Finally, comparison to others by way of social media is another way individuals may develop body image issues and attempt to combat them through weight loss.[9] Overall, the influence of coaches, teammates, and society as a whole plays into an athlete's self-perception and may push them to engage in behaviors which lead to LEA.

Conclusion

The primary component of the Female and Male Athlete Triads is LEA—that is, prolonged LEA can lead to the other two symptoms of the Triad. While males and females can both suffer from Triad symptoms because of LEA, males can withstand a greater energy deficit than females and therefore have to cross a lower LEA threshold before experiencing these symptoms. In both sexes, inadequate carbohydrate intake is often a primary contributor to LEA. Thus far, true LEA prevalence has been hard to assess due to varying methods which examine the issue. Additionally, LEA across different activity types is not entirely clear, although it has been established that leanness, weight class and aesthetic sports tend to have more athletes with LEA. While LEA does not always come about due to an ED or DE, presence of these can cause and/or exacerbate LEA. EDs and DE are common in both males and females, although they are more common in females. The EDI-3 and EDI-SC are tools used to assess ED risk; the EDI-SC examines specific pathogenic behaviors while the EDI-3 examines ED-specific as well as psychological issues, as these are indicative of ED risk as well. An individual's eating habits and behaviors are heavily influenced by their environment, making the role of coaches, teammates, family and friends important to an individual's self-perception and ultimately their tendency to engage in behaviors which could lead to LEA.

CHAPTER II: METHODS

Study Design

This study is cross-sectional with participants in a free-living environment (going about their daily activities as normal). This data was analyzed as part of a larger previous study. The independent variable in this study is EA, which is measured as normal or low. The dependent variables in this study are macronutrient intake (carbohydrates, proteins, and fats) and DE/ED risk (at risk or not at risk).

Participants

This study evaluated a previously collected sample of 58 (35 male and 23 female) physically active individuals. The inclusion criteria for this study is that the individuals engage in moderate exercise at least 3 times per week for at least 1 hour. Exclusion criteria include that the individuals are not currently training or exercising, have had a previous ED, has a known metabolic disease, long-term use of steroids, history of disease including cardiovascular, pituitary and thyroid, pregnancy, and not completing all parts of the study. These participants are recreational athletes including CrossFit athletes, recreational runners, weightlifters, cyclists, participants in recreational sports, and other types of physical activity.

Instruments

Basic anthropometric information was collected from participants including age (years), height (cm), weight (kg), BMI (kg/m^2), FFM (kg), and body fat %. Information regarding energy expenditure, intake and availability was also collected and includes resting metabolic rate (RMR) (kcals), EI (kcals), EEE (kcals), total daily energy expenditure (TDEE) (kcals), EA (kcal/kg FFM), and daily macronutrient intake including carbohydrates (g), proteins (g), and fats (g).

RMR was measured using indirect calorimetry using the MedGem (*Microlife MedGem*; HealtheTech, Golden, CO), a clinically validated way to measure RMR.[13] Participants recorded their dietary intake in a food log for which portion sizes were explained and samples given for 7 consecutive days to examine EI and macronutrient intake. To measure EEE, a training log was recorded for 7 consecutive days using a dietary software program (ESHA food processor 8.0, Salem, OR). EEE was measured in 2 ways: determining the metabolic equivalent of activity[28] then using the Heyward equation[29] to calculate EEE, and having participants wear a SenseWear Armband (BodyMedia Inc) during physical activity during the collection period.[13,30] TDEE will also be determined using these measures in conjunction with factors including duration, intensity of activity, weight, age, and gender.

To analyze DE/ED risk, participants completed the EDI-3 and EDI-3 SC. The EDI-3 is composed of 91 items within 12 primary scales (3 ED-specific scales and 9 general psychological scales) organized into 6 composites (one ED-specific and 5 psychological constructs) to assess the presence and magnitude of traits which are significant in those with clinically diagnosed EDs. Each scale description includes criteria for being considered elevated clinical, typical clinical, and low clinical.[27] This tool is used in this study to assess risk of DE, not to diagnose clinical EDs. The EDI-3 SC is a checklist in which participants report frequency of DE/ED symptoms including dieting, exercise, binge eating, purging, laxatives, diet pills, and diuretics, as well as menstrual cycle and current medication information.[27] This tool is used in this study to assess risk of DE, not to diagnose EDs.

Study Procedures

The study from which the data was taken from was approved by the Institutional Review Board from the University of South Carolina. The study consisted of an introductory informational meeting for participants, a 7-day data collection period, and a post-collection period. The introduction meeting consisted of the screening process, getting participants' consent, surveys and injury questionnaires, anthropometric measurements, equipment overview, and RMR measurement. During the collection period, participants were frequently reminded to complete food and activity logs and wear their heart rate monitors. The post-collection period allowed participants to review and submit food and activity logs. Differences between males and females in all variables mentioned above in the instruments section were analyzed for statistical significance.

Data Analysis

SPSS statistical software (version 28; SPSS Inc, Chicago, IL) was used to analyze the data in this study. We calculated power using G*Power software 3.1.9.4, which indicated we needed 20 males and 20 females for our study. Our study had 35 males and 23 females, therefore our study met power. Descriptive statistics (mean and standard deviation) for males and females were calculated for height, weight, BMI, FFM, and body fat %, RMR, EI, EEE, TDEE, EA, and intake of carbohydrates, proteins and fats. A threshold of 30 kcal/kg FFM for females and 20 kcal/kg FFM for males was used to constitute LEA. Additionally, mean and standard deviation of raw scores as well as percentages for low, typical and elevated clinical levels were calculated for males and females for each of the EDI-3 scales and composites. Frequencies of pathogenic behaviors as detailed in the EDI-SC were analyzed to determine whether individuals were at risk for disordered eating. Cross tabulations and chi-square analysis were used to determine the correlation between LEA and risk for disordered eating. Significance level of $P < .05$ was used for all analyses.

Chapter III: Results

This study examined 58 physically active individuals including 35 males and 23 females participating in various activities such as CrossFit, recreational running, weightlifting, cycling, recreational sports, and other physical activities. First, anthropometric measurements were collected including height, weight, BMI, FFM, and body fat % for which mean and standard deviation for males and females is shown in Table 1. Table 2 shows measurements of RMR, EI, EEE, TDEE, and EA as well as macronutrient intake (proteins, carbohydrates, and fats) for males and females along with the mean and standard deviation of each measure. Macronutrient intake was assessed for each individual and classified as low, adequate, or high based on recommendations for high activity level from the American College of Sports Medicine[10] and is summarized in Table 3. Table 4 summarizes the participants' responses to the EDI-3[27] and includes the mean and standard deviation of raw scores for each scale and composite as well as number and % of participants which fall under low clinical, typical clinical, or elevated clinical classification[27] for both males and females. Table 5 summarizes participants' responses to the EDI-SC,[27] providing the frequency of each pathogenic behavior for males and females as well as within gender % and within behavior % for each behavior. Table 6 summarizes overall ED risk for males, females, and all individuals based on EDI-3 and EDI-SC responses by showing how many individuals and what % within gender present as typical clinical or elevated clinical on any of the EDI-3 scales, EDI-SC behaviors, or both. Table 7 summarizes total LEA risk, total ED risk, LEA with ED risk, LEA without ED risk, and ED risk without LEA, providing number of males, females, and all individuals as well as within gender % for each category.

Energy Needs and Macronutrient Intake

Overall, significant differences were found between males and females in terms of energy needs and intake. Mean RMR for males and females was 1858.9 kcals and 1386.5 kcals respectively and was found to be significantly different ($P < .001$). Mean EI was also significantly different ($P < .001$) with 2665.1 kcals and 1749.8 kcals for males and females respectively. EEE was significantly different ($P = .002$) for males and females with 780.1 kcals and 467.0 kcals respectively. TDEE was significantly different ($P < .001$) for males and females with 2628.7 and 2342.1 respectively. While all of these statistics were found to be statistically significant, no significant difference ($P = .840$) was found in EA for males and females with 27.1 kcal/kg/FFM and 26.4 kcal/kg/FFM respectively. Intake of all three macronutrients was found to be significantly different between males and females, with proteins ($P < .001$) being 135.3 for males and 90.9 for females; carbohydrates ($P < .001$) being 300.1 for males and 192.6 for females; and fats ($P = .002$) being 97.6 for males and 65.7 for females. This information is summarized in Table 2.

Next, average intake of each macronutrient was assessed for males and females to determine whether intake was low, adequate, or high based on nutritional guidelines for high activity levels from the American College of Sports Medicine.[10] Ultimately we found 25.7% (n = 9) males and 39.1% (n = 9) of females had low protein intake; 45.7% (n = 16) of males and 39.1% (n = 9) of females had adequate protein intake; and 28.6% (n = 10) of males and 21.7% (n = 5) of females and high protein intake. No significant differences were found across sex and levels of protein intakes [$\chi^2_{2,58} = 1.195$, $p = .550$]. Next, we found 91.4% (n = 32) of males and 100% (n = 23) of females had low carbohydrate intake; 8.6% of males (n = 3) and 0% of females had adequate carbohydrate intake; and no one had high carbohydrate intake. No significant differences were found across sex and levels of carbohydrate intakes [$\chi^2_{1,58}$ = 2.079, p = .149], although it is important to note that only 3 participants had even adequate intake, all of whom were male. Finally, we found no one had low fat intake, 62.9% (n = 22) of males and 69.6% (n = 16) of females had adequate fat intake; and 37.1% (n = 13) of males and 30.4% (n = 7) of females had high fat intake. No significant differences were found across sex and levels of fat intakes [$\chi^2_{1,58}$ = .276, p = .599], although it is important to note that no single participant presented with low fat intake. This information is summarized in Table 3.

ED Risk and LEA Risk

Responses to the EDI-3 showed significant differences across sex and a few of the scales and composites. Significant differences in males' and females' raw scores were found in the Drive for Thinness (DT) (P = .015) and Body Dissatisfaction (BD) (P = .004) scales as well as the Eating Disorder Risk Composite (EDRC) (P = .009). While the Overcontrol Composite (OC) showed no significant difference (P = .055) in males' and females' raw scores, there was a significant difference [$\chi^2_{2,58}$ = 6.132, p = .047], in the male and female clinical levels of the OC: 65.7% (n = 23) of males presented as low clinical, 34.3% (n = 12) as typical clinical, and none as elevated clinical; 87.0% (n = 20) of females presented as low clinical, 8.7% (n = 2) as typical clinical, and 4.3% (n = 1) as elevated clinical. While many of the scales and composites in the EDI-3 show no significant differences across sex, it is important to observe the number of typical clinical and elevated clinical cases of each as this indicates ED risk. Table 4 summarizes this information.

The EDI-SC assessment showed significant differences across sex and some pathogenic behaviors. Significant differences were found in the dieting behaviors of males and females [$\chi^2_{1,58}$ = 5.836, p = .016] with 37.1% (n = 13) of males and 69.6% (n = 16) of females engaged in dieting behaviors. Significant differences were also found in the purging behaviors of males and females [$\chi^2_{1,58}$ = 4.814, p = .028] with 0% of males and 13.0% (n = 3) of females engaged in purging behavior. While no other significant differences were found across sex and pathogenic behaviors, it is important to note the number of individuals engaged in these behaviors as they indicate ED risk. Table 5 summarizes this information.

Overall, ED risk based on EDI-3, EDI-SC, or both was found to be significantly different across sex [$\chi^2_{3,58}$ = 12.124, p = .007]. 37.1% (n = 13) of males and 8.7% (n = 2) of females were not at risk for EDs; 17.1% (n = 6) of males and 4.3% (n = 1) of females were at risk based on EDI-3 responses but not EDI-SC; 14.3% (n = 5) of males and 47.8% (n = 11) of females were at risk based on EDI-SC responses but not EDI-3; and 31.4% (n = 11) of males and 39.1% (n = 9) of females were at risk based on both EDI-3 and EDI-SC responses. Table 6 summarizes this information.

Overall, LEA risk regardless of ED risk was found to be significantly difference across sex [$\chi^2_{1,58}$ = 10.032, p = .002], and overall ED risk (not specified by EDI-3, EDI-SC, or both) was significantly different across sex [$\chi^2_{1,58}$ = 5.858, p = .016]. Distribution of LEA risk with ED risk, LEA risk without ED risk, and ED risk without LEA risk was significantly different across sex [$\chi^2_{1,58}$ = 6.478, p = .011]. 31.4% (n = 11) of males and 73.9% (n = 17) of females were found to have LEA. 62.9% (n = 22) of males and 91.3% (n = 21) of females were found to have ED risk. 25.7% (n = 9) of males and 69.6% (n = 16) of females had LEA with ED risk. 5.7% (n = 2) of males and 4.3% (n = 1) of females had LEA without ED risk, and 37.1% (n = 13) of males and 21.7% (n = 5) of females had ED risk with no LEA. Table 7 summarizes this information.

CHAPTER IV: DISCUSSION AND CONCLUSION

The purpose of this study was to assess prevalence of LEA and ED risk in physically active individuals and examine differences between males and females. Ultimately we found differences across sex and LEA risk and ED risk, although prevalence was high in males and females.

Energy Availability

EA was very similar in males and females with 27.1 kcal/kg FFM and 26.4 kcal/kg FFM respectively. Although there were significant differences across sex in RMR, EI, EEE, TDEE and all three macronutrients, no significant difference was found in EA. However, even though the EA numbers are similar, the implications for males and females are not the same due to males' ability to withstand a greater energy deficit. With the male LEA threshold of 20 kcal/kg FFM and female threshold of 30 kcal/kg FFM, the average female in this study had LEA while the average male did not, despite the similar EA number. One study found prevalence of EA below 30 kcal/kg FFM in males and females to be similar: 56% vs 51% in adolescent males and females respectively across a variety of sports; 25% vs 31% in male and female endurance runners and walkers; and 42% vs 29% in male and female cross-country runners.[4] This is consistent with our study results in that male and female EA were similar, but again we must consider males' lower LEA threshold. LEA risk was significantly different (p=.002) across sex with 31.4% (n=11) of males and 73.9% (n=17) of females having LEA. Although exact prevalence of LEA in males and females has proven difficult to determine, our findings are consistent with existing literature in that LEA prevalence is high among males and females, although it is higher in females. This could be due in part to the fact that females may undereat for reasons not related to performance or training goals.[7]

Macronutrient Intake

Intake of carbohydrates, proteins and fats was significantly different across sex, although distribution of intake level (low, adequate, high) was not. Average male protein intake was higher than females, and a larger percentage of males fell within the adequate and high consumption range; a larger percentage of females fell within the low range. Carbohydrate intake was low across males and females with only 8.6% (n=3) of males and 0% of females having adequate intake. No participants had high carbohydrate intake. One study found that females had such low EI that females on a high % carbohydrate diet consumed nearly the same amount of carbohydrates than males on a low % carbohydrate diet.[7] Another study found a majority of athletes across all sports have inadequate carbohydrate intake.[3] This literature is consistent with our findings of low carbohydrate intake across all participants, especially females. Fat intakes for all participants fell within the adequate and high ranges with none in the low range. This, in combination with low carbohydrate intake, could be related to the high number of CrossFit athletes in this study. Low-carbohydrate diets such as keto, paleo, or zone diets are often used by CrossFit athletes to increase fat oxidation in the short-term; however, long-term use of these diets can be harmful to high-intensity exercise.[32]

ED Risk

Significant differences were found across sex and ED risk (p=.016) with 62.9% (n=22) of males and 91.3% (n=21) females found to have ED risk based on responses to the EDI-3 and EDI-SC. Participants were considered to be at risk if they engaged in any pathogenic behaviors assessed by the EDI-SC, scored in the typical or elevated clinical level for any EDI-3 composites, or both. The distribution of ED risk based on responses to the ED assessment tools—not at risk, at risk based on EDI-3 only, at risk based on EDI-SC only, or at risk based on

EDI-3 and EDI-SC—was significantly different across sex as well. Two categories were particularly different between males and females: 37.1% (n=13) of males had no ED risk whereas only 8.7% (n=2) of females had no ED risk; 14.3 (n=5) of males had ED risk based only on EDI-SC while 47.8% (n=11) of females had ED risk based only on EDI-SC. These results are consistent with existing literature in that females overall have higher ED risk than males and higher frequency of pathogenic behaviors which indicate ED risk. Behaviors such as dieting are particularly prevalent among females whether their reasoning is related to sports or not, and more women diet to improve appearance rather than performance.[7] One study of collegiate female athletes and dancers found ED risk prevalence to be 76%, which is slightly lower than we found in our study, but emphasizes high ED risk in females nonetheless.[31] Although females were found to have higher ED risk than males, it is important to note the 62.9% prevalence in males as this is still a significant portion of the males in this study.

EDI-3 and EDI-SC

Within the EDI-3, significant differences were found across sex and raw scores in the Drive for Thinness (*p*=.015) and Body Dissatisfaction (*p*=.004) scales and Eating Disorder Risk Composite (*p*=.009). This, again, is consistent with existing literature as females tend to have higher ED risk than males,[7] and each of these scales and composite measures ED risk. The distribution of clinical level in the Overcontrol Composite (*p*=.047) was significantly different across sex as well. The Overcontrol Composite sums the T-scores of the Perfectionism and Asceticism scales, both of which categorized many participants into typical and even elevated clinical ranges. However, males had higher instances of typical and elevated clinical ranges in both cases. Ample research has found perfectionism to be associated with disordered eating behaviors in female athletes, although more recent studies have found a similar association in males,[8] which is consistent with our findings here. Perfectionism is common in athletic populations, especially in elite athletes as they strive toward unrealistically high expectations in their sports. While perfectionism is often seen as a positive trait in sports to enhance performance, excessive desire for perfection can cause stress and anxiety and even lead to disordered eating behaviors in pursuit of certain performance goals.[31] This explains why so many participants scored highly in this EDI-3 scale.

Although not all scales and composites showed significant differences across sex, it is important to observe the distribution of the clinical levels of each as some of them show a large percentage of participants scoring in typical or elevated clinical range. Typical clinical range in any scale or composite means that the participant's score is what someone with a diagnosed ED would typically score, so scoring in this range and especially elevated clinical range is a cause for concern. As previously discussed, perfectionism is one scale where many participants scored in the typical or elevated ranges. Other scales with similarly high scores include Interpersonal Insecurity, Interpersonal Alienation, and Maturity Fears. This shows that ED risk stems not only from ED-specific issues but also from general psychological problems.

Within the EDI-SC, significant differences were found across sex and dieting (p=.016) and purging (p=.028) behaviors. Females exhibit more frequent engagement in this behaviors, which is again consistent with existing literature which finds females to have higher ED risk than males.[7] Regarding pathogenic behaviors among females specifically, our study found instances of each behavior to be similar to a previous study: 69.9% prevalence of dieting in our study versus 51.2% in the previous study; 34.8% versus 19.8% prevalence of binge eating; 13.0% versus 12.4% purging prevalence; 0% versus 3.3% use of laxatives; 21.7% versus 7.4% use of diet pills; and 4.3% versus 1.7% use of diuretics. Exercise to control weight distribution was also similar with 13.0% in our study using exercise to control weight 75%-100% of the time versus 13.2% in a previous study.[31]

While only dieting and purging were significantly different across sex, it is again important to look at the percentage of participants who engaged in the behaviors. 37.1% of males and 69.9% of females have engaged in dieting behaviors. This statistic alone puts 37.1% of males and 69.9% of females at risk for EDs. Table 5 also breaks down instances by percentages within behavior to show whether male or female participants were primarily responsible for certain behaviors. For example, females comprised 100% of purging behavior in this study. Any instance of these behaviors indicates ED risk, so it is concerning when prevalence is this high.

LEA with or without ED Risk

In addition to the significant differences across sex and LEA and ED risk, the relationship between LEA and ED risk was found to be statistically significant (p=.011). 25.7% (n=9) of males and 69.6% (n=16) of females had LEA with ED risk; 5.7% (n=2) of males and 4.3% (n=1) of females had LEA with no ED risk; and 37.1% (n=13) of males and 21.7% (n=5) of females had ED risk with no LEA. These numbers show that LEA does not often come without ED risk, and ED risk does not often come without LEA. Therefore, presence of one is likely to come with presence of the other. We found LEA risk to be slightly lower and ED risk to be higher in females compared to a previous study, which found LEA prevalence of 81%, ED risk prevalence of 76%, LEA with ED risk prevalence of 76%, and LEA without ED risk prevalence of 24%.[31] This supports our finding that LEA and ED risk coexist more often than not.

Limitations

Although our study found significant differences across sex and LEA and ED risk and high prevalence of both in males and females, there are some limitations which need to be addressed. First, we assumed that all participants were truthful in reporting daily food logs and questionnaires. Females particularly may underreport EI in their food logs,[12] and individuals with EDs or disordered behaviors tend to underreport EI in their food logs as well. If this is the case, we may have gathered inaccurate information regarding EI, which in turn would lead to incorrect EA numbers and macronutrient intakes. If true EA is higher than we found, fewer females might have LEA risk, and perhaps the difference across sex would not be significantly different. A second limitation is individuals may have inconsistent or peculiar or simply untrue responses on the EDI-3 and/or EDI-SC. The EDI-3 details 3 scales which assess response style: inconsistency, infrequency, and negative impression. High scores on any of these scales means that results should be interpreted with caution.[27] If the responses on these tools in our study provided us with skewed or untrue information, we could have made inaccurate conclusions regarding ED risk. A third limitation is that with such a wide variety of activity types, we have no way to differentiate across activity level. Many participants in our study were CrossFit athletes who frequently engage in intense exercise, while some participants may expend less energy in activities like recreational sports or lower intensity walking/running. With macronutrient intake, specifically carbohydrate intake, we used “high” activity level to categorize adequate intake for all participants, when in reality some participants may have fallen in the “moderate” range, and perhaps some in the “very high” range.[10] We could have miscategorized some participants’ macronutrient intake if they fell within an activity range other than “high.”

Future Research

Future research should focus on prevalence of the Triad symptoms, especially LEA, in male and female physically active individuals. True prevalence of LEA has been difficult to find thus far due to varying methods in different studies, so one agreed-upon figure to quantify prevalence would be helpful. LEA across different activity types would be another direction to take future research as LEA varies widely among athletes participating in different sports. LEA tends to be higher among weight class, leanness, aesthetic, and antigravitational sports, but solid numbers for prevalence in males and females across many different activities could be helpful. Additionally, future research could focus on ED risk in conjunction with LEA risk across sex and different activity types.

Clinical Significance and Conclusion

LEA in physically active individuals, both male and female, is highly prevalent. Even with significantly different RMR, EI, and EEE, males and females had similarly low EA with 27.1 and 26.4 kcal/kg FFM respectively. However, this EA figure is more of an issue for females as males can handle a greater energy deficit before experiencing consequences of clinical LEA. A greater percentage of females than males had LEA, and this difference was statistically significant; however, prevalence was high among both sexes. Our study shows that physically active individuals, regardless of sex or activity, often have LEA risk.

Our study found ED risk to be prevalent among male and female physically active individuals, although it is higher for females. Disordered eating behaviors are common among physically active individuals with higher prevalence among females, especially in pathogenic behaviors like dieting and purging. Additionally, many individuals had ED risk based on psychological factors rather than ED-specific factors, so it is important to assess both behavior types. One psychological factor which is particularly dangerous to athletes and physically active individuals is perfectionism, as unchecked perfectionist behaviors can lead to disordered eating behaviors.

Finally, LEA with ED risk is prevalent among male and female physically active individuals. These two factors have a statistically significant relationship, and our study shows that one does not often exist without the other. That is, if an individual has LEA, they are likely to have ED risk, and vice versa. Although females had higher prevalence of LEA with ED risk than males, this combination was common in both sexes. Overall, many physically active individuals tend to have LEA, ED risk, and often both.

REFERENCES

1. Nattiv, A., Loucks, A. B., Manore, M. M., Sanborn, C. F., Sundgot-Borgen, J., Warren, M. P., & American College of Sports Medicine (2007). American College of Sports Medicine position stand. The female athlete triad. *Medicine and science in sports and exercise*, *39*(10), 1867–1882. https://doi.org/10.1249/mss.0b013e318149f111
2. Javed, A., Tebben, P. J., Fischer, P. R., & Lteif, A. N. (2013). Female athlete triad and its components: toward improved screening and management. *Mayo Clinic proceedings*, *88*(9), 996–1009. https://doi.org/10.1016/j.mayocp.2013.07.001
3. Tenforde, A. S., Barrack, M. T., Nattiv, A., & Fredericson, M. (2016). Parallels with the Female Athlete Triad in Male Athletes. *Sports medicine (Auckland, N.Z.)*, *46*(2), 171–182. https://doi.org/10.1007/s40279-015-0411-y
4. Nattiv, A., De Souza, M. J., Koltun, K. J., Misra, M., Kussman, A., Williams, N. I., Barrack, M. T., Kraus, E., Joy, E., & Fredericson, M. (2021). The Male Athlete Triad-A Consensus Statement From the Female and Male Athlete Triad Coalition Part 1: Definition and Scientific Basis. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine*, *31*(4), 335–348. https://doi.org/10.1097/JSM.00000000000 00946
5. Statuta S. M. (2020). The Female Athlete Triad, Relative Energy Deficiency in Sport, and the Male Athlete Triad: The Exploration of Low-Energy Syndromes in Athletes. *Current sports medicine reports*, *19*(2), 43–44. https://doi.org/10.1249/JSR.0000000000000679
6. Williams, N. I., Statuta, S. M., & Austin, A. (2017). Female Athlete Triad: Future Directions for Energy Availability and Eating Disorder Research and Practice. *Clinics in sports medicine*, *36*(4), 671–686. https://doi.org/10.1016/j.csm.2017.05.003
7. Loucks, A. B., Kiens, B., & Wright, H. H. (2011). Energy availability in athletes. *Journal of sports sciences*, *29 Suppl 1*, S7–S15. https://doi.org/10.1080/02640414.2011.588958
8. Logue, D. M., Madigan, S. M., Melin, A., Delahunt, E., Heinen, M., Donnell, S. M., & Corish, C. A. (2020). Low Energy Availability in Athletes 2020: An Updated Narrative Review of Prevalence, Risk, Within-Day Energy Balance, Knowledge, and Impact on Sports Performance. *Nutrients*, *12*(3), 835. https://doi.org/10.3390/nu12030835
9. Wasserfurth, P., Palmowski, J., Hahn, A., & Krüger, K. (2020). Reasons for and Consequences of Low Energy Availability in Female and Male Athletes: Social Environment, Adaptations, and Prevention. *Sports medicine - open*, *6*(1), 44. https://doi.org/10.1186/s40798-020-00275-6
10. Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). American College of Sports Medicine Joint Position Statement. Nutrition and Athletic Performance. *Medicine and science in sports and exercise*, *48*(3), 543–568. https://doi.org/10.1249/MSS.0000000000000852
11. Loucks A. B. (2004). Energy balance and body composition in sports and exercise. *Journal of sports sciences*, *22*(1), 1–14. https://doi.org/10.1080/0264041031000140518
12. Reed, J. L., De Souza, M. J., & Williams, N. I. (2013). Changes in energy availability across the season in Division I female soccer players. *Journal of sports sciences*, *31*(3), 314–324. https://doi.org/10.1080/02640414.2012.733019

13. Drenowatz, C., Eisenmann, J. C., Pivarnik, J. M., Pfeiffer, K. A., & Carlson, J. J. (2013). Differences in energy expenditure between high- and low-volume training. *European journal of sport science*, *13*(4), 422–430. https://doi.org/10.1080/17461391.2011.635707
14. Loucks A. B. (2007). Low energy availability in the marathon and other endurance sports. *Sports medicine (Auckland, N.Z.)*, *37*(4-5), 348–352. https://doi.org/10.2165/00007256-200737040-00019
15. Burke, L. M., Hawley, J. A., Wong, S. H., & Jeukendrup, A. E. (2011). Carbohydrates for training and competition. *Journal of sports sciences*, *29 Suppl 1*, S17–S27. https://doi.org/10.1080/02640414.2011.585473
16. Phillips, S. M., & Van Loon, L. J. (2011). Dietary protein for athletes: from requirements to optimum adaptation. *Journal of sports sciences*, *29 Suppl 1*, S29–S38. https://doi.org/10.1080/02640414.2011.619204
17. United States Department of Agriculture. (n.d.). *Home: Dietary guidelines for Americans*. https://www.dietaryguidelines.gov/
18. Burke L. M. (2015). Re-Examining High-Fat Diets for Sports Performance: Did We Call the 'Nail in the Coffin' Too Soon?. *Sports medicine (Auckland, N.Z.)*, *45 Suppl 1*(Suppl 1), S33–S49. https://doi.org/10.1007/s40279-015-0393-9
19. Barnes M. J. (2014). Alcohol: impact on sports performance and recovery in male athletes. *Sports medicine (Auckland, N.Z.)*, *44*(7), 909–919. https://doi.org/10.1007/s40279-014-0192-8
20. Beard, J., & Tobin, B. (2000). Iron status and exercise. *The American journal of clinical nutrition*, *72*(2 Suppl), 594S–7S. https://doi.org/10.1093/ajcn/72.2.594S
21. Institute of Medicine (US) Panel on Micronutrients. (2001). *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. National Academies Press (US).
22. Larson-Meyer, D. E., & Willis, K. S. (2010). Vitamin D and athletes. *Current sports medicine reports*, *9*(4), 220–226. https://doi.org/10.1249/JSR.0b013e3181e7dd45
23. National Institutes of Health Office of Dietary Supplements. (2018). *Vitamin D fact sheet for health professionals.* https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/#h2
24. Sale, C., & Elliott-Sale, K. J. (2019). Nutrition and Athlete Bone Health. *Sports medicine (Auckland, N.Z.)*, *49*(Suppl 2), 139–151. https://doi.org/10.1007/s40279-019-01161-2
25. National Institutes of Health Office of Dietary Supplements. (2016). *Calcium fact sheet for health professionals.* https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/#h2
26. Juwono, I.D., Tolnai, N. & Szabo, A. (2021). Exercise Addiction in Athletes: a Systematic Review of the Literature. *International Journal of Mental Health and Addiction*. https://doi.org/10.1007/s11469-021-00568-1
27. Garner, David. (2004). Eating disorder inventory-3 (EDI-3) Professional Manual. Lutz, FL: Psychological Assessment Resources. International Journal of Eating Disorders. 35. 478-479.
28. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and science in sports and exercise.* 2000;32(9; SUPP/1):S498-S504.
29. Gibson AL, Wagner D, Heyward V. *Advanced Fitness Assessment and Exercise Prescription, 8E*. Human kinetics; 2018.

30. St-Onge, M., Mignault, D., Allison, D. B., & Rabasa-Lhoret, R. (2007). Evaluation of a portable device to measure daily energy expenditure in free-living adults. The American journal of clinical nutrition, 85(3), 742–749. https://doi.org/10.1093/ajcn/85.3.742
31. Torres-McGehee, T. M., Emerson, D. M., Pritchett, K., Moore, E. M., Smith, A. B., & Uriegas, N. A. (2020). Energy Availability with or without Eating Disorder Risk in Collegiate Female Athletes and Performing Artists. Journal of athletic training, 56(9), 993–1002. Advance online publication. https://doi.org/10.4085/JAT0502-20
32. Dos Santos Quaresma, M., Guazzelli Marques, C., & Nakamoto, F. P. (2021). Effects of diet interventions, dietary supplements, and performance-enhancing substances on the performance of CrossFit-trained individuals: A systematic review of clinical studies. *Nutrition (Burbank, Los Angeles County, Calif.)*, *82*, 110994. https://doi.org/10.1016/j.nut.2020.110994

Table 1. Physical measurements for male (n=35) and female (n=23) recreational athletes

Anthropometric Measurements	Male M±SD	Females M±SD
Age (years)	26.0 ± 4.9	26.9 ± 6.1
Height (cm)	178.9 ± 6.3	164.6 ± 6.6
Weight (kg)	78.7 ± 10.5	64.2 ± 6.9
BMI (kg/m^{2})	24.6 ± 3.2	23.7 ± 2.2
FFM (kg)	68.7 ± 7.2	48.7 ± 4.4
Body Fat Percent (%)	14.9 ± 5.9	21.2 ± 5.9

Table 2. Energy needs assessment for males (n=35) and females (n=23) recreational athletes.

Energy Needs	Males M±SD	Females M±SD	P-value
RMR (kcals)	1858.9 ± 440.1	1386.5 ± 279.1	<.001
EI (kcals)	2665.1 ± 926.7	1749.8 ± 549.7	<.001
EEE (kcals)	780.1 ± 428.1	467.0 ± 237.5	.002
TDEE (kcals)	2628.7 ± 166.6	2342.1 ± 137.1	<.001
EA (kcal/kg/FFM)	27.1 ± 11.3	26.4 ± 12.5	.840
Macronutrients			
Protein (g)	135.3 ± 52.3	90.9 ± 33.0	<.001
Carbohydrates (g)	300.1 ± 118.7	192.6 ± 57.0	<.001
Fats (g)	97.6 ± 42.1	65.7 ± 28.9	.002

Table 3. Macronutrient assessment based on recommendations for physically active populations for all recreational athletes (n=58) and within males (n=35), and females (n=23).

	All		Male		Female		
Macronutrients	**%**	**n**	**% (n/35)**	**n**	**% (n/23)**	**n**	**P-Value**
Protein							.550
Low	31.0	18	25.7	9	39.1	9	
Adequate	43.1	25	45.7	16	39.1	9	
High	25.9	15	28.6	10	21.7	5	
Carbohydrates							.149
Low	94.8	55	91.4	32	100.0	23	
Adequate	5.2	3	8.6	3	0	0	
High	0	0	0	0	0	0	
Fats							.599
Low	0	0	0	0	0	0	
Normal	65.5	38	62.9	22	69.6	16	
High	34.5	20	37.1	13	30.4	7	

Table 4: Eating disorder characteristics (n=58). Frequencies are reported "within": sub-discipline group: Males (n = 35) and Females (n = 23). Data is represented in means and standard deviation for raw scores and presented in percent (%) and frequency (n) for categorical data.

	Males				Females					
	Raw Score	**Low Clinical**	**Typical Clinical**	**Elevated Typical**	**Raw Score**	**Low Clinical**	**Typical Clinical**	**Elevated Clinical**	**P-value (raw score)**	**P-value (clinical level)**
Eating Disorders Risk Scales	**Mean±SD**	**% (n/35)**	**% (n/35)**	**% (n/35)**	**Mean±SD**	**% (n/23)**	**% (n/23)**	**% (n/23)**		
Drive for Thinness (DT)	2.7±3.7	97.1 (34)	2.9 (1)	0 (0)	5.4±4.6	95.7 (22)	4.3 (1)	0 (0)	.015	.761
Bulimia (B)	1.9±2.5	82.9 (29)	17.1 (6)	0 (0)	2.1±2.1	82.6 (19)	17.4 (4)	0 (0)	.768	.980
Body Dissatisfaction (BD)	4.1±5.3	100.0 (35)	0 (0)	0 (0)	9.2±7.7	91.3 (21)	8.7 (2)	0 (0)	.004	.076
Psychological Scales										
Low Self-Esteem (LSE)	1.5±2.6	97.1 (34)	2.9 (1)	0 (0)	1.3±1.5	100.0 (23)	0 (0)	0 (0)	.748	.414
Personal Alienation (PA)	1.9±2.0	100.0 (35)	0 (0)	0 (0)	2.7±2.7	100.0 (23)	0 (0)	0 (0)	.206	n/a
Interpersonal Insecurity (II)	4.5±3.8	74.3 (26)	25.7 (9)	0 (0)	5.4±4.5	69.6 (16)	26.1 (6)	4.3 (1)	.381	.457
Interpersonal Alienation (IA)	3.6±2.8	71.4 (25)	28.6 (10)	0 (0)	4.2±3.5	69.6 (16)	30.4 (7)	0 (0)	.460	.879
Interceptive Deficits (ID)	1.7±2.4	97.1 (34)	2.9 (1)	0 (0)	3.0±2.9	100.0 (23)	0 (0)	0 (0)	.074	.414
Emotional Dysregulation (ED)	1.6±2.4	91.4 (32)	5.7 (2)	2.9 (1)	2.1±2.0	78.3 (18)	21.7 (5)	0 (0)	.453	.143
Perfectionism (P)	12.3±4.6	25.7 (9)	54.3 (19)	20.0 (7)	10.6±4.3	43.5 (10)	39.1 (9)	17.4 (4)	.163	.359
Asceticism (A)	5.1±3.0	85.7 (30)	14.3 (5)	0 (0)	3.7±2.8	95.7 (22)	4.3 (1)	0 (0)	.072	.224
Maturity Fears (MF)	5.3±4.3	54.3 (19)	37.1 (13)	8.6 (3)	6.3±4.6	47.8 (11)	43.5 (10)	8.7 (2)	.407	.881
Composite										
ED Risk Composite (EDRC)	87.4±11.9	100.0 (35)	0 (0)	0 (0)	96.8±14.3	95.7 (22)	4.3 (1)	0 (0)	.009	.213
Ineffectiveness Composite (IC)	62.0±6.8	97.1 (34)	2.9 (1)	0 (0)	62.8±6.4	100.0 (23)	0 (0)	0 (0)	.634	.414
Interpersonal Problems Composite (IPC)	75.9±9.6	82.9 (29)	17.1 (6)	0 (0)	78.3±12.3	73.9 (17)	26.1 (6)	0 (0)	.404	.411
Affective Problems Composite (APC)	69.7±6.7	94.3 (33)	5.7 (2)	0 (0)	72.6±5.9	100.0 (23)	0 (0)	0 (0)	.099	.243
Over control Composite (OC)	84.1±10.9	65.7 (23)	34.3 (12)	0 (0)	78.6±9.8	87.0 (20)	8.7 (2)	4.3 (1)	.055	.047
General Psychological Maladjustment (GPMC)	333.7±25.3	100.0 (35)	0 (0)	0 (0)	335.7±25.7	100.0 (23)	0 (0)	0 (0)	.762	n/a

Table 5: Pathogenic behaviors "At Risk" for associated behavior for males (n=35) for females (n=23). Values are presented in percent (%) and sample size (n).

		Males			Females			
	ALL (n)	n	Within Gender % (n/35)	Within Behavior % (n/ALL)	n	Within Gender % (n/23)	Within Behavior % (n/ALL)	P-value
Pathogenic Behaviors								
Dieting	29	13	37.1	44.8	16	69.9	55.2	.016
Binge Eating	18	10	28.6	55.6	8	34.8	44.4	.617
Purging	3	0	0	0	3	13.0	100.0	.028
Laxatives	2	2	5.7	100.0	0	0	0	.243
Diet Pills	8	3	8.6	37.5	5	21.7	62.5	.155
Diuretics	2	1	2.9	50.0	1	4.3	50.0	.761
Exercise to Control Weight								.120
0% of time	20	15	42.9	75.0	5	21.7	25.0	
<25% of time	20	13	37.1	65.0	7	30.4	35.0	
25%-50% of time	13	5	14.3	38.5	8	34.8	61.5	
More than 75% of time	4	1	2.9	25.0	3	13.0	75.0	
100% of time	1	1	2.9	100.0	0	0	0	

Table 6: Distribution of ED risk (Percent within gender and Sample Size)

	Not at Risk	EDI-3 Only	EDI-SC Only	Both	P-value
	% (n)	**% (n)**	**% (n)**	**% (n)**	
All Athletes	25.9 (15)	12.1 (7)	27.6 (16)	34.5 (20)	.007
Males	37.1 (13)	17.1 (6)	14.3 (5)	31.4 (11)	
Females	8.7 (2)	4.3 (1)	47.8 (11)	39.1 (9)	

Table 7: Distribution of LEA, ED, and LEA with ED risk (Percent within gender and Sample Size)

	LEA Risk	ED Risk	LEA with ED Risk	LEA with no ED risk	ED risk with no LEA
	% (n)	**% (n)**	**% (n)**	**% (n)**	**% (n)**
All Athletes	48.3 (28)	74.1 (43)	43.1 (25)	5.2 (3)	31.0 (18)
Males	31.4 (11)	62.9 (22)	25.7 (9)	5.7 (2)	37.1 (13)
Females	73.9 (17)	91.3 (21)	69.6 (16)	4.3 (1)	21.7 (5)
P-value	.002	.016		.011*	

*Significance of LEA and ED risk distribution

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

UNIVERSITY OF
SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
APPROVAL LETTER

Toni Torres-McGehee , PhD
College of Education
Department of Physical Education
1300 Wheat Street, Blatt PE Center 218
Columbia SC 29208,

Re: **Pro00092173**

Dear Dr. Toni Torres-McGehee:

This is to certify that the research proposal entitled, ***Examination of the Female and Male Athlete Triad Components in Physically Active Individuals,*** was reviewed and approved by the University of South Carolina Institutional Review Board (USC IRB) at a convened meeting held on **1/29/2020**. The research proposal was approved with respect to human subjects as adequately protecting the rights and welfare of the individuals involved. Subjects are not subjected to undue risk in the light of potential benefits to be derived from this study. No IRB member, who has a conflicting interest in the referenced proposal, was involved in the review or approval of this proposal, except to provide information at the request of the USC IRB.

Approval is for a one-year period from **1/29/2020** to **1/28/2021**. The Principal Investigator must submit a Continuing Review and required attachments to request continuing approval or closure. IRB approval for the study will expire if continuing review approval is not granted before **1/28/2021.**

When applicable, approved consent/assent documents are located under the "Stamped ICF" tab on the Study Workspace screen in eIRB.

PRINCIPAL INVESTIGATORS ARE TO ADHERE TO THE FOLLOWING APPROVAL CONDITIONS

- The research must be conducted according to the proposal/protocol that was approved by the USC IRB
- Changes to the procedures, recruitment materials, or consent documents, must be approved by the USC IRB prior to implementation
- *If applicable*, each subject should receive a copy of the approved date stamped consent document
- It is the responsibility of the principal investigator to report promptly to the USC IRB the following:
  - Unanticipated problems and/or unexpected risks to subjects
  - Adverse events effecting the rights or welfare of any human subject participating in the research study
- Research records, including signed consent documents, must be retained for at least (3) three years after the termination of the last IRB approval.
- No subjects may be involved in any research study procedure prior to the IRB approval date, or after the expiration date.
- At the time of study closure, a Continuing Review form is to be used for the final report to the USC IRB.

The Office of Research Compliance is an administrative office that supports the USC IRB. If you have questions, contact Lisa Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager

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