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The Relationship between Eating Disorders, Weight Control Methods, and Body Satisfaction in Elite Female Runners Competing at the 2020 U.S. Olympic Marathon Trials

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THE RELATIONSHIP BETWEEN EATING DISORDERS, WEIGHT CONTROL METHODS, AND BODY SATISFACTION IN ELITE FEMALE RUNNERS COMPETING AT THE 2020 U.S. OLYMPIC MARATHON TRIALS

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ABSTRACT

THE RELATIONSHIP BETWEEN EATING DISORDERS, WEIGHT CONTROL METHODS, AND BODY SATISFACTION IN ELITE FEMALE RUNNERS COMPETING AT THE 2020 U.S. OLYMPIC MARATHON TRIALS

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The prevalence of eating disorders in athletes is higher than in the general population. Various training styles, weight periodization, and presence of eating disorder (ED) may affect energy availability. This study investigated the relationship between lifetime prevalence of ED with training, body satisfaction, and weight-control methods among elite female endurance athletes. Female runners who participated in the 2020 U.S. Olympic Team Trials Marathon completed an online questionnaire examining training volume, weight-control methods, and self-reported current or past ED. Questions 1-19 were analyzed for this investigation. Participants were grouped according to responses on presence of ED. Thirty-two percent of participants reported previous ED diagnosis and 6% reported current ED. Runners who reported ED were significantly more likely to experience weight dissatisfaction and report energy restriction in the three months prior to the marathon. Consistent with previous literature, a substantial percentage of participants reported ED. This investigation suggests that ED may affect weight control methods and increase feelings of body dissatisfaction in competitive female runners.

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CHAPTER I

INTRODUCTION

Eating disorders have the highest mortality rate of any mental health condition.[1] Approximately 9% of the United States population will experience an eating disorder in their lifetime, about 28.8 million Americans.[2] Worldwide, 8.4% of women and 2.2% of men are estimated to experience eating disorders.[3] Females are twice as likely to have an eating disorder compared to males, and 90% of eating disorder cases occur in individuals under 25 years old.[2] Anorexia nervosa and bulimia nervosa may be the most well-known eating disorders, but they are not the most common. Other specified feeding or eating disorder (OSFED) is the most frequently reported eating disorder, followed by binge eating disorder (BED).[3]

In recent years, additional attention has been paid to the increased prevalence of eating disorders in athletes. In fact, the prevalence of eating disorders in sport is higher than the general population, especially within sports that emphasize the importance of leanness for performance, including endurance sports such as distance running.[4–6] There are a variety of factors that put athletes at an increased risk for eating disorders, including emphasis on body composition for performance, body satisfaction, exercise dependence, and knowledge and beliefs surrounding weight control methods.[4,5] Consequences of disordered eating and eating disorders in athletes include negative health and performance effects related to low energy availability and relative energy deficiency in sport.[7,8] Specifically, elite athletes, female athletes, and endurance athletes are groups at highest risk for eating disorders, as they encounter a dangerous combination of risk factors for the development of disordered eating and eating disorders.[4]

CHAPTER II

LITERATURE REVIEW

Eating Disorders in Athletes

Athletes are more likely to develop disordered eating and clinical eating disorders than non-athletes.[4,9] It is clear, however, that the prevalence of eating disorders (EDs) in athletes varies between different sports. The prevalence of EDs is higher among athletes participating in sports that emphasize leanness or weight-control as important factors in performance.[4,5,9] Such sports include weight class sports such as wrestling, boxing, and marital arts, aesthetic sports such as gymnastics, figure skating, and dance, endurance sports such as distance running, swimming, cross-country skiing, and cycling, and antigravitation sports including pole vaulting, ski jumping, and high jump.[6,10] Sports that do not emphasize leanness as vital to performance outcomes include ice hockey, racquet sports, swimming, volleyball, and sailing, to name a few.[6] While statistics vary between studies, researchers agree that the prevalence of disordered eating and EDs is higher in aesthetic and weight dependent sports, ranging up to 40% of athletes, while sports not emphasizing leanness may have an ED prevalence up to 12%.[9,10]

Similar to the general population, female athletes are at increased risk of EDs compared to male athletes.[4,9] Elite athletes are also at an increased risk for EDs when compared to developing athletes, however, collegiate athletes may experience the highest prevalence of disordered eating behaviors.[4,5,9] While EDs may go underreported in the general population, elite athletes may underreport EDs more frequently than non-athletes.[11]

Risk Factors for Eating Disorders in Athletes

The development and perpetuation of EDs involves a variety of factors including biological predispositions, psychology, sociocultural influences, as well as physical and sexual trauma.[10] Along with these typical risk factors, athletes are vulnerable to sport-related influences including a frequent focus on body and weight, negative coaching behaviors, motivation to improve performance, elevation of perfectionism as an advantageous personality trait, lack of time to prepare proper meals, risk for exercise compulsivity, and promotion of dieting and body ideals within sport.[5,10]

Body dissatisfaction. Specifically, body dissatisfaction plays an important role in the development of eating disorders.[12–14] Athletes are faced with two levels of possible body dissatisfaction; body dissatisfaction related to societal body image ideals, and body dissatisfaction related to sport performance, as body composition is often closely tied with performance outcomes.[12] Dissatisfaction with weight and appearance increases the risk of disordered eating.[12] Anderson et al. (2016) determined that female runners specifically reported higher appearance-related body dissatisfaction and higher performance-related body dissatisfaction when compared to male runners, with both types of body dissatisfaction accounting for association with EAT-26 scores in the female runners.[12] The female runners in this study also scored significantly higher on ED symptomology than the male runners.[12] Another study examining female runners, cyclists and paddlers found that a self-loathing score, similar to body dissatisfaction, was associated with eating disorder symptoms.[15] Prnjak et al. (2019) suggested body dissatisfaction to be the single largest predictor of dieting, a symptom of disordered eating, in one study.[13] Athletes may regularly engage in dieting more often than the

general population in an attempt to achieve a certain body composition to improve performance, or to meet a body ideal within their sport.[16] Athletes who engage in dieting with a desire for weight loss are more likely to develop EDs.[10]

Perfectionism. The etiology of body satisfaction may be complex, but Prnjak et al. (2019) links perfectionism to body dissatisfaction and disordered eating.[13] Prnjak et al. (2019) measured adaptive and maladaptive perfectionism in male and female athletes to determine any link between this personality trait with dieting and disordered eating.[13] Adaptive perfectionism relates to strivings of an athlete to improve performance and is associated with greater training performance, lower training distress, and may often lead to greater achievement in sport.[13] In contrast, maladaptive perfectionism involves self-evaluation and comparison, which can instill negative emotions and behaviors and increase risk of body dissatisfaction and exercise dependence.[13] Yet, some researchers note that adaptive perfectionism rarely exists only on its own without any kind of self-evaluation or criticism, and therefore should be studied further to determine disordered eating risk with this seemingly-positive adaptive perfectionism.[13,17] Indeed, Prnjak et al. (2019) discovered body satisfaction was significantly correlated with both types of perfectionism and dieting in female athletes.[13] Another study found that younger female runners with neurotic traits specifically were most at risk for EDs.[18]

Training methods. Athletes with a history of EDs have been found to have lower self-esteem and greater body weight dissatisfaction and often use excessive exercise to control weight.[19] In order to understand pathological eating behaviors in athletes, the role of pathological exercise must also be examined. Physical activity is perceived as beneficial to health and certainly essential to every athlete's training. Exercise can,

however, become compulsive and problematic and lead to increased risk of disordered eating.[20] Gorrell and Anderson (2018) confirmed the link between compulsive exercise and EDs in runners.[20] While there was an association between compulsive exercise and EDs in male and female athletes, female runners who demonstrated compulsive exercise on the Compulsive Exercise Test (CET) also had higher incidence of EDs than the male runners, as determined by the Eating Disorder Examination Questionnaire (EDE-Q).[20] Similarly, Di Lodovico et al. (2018) examined compulsive exercise in runners and found that athletes who reported an ED were more likely to be women and younger adults.[18] Furthermore, these researchers found that runners with EDs were at higher risk for exercise addiction, employed a restrictive diet, and reported running to lose weight more often as the non-ED runners.[18] Interestingly, compulsive exercise does not necessarily imply higher training volumes or greater intensity. Di Lodovico et al. (2018) did not find any significant difference in hours of training, frequency of weekly training, or months spent training between ED and non-ED groups. Similarly, Hully and Hill (2001) found a slight increase in training per week in female athletes with a history of EDs compared to controls, although not significant.[19] Compulsive exercise is likely related to feelings, motivations, and relationship to the exercise, rather than the quantity, duration or intensity of exercise.[21,22] Specifically maladaptive exercise, such as exercising to reduce weight, is more related to ED development than the rewarding effects of activity.[21] One study in long distance runners found that athletes with a strong athlete identity had increased risk for compulsive exercise and EDs than athletes that did not report a strong athlete identity.[23] Turton et al. (2017) defined athlete identity as the "degree to which an individual identifies with an athlete role." A strong athlete identity occurs when sport is

considered a defining and central factor of one's life, which may cause comments about body and weight being a direct comment on the person's self-worth, rather than performance.[23]

Coaching and teammate behaviors. Training assessments, coaching behaviors, and teammate actions can affect risk of ED in athletes.[9,24,25,27] While body composition assessments have become more frequently utilized with access to technology like dual energy x-ray absorptiometry (DEXA) and BOD POD® body composition testing, Ackerman et al. (2020) suggests that body composition assessments be individualized to the specific level of athlete in order to help prevent EDs.[24] No body composition assessments are necessary for developing athletes, a category that includes athletes competing at levels lower than a collegiate or national level.[24] Limited focus should be placed on body composition testing in collegiate athletics, while some periodized assessments may be appropriate in elite athletes who specifically have positive self-body image.[24]

A lack of knowledge may exist around disordered eating and consequences of low energy availability in athletes, and false beliefs around weight loss can be endorsed by coaches and teammates.[10] In a population of ultra-endurance runners, almost half of the runners reported believing loss of menstruation was a normal part of training.[25] While low body fat mass is endorsed to be beneficial for performance in endurance sports, it is not always advantageous, and amenorrhea can signal low energy availability which can negatively affect performance.[26] In a group eumenorrheic and amenorrheic runners, the eumenorrheic runners experienced less injuries and trained more than the amenorrheic runners.[26]

Teammates can influence the behavior of other teammates, including eating behavior.[27] One study examining female collegiate cross-country runners found that runners with higher a body mass index (BMI) were discouraged from dieting behavior less often than runners with a lower BMI.[27] The effects of low energy availability are not limited to a particular BMI, therefore, it is important that athletes and teammates build knowledge and helpful communication in this realm.[27]

Role of body composition in performance. In the case of elite endurance athletes, the role of weight and body composition on performance cannot completely be ignored. Body weight has been associated with faster half marathon finishing times in men, and a faster finishing time in the 1500m race in a case study.[28,29] Recent studies have suggested that it is neither realistic nor healthy that elite runners maintain a competition BMI year round.[29,30] Weight periodization has been proposed as a method to optimize body composition over the competition year.[29,30] Stellingwerf (2018) defines weight periodization as "the strategic manipulation of energy intake and energy expenditure between various training phases to reach a targeted body composition range that is optimal for performance (e.g. peak power to weight ratio), while minimizing risk to short-term and long-term health."[29] Stellingwerf (2018) notes that weight periodization done correctly can decrease risk of developing low energy availability and relative energy deficiency in sport, which have serious health and performance consequences.[29] Research surrounding weight periodization is fairly recent and the impact on disordered eating risk is not known.

Consequences of Eating Disorders in Runners

Low energy availability and relative energy deficiency in sport. Disordered eating in athletes can contribute to an array of negative consequences including low energy availability and negative health and performance outcomes.[9] Energy availability refers to the energy remaining for optimal health and physiological function after exercise energy expenditure (EEE) is subtracted from energy intake (EI), and normalized for fat free mass.[7] Low energy availability (LEA), defined as < 30 kcal·kg FFM^{-1}·day^{-1} , exists when there is either a decrease in caloric intake, an increase in energy output, or both and can have negative physiological effects on bone, endocrine, and immune health, leading to an increased risk of bone fractures and illness.[5,7] LEA can occur in the setting of an ED, or with no ED present.[31] These symptoms of LEA can lead to the development of Relative Energy Deficiency in Sports (RED-S).[8] RED-S can lead to the slowing of metabolism, decreased growth hormone production, impaired glucose utilization, and many more deleterious metabolic fluctuations which can affect performance.[8] Between 2-60% of athletes may experience signs and symptoms of RED-S depending on their sport category, with endurance and aesthetic sports having the highest prevalence.[8,24] Athletes who are at higher risk for EDs are also most at risk for LEA.[10] As Ackerman et al. (2020) notes in a recent editorial, diagnostic factors associated with RED-S include chronic restriction, large changes in body weight or composition in short time periods, and alterations in training. Runners may reduce their energy availability intentionally to achieve a goal body composition, compulsively related to the presence of disordered eating, or inadvertently when a lack of hunger cues to match energy expenditure exists.[7]

A risk factor for the development of RED-S is a general lack of knowledge of LEA and the female athlete triad. One study examining knowledge of the female athlete triad in South African ultra-marathoners found that 83% of participants either did not know what the female athlete triad was or believe they were at risk for the triad.[25] In contrast, researchers found that 44% of the participants were found to be at risk for the female athlete triad, according to scores on the low energy availability in females questionnaire (LEAF-Q).[25] Of those at risk for the triad, 8.9% had clinical EDs, 29.6% had subclinical EDs, and 61.5% had no ED.[25] Folscher et al. (2015) argues that females engaging in endurance sports are inevitably at risk for the triad, especially since many female endurance athletes will try to lose weight without seeking professional advice, commonly resulting in LEA.[7,25] Indeed, 50% of marathoners in this study reported training to prevent weight gain, about half of participants reported restricting calorie and macronutrient intake, and one-third were at risk for the female athlete triad related to disordered eating behavior.[25]

Conclusion

Disordered eating and eating disorders are more prevalent in athletes than the general population.[4,9] Not only do athletes encounter risk factors for EDs related to societal body ideals, but they are exposed to increased focus on weight and body composition, dieting practice to reach goal weight for competitions, and may have predisposing psychological factors such as perfectionism.[5,10] A lack of knowledge may exist around disordered eating and consequences of LEA in athletes, and false beliefs around weight loss can be perpetuated by coaches and teammates.[10] Female athletes, elite athletes, and endurance athletes are groups at highest risk of eating disorders, yet few

studies have examined this particular population in relation to eating disorders. More research aimed at studying risks and prevalence of disordered eating among elite female endurance athletes is warranted, as they appear vulnerable to a dangerous combination of risk factors associated with eating disorders.

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CHAPTER III

JOURNAL ARTICLE

The Relationship Between Eating Disorders, Weight Control Methods, and Body Satisfaction in Elite Female Runners Competing at the 2020 U.S. Olympic Marathon Trials

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Abstract

Athletes participating in endurance sports report more frequent attempts to lose weight and greater training volumes than athletes participating in non-aesthetic sports. Various training styles, weight periodization, and presence of eating disorder (ED) may affect energy availability. **Purpose:** This study investigated the relationship between lifetime prevalence of ED with training, body satisfaction, and weight-control methods among elite female endurance athletes. **Methods**: Female runners (n = 146) who participated in the 2020 U.S. Olympic Team Trials Marathon completed an online questionnaire (34 questions) examining training volume, weight-control methods, and self-reported current or past ED. Questions 1-19 were analyzed for this investigation. Participants were grouped according to responses on presence of ED. Chi-square test indicated statistically different when $p \leq 0.05$. **Results:** 32% of participants reported previous ED diagnosis and 6% reported current ED. Runners who reported ED were significantly more likely to experience weight dissatisfaction ($\chi^2(3) = 9.59$, $p = .022$) and restricting or reducing food in the three months prior to the marathon ($\chi^2(5) = 17.58$, $p = .004$). **Conclusion:** Consistent with previous literature, a substantial percentage of participants reported ED. This investigation suggests that ED may affect weight control methods and increase feelings of body dissatisfaction in competitive female runners.

Introduction

Nutrition and body composition play important roles in athletic performance and are often emphasized in elite sports where athletes are seeking to gain a competitive advantage (Hagmar et al., 2008; Stellingwerff, 2018). An emphasis on diet and body composition, however, is a double-edged sword and can often put athletes at risk for disordered eating habits. The Australian Institute of Sport (AIS) and the National Eating Disorders Collaboration (NEDC) suggest that there is a spectrum of athlete eating habits that ranges from high performance nutrition to disordered eating, and athletes may move along this spectrum over the course of their career and various training cycles (Wells et al., 2020). This phenomenon is complicated by weight periodization commonly practiced in sport for performance purposes (Jeukendrup, 2017; Stellingwerff, 2018). In comparison to non-athletes, athletes are more likely to develop disordered eating and clinical eating disorders, and the prevalence of eating disorders is higher among female, elite, and athletes participating in aesthetic or weight sensitive sports (Joy et al., 2016; Sundgot-Borgen & Torstveit, 2004; Wells et al., 2020). Specifically, an increased prevalence of eating disorders exist in endurance sports, such as running, in both males and females which is likely related to the thought that extra weight may negatively affect performance (Rust et al., 2011; Sundgot-Borgen & Torstveit, 2004). Risk factors for disordered eating in athletes include body dissatisfaction, low self-esteem, personality traits such as perfectionism, physical ideals, coaching behaviors and accepted "norms" within the sport, and participating in sports emphasizing leanness (including endurance sports, antigravitation sports such as pole vaulting, and sports with aesthetic

considerations such as gymnastics) (Hagmar et al., 2008; Sundgot-Borgen & Torstveit, 2004; Wells et al., 2020).

Elite athletes participating in endurance and weight-sensitive sports report more frequent attempts to lose weight, greater variation in weight during the year leading up to competition, and lower mean body weight in comparison to athletes in sports which do not emphasize leanness, including ice hockey, volleyball, and sailing (Hagmar et al., 2008). While attempts to lose weight and weight fluctuations may be signs of disordered eating, they may also reflect body composition periodization, as described by Stellingwerff (2018). Weight periodization may help athletes achieve body composition goals while optimizing energy availability (EA), minimizing illness and injury risk, and maintaining eumenorrhea. For endurance athletes specifically, low body weight has been associated with faster race times (Rust et al., 2011; Stellingwerff, 2018). Body weight periodization has been found to help endurance athletes achieve competition goals while avoiding the deleterious effects of maintaining peak body composition year round (Stellingwerff, 2018). However, weight periodization and healthful methods used to achieve weight goals present a challenge in identifying disordered eating as energy restriction and weight loss are not always pathological behaviors in athletes.

Body satisfaction plays an important role in the development of eating disorders (Anderson et al., 2016; Prnjak et al., 2019; Wells et al., 2020). Anderson et al. (2016) notes that female athletes may be susceptible to both appearance and performance-related weight ideals. In addition, Prnjak et al. (2019) observed that perfectionism is a trait present in many high level athletes which can stimulate both beneficial tendencies, like striving for high achievement, and harmful tendencies, like disordered eating. Body

dissatisfaction may serve as the bridge between perfectionism and disordered eating tendencies in female athletes (Prnjak et al., 2019). In fact, body dissatisfaction was the single biggest predictor of dieting, a symptom of disordered eating, in this study (Prnjak et al., 2019). Haakonssen et al. (2015) found over half of female cyclists reported a desire to change their body weight at least once a week, and about 14% of the cyclists reported a previous eating disorder diagnosis.

Manipulating training volume, such as weekly mileage, is an important part of the training regimen for marathon runners; however, athletes with a history of eating disorders and body weight dissatisfaction may use excessive exercise to control weight (Hulley & Hill, 2001; Karp, 2007). For example, Karp (2007) found that among female runners who qualified for the U.S. Olympic Marathon Trials, elite runners had higher mileage training volumes per week compared to national-class runners, but Hulley and Hill (2001) found that female athletes with a history of an eating disorder trained slightly more hours than the control group per week, although not significant. Comparatively, Hagmar et al. (2008) noted greater training volumes (longer training duration, frequency and intensity) in elite athletes in lean sports (such as endurance sports) when compared to athletes in non-lean sports.

Training styles, weight periodization, and presence of disordered eating can affect energy availability, an issue that has come to the forefront of recent research, especially in female athletes. Low energy availability (LEA), defined as < 30 kcal·kg FFM^{-1}·day^{-1}, exists when there is either a decrease in caloric intake, an increase in energy output, or both, and it can have negative physiological effects on bone, endocrine, and immune health, leading to an increased risk of bone fractures and illness (Loucks, 2007; Wells et

al., 2020). The multitude of consequences associated with LEA are collectively referred to as Relative Energy Deficiency in Sports (RED-S) (Mountjoy et al., 2014). LEA may be due to conscious restriction of food intake or inadvertent under compensation of dietary intake relative to energy expenditure. Marathoners may reduce their energy availability intentionally to achieve a goal body composition, compulsively related to the presence of disordered eating, or inadvertently (especially in the setting of a diet low in fat and high in carbohydrates) (Loucks, 2007; Stellingwerff, 2018).

Many studies have evaluated the prevalence and risk of disordered eating, RED-S, and LEA among athletes, especially female collegiate athletes. The studies examining specific weight control methods, training volume, and history of disordered eating are still lacking among elite athletes. Therefore, the purpose of this study is to investigate the relationship between eating disorders, weight-control methods, and body satisfaction among elite female endurance athletes.

Methods

Subjects

Female participants who qualified for and participated in the 2020 U.S. Olympic Team Trials Marathon (February 29, 2020; Atlanta, Georgia) of any age or ethnicity were eligible to participate in the study. Participants were offered the opportunity to win one of three $100 Amazon gift cards for participating in and completing the online questionnaire. Two weeks post-race, 396 qualified athletes were contacted via Facebook or Instagram direct message requesting their participation in the study. This study was granted approval by the Human Subjects Review Committee at Southern Utah University.

Design

A cross-sectional study was implemented where participants completed a questionnaire of 34 questions. Questions included the following topics: anthropometrics, fastest marathon times, body weight at fastest marathon time, training volume (i.e., mileage per week), types of training (running, strength training, swimming, etc.), incidence of stress fracture, weight satisfaction, weight-control methods, history or presence of eating disorder, menstruation, and emotional stress. The survey was created using the Qualtrics platform.

Data collection for this study was performed online from February 2, 2020 to March 20, 2020 . Athletes who chose to participate were directed to the Qualtrics survey via a link, and upon entering the Qualtrics site were given participation information regarding estimated time requirements, assurance of confidentiality, nature of the questions, and directions to be included in a random drawing for one of three Amazon gift cards. Participants then agreed to the terms outlined in the informed consent (Question 1 of the survey) or could choose to close their browser window. All data collected was anonymous. After completing the survey, participants were given a link that directed them to another Qualtrics survey where they could enter their email address to be included in a random drawing of three participants, each awarded a $100 Amazon gift card. Email addresses could not be traced back to any of the original survey responses.

Statistical Analysis

Data was analyzed using Microsoft Excel and SPSS. For the purposes of this investigation, survey questions 1-19 were analyzed. Descriptive data was reported as

mean ± standard deviation (SD) for age, weight, and height. Body mass index (BMI) was calculated using self-reported height and weight and was measured in kg/m^2. Chi-square tests were performed to analyze nominal data, including presence of eating disorder, weight dissatisfaction, pursuing a race weight, food restriction, and training methods. Independent *t* tests and one-way ANOVA tests were used to compare training volumes and performance outcomes related to weight control methods and reported eating disorders. *P* values less than 0.05 were considered statistically significant.

Two questions in the survey evaluated the presence of an eating disorder (ED). Question 18 inquired about history or past diagnosis of ED and question 19 examined any current struggle with an ED. To simplify analysis for this study, a variable was created to account for lifetime prevalence of eating disorder, which accounted for each participant that had reported an ED in the past, present, or both (ED). The survey also allowed the participants to choose "I'm not sure" as a response for questions 18 and 19. Participants who reported an ED for one of the two questions (either past ED or current ED), but answered "I'm not sure" in response to the other question were included in the ED group. Similarly, participants who reported no ED for one of the two questions (either past ED or current ED), but answered "I'm not sure" in response to the other question were included in the NO ED group. Participants who reported "I'm not sure" for past ED and current ED were omitted from analysis ($N = 158$, $n = 146$).

Results

Participant descriptive characteristics ($n = 146$), training volume, and performance are displayed in Table 1. Seven participants were excluded due to failure to complete the questions regarding past or current eating disorder, as this is the primary

independent variable in this investigation. Five additional participants were excluded for reporting "I'm not sure" for both past ED and current ED (questions 18 and 19). There were no significant differences for descriptive characteristics**,** training volume, and marathon performance between participants who self-reported ED versus NO ED (Table 1).

Table 1. Participant descriptive characteristics, training volume, and marathon performance.

Variable	Total (mean ± SD)	ED reported (mean ± SD)	No ED (mean ± SD)
N	146	48 (32.88%)	98 (67.12%)
Age (y)	30.80 ± 5.00	29.07 ± 4.39	31.71 ± 5.08
Height (cm)	166.39 ± 7.53	167.27 ± 7.56	165.96 ± 7.52
Weight (kg)	53.76 ± 4.75	54.27 ± 4.90	53.52 ± 4.69
BMI (kg/m^2)	19.41 ± 1.42	19.47 ± 1.63	19.38 ± 1.33
Approximate weight at fastest marathon time (kg)	53.09 ± 4.70	53.61 ± 5.0	52.85 ± 4.58
Longest run in training (kilometers)	35.98 ± 3.90	35.73 ± 3.80	36.13 ± 4.00
Fastest marathon time	2:39:57 ± 0:08:05	2:40:12 ± 0:9:16	2:39:49 ± 0:07:27

*Data are displayed as **mean ± SD.** BMI, body mass index.*

Approximately 32% of participants reported an ED. Past diagnosis of ED was found to be significantly related to current presence of ED (χ^2 (1) = 14.47, $p < .001$). Of those who reported an ED, 97% reported past diagnoses and 18% reported current struggles with an ED. Fifty-one percent of participants who reported past ED indicated

anorexia nervosa, while 55% of participants who reported current ED indicated EDNOS (Table 2). Several participants reported experiencing more than one type of ED (Table 2).

Table 2. Types of Eating Disorders Reported

	Anorexia	Bulimia	BED	EDNOS	Participants reporting multiple EDs
Past ED	24 (51%)	12 (26%)	9 (19%)	18 (38%)	12
Current ED	3 (33%)	0 (0%)	1 (11%)	5 (55%)	0

Data reported in number of participants. ENDOS, eating disorders not otherwise specified

Of all athletes, 67.1% reported consciously restricting or reducing energy intake, 44.5% reported some form of weight dissatisfaction, and 24.7% reported trying to achieve or maintain a specific race weight in the three months prior to the marathon (Table 3). Figures 1 and 2 display frequency of self-reported weight dissatisfaction and frequency of self-reported energy restriction, respectively. Participants with a higher body weight were more likely to report weight dissatisfaction ($p = .004$). In addition, participants who reported ED were significantly more likely to consciously restrict food (χ^2 (5) = 17.58, $p = .004$) and experience weight dissatisfaction in the three months prior to the marathon (χ^2 (3) = 9.59, $p = .022$) than those reporting no ED. ED was not associated with a significant difference in training volume, performance outcomes, or trying to achieve or maintain a specific race weight prior to the marathon. Figure 3 displays frequency of techniques participants used to achieve race weight.

Table 3. Frequency of self-reported weight control methods in all athletes, and in ED vs. NO ED

	All athletes (n = 146)	**ED (n = 48)**	**NO ED (n = 98)**	**Chi square Test *p***
Restricting food, in any respect	98 (67.1%)	41 (85.4%)	57 (58.2%)	
No	48 (32.9%)	7 (14.6%)	41 (41.8%)	0.001*
Total (n, %)	***146 (100%)***	***48***	***98***	
Weight dissatisfaction, in any respect	65 (44.5%)	30 (62.5%)	35 (35.7%)	
No	81 (55.5%)	18 (37.5%)	63 (64.3%)	0.002*
Total (n, %)	***146 (100%)***	***48***	***103***	
Trying to achieve or maintain race weight, in any respect°	36 (24.7%)	13 (27.1%)	23 (23.5%)	0.658
No	109 (74.7%)	35 (72.9%)	74 (75.5%)	
Total (n, %)	***145 (99.4%)***	***48 (100%)***	***97 (100%)***	

** Significant difference between ED and NO ED when p < 0.05*

°n = 145, missing one response. Data are reported as n (%).

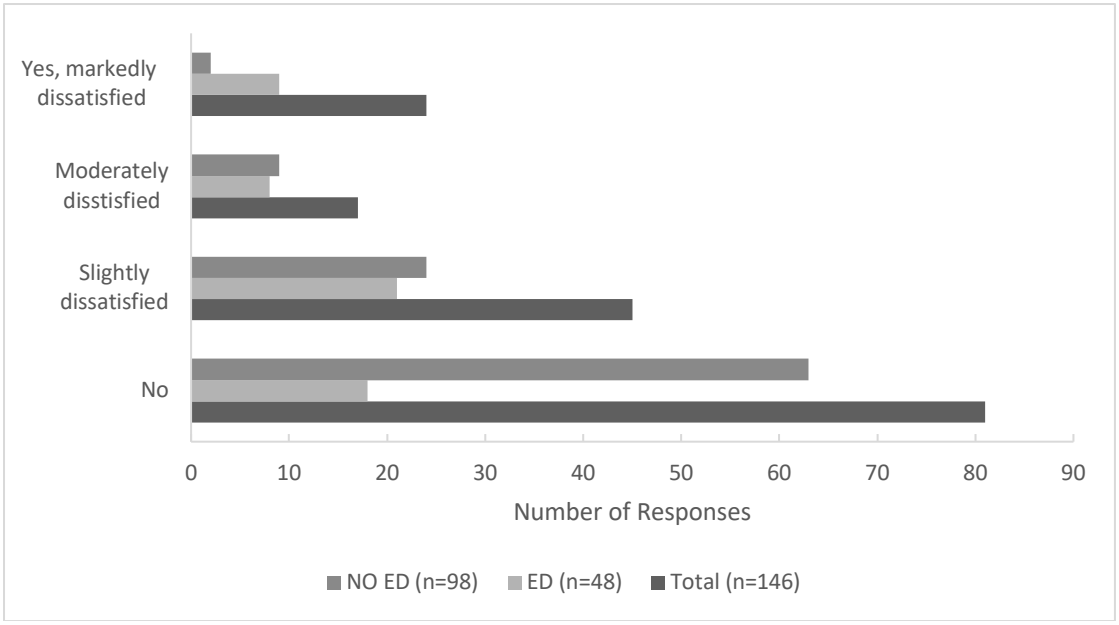

Figure 1. Frequency of self-reported weight dissatisfaction in three months prior to marathon among all athletes, and in ED vs. NO ED

The majority of athletes (62.5%) reported experiencing some level of weight dissatisfaction.

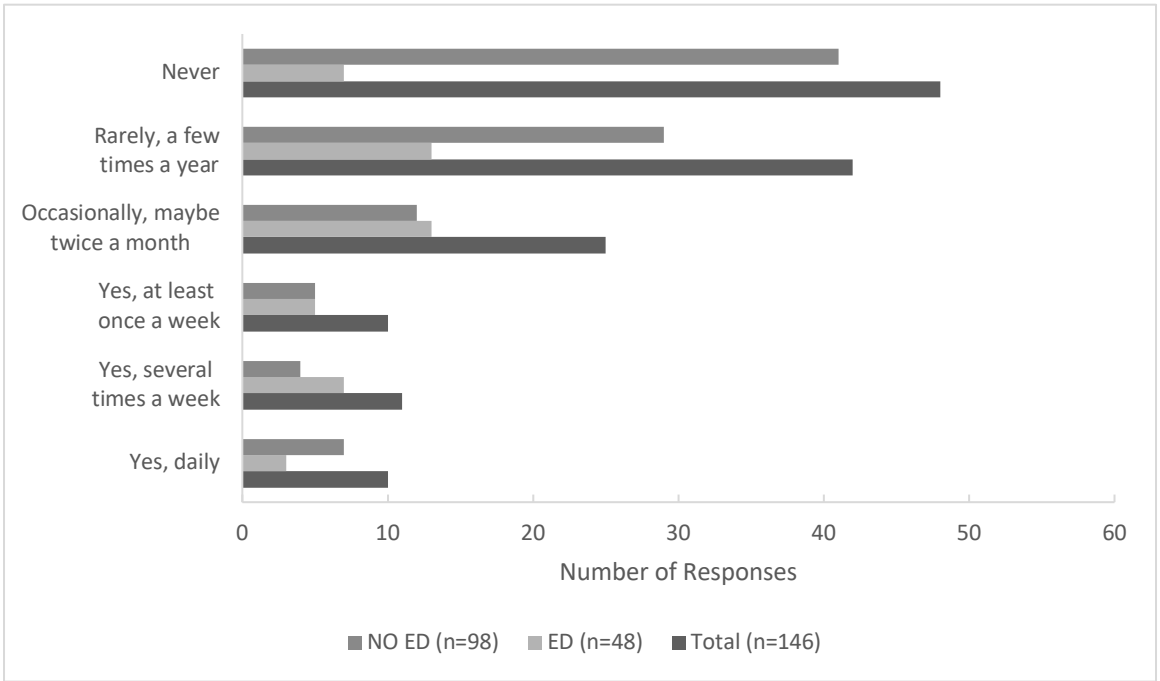

Figure 2. Frequency of "consciously restricting or reducing food eaten" among all athletes, and in ED vs. NO ED.

Of athletes who reported NO ED, 41 reported never engaging in food restriction, compared to just 7 ED athletes. Most athletes reported engaging in some level of energy restriction over the course of 1 year.

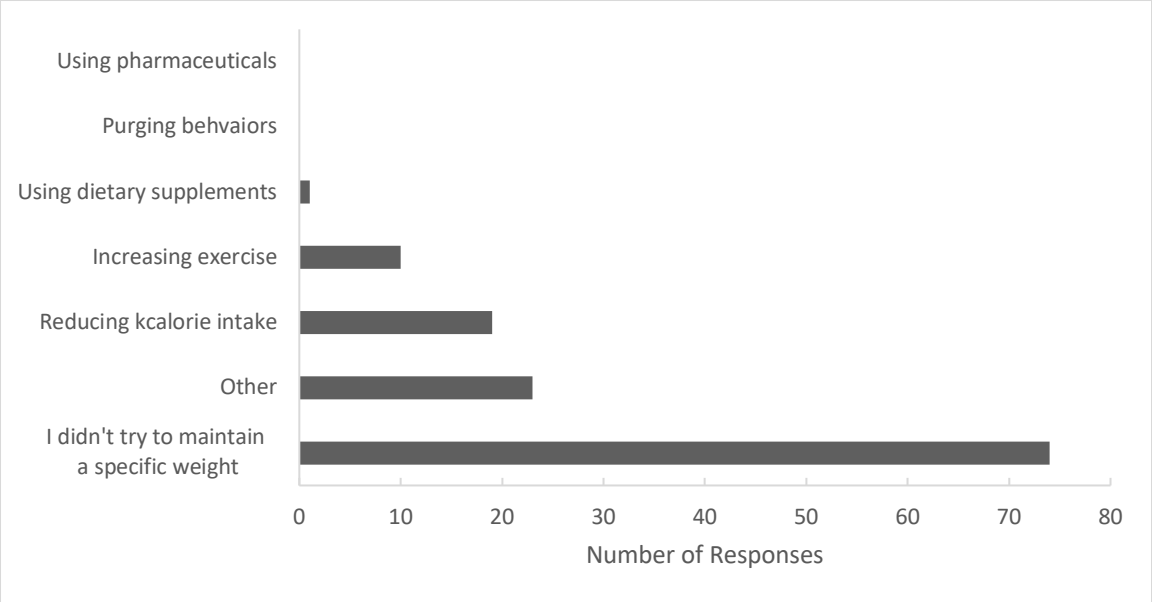

Figure 3. Self-reported techniques to achieve or maintain a "race weight" in the three months prior to the marathon.
Reducing energy intake and increasing exercise were the most common methods used to achieve a race weight, although most participants reported not trying to achieve a specific race weight prior to the marathon. One participant reported using dietary supplements, while no participants reported using pharmaceuticals or purging behaviors.

Discussion

The current study examined the relationship between reported ED and training and weight control methods among elite female runners competing at the 2020 U.S. Olympic Marathon Trials. The primary finding of this investigation suggests, among elite female marathoners who self-report a diagnosis of an ED (past or present), that there is a higher prevalence of conscious caloric restriction and body weight dissatisfaction when compared to elite female runners of similar ability with no ED history. In addition, body weight, BMI, and training volume were not related to ED which may be a result of the homogeneity of the sample and specific standardized training schedules that the runners followed in the three months prior to the marathon.

Prevalence of Eating Disorders

Thirty-two percent of participants reported an ED which is consistent with previous studies identifying the increased prevalence of ED and disordered eating in the female athlete population (Coelho et al., 2014; Sundgot-Borgen & Torstveit, 2004). A previous study examining eating disorders in elite distance runners found 16% of participants had an ED at the time of the study (Hulley & Hill, 2001), while 6% of participants reported such in the current study. The prevalence of disordered eating/ED in aesthetic sports is estimated to be 40%, and 15-30% for elite female athletes (Coelho et al., 2014) which is consistent with the 32% of participants reporting ED in this study. In contrast, the prevalence of disordered eating in the general population can range up to 21% which is lower than the prevalence noted in athletes from previous studies (Coelho et al., 2014; Sundgot-Borgen & Torstveit, 2004). Eating disorders are historically underreported in the general population, and elite athletes may underreport eating disorders more frequently than non-athletes (Sundgot-Borgen, 1993).

Body Satisfaction

Athletes who reported ED were more likely to report body dissatisfaction than athletes that did not report ED, yet almost half of all the athletes reported some form of body dissatisfaction. Higher body weight was associated with greater body dissatisfaction. Research suggests that females are more likely to be concerned with body weight than males, endurance athletes are more likely to suffer from disordered eating than athletes of other sports, and elite athletes likely possess a strong perfectionism trait (Prnjak et al., 2019; Sundgot-Borgen & Torstveit, 2004). These factors suggest that the elite female endurance athlete population is particularly vulnerable to body

dissatisfaction and eating disorders. In fact, body satisfaction has been reported to be the largest independent predictor of dieting (Prnjak et al., 2019). Another study showed body satisfaction acted as a mediator between perfectionism and disordered eating in synchronized swimmers (Ferrand et al., 2007).

Energy Restriction

Almost two-thirds of participants reported restricting or reducing food intake, however, the level of calorie restriction is unknown. These athletes may be participating in weight periodization which may help athletes reach desired body composition for competition while maintaining optimal EA (Heikura et al., 2018; Stellingwerff, 2018). Conversely, less than one-third of participants reported trying to achieve a race weight in the current study. Heikura et al. (2018) found that female athletes may be more conscious of extra carbohydrate and energy intake when engaging in weight periodization practices. Seventy-nine percent of female endurance athletes were found to eat significantly less energy on easy training days in comparison to 52% of the male athletes (Heikura et al., 2018). In the current study and in the Heikrua et al. (2018) study, it is unclear if the food restriction is due to lower energy requirements of females, lack of knowledge, body image concerns, disordered eating, or a combination of factors.

Training and Performance

No differences in training metrics were found between participants that reported ED versus NO ED. These results may be attributed to the questions referring to the training in the three months prior to the marathon, and athletes generally following similar training regimens in those months. No significant differences were found in performance metrics between participants reporting ED versus those that reported NO

ED. Body weight and body mass index were not associated with marathon finishing time, in contrast to previous studies such as Rust et al. (2011) who found body mass index to be related to race time, although their study participants were male half marathoners. The lack of association in this study may be due to sampling of a homogenous population of athletes with similar body weights and marathon finish times. Similar to Sjodin and Svendenhag (1985) which notes that while there is a strong correlation between VO_2 max and marathon finishing time in heterogenous populations, this relationship does not exist in homogenous populations.

Limitations, and Suggestions for Future Research

Limitations of this study include the self-reported nature of the data and missing data from uncompleted surveys. Furthermore, including additional questions from eating disorder screening tools may enhance the data collected on the behaviors associated with EDs in this population. Although we did not find a difference in training volume between ED and NO ED, assessing risk of exercise dependence in elite athletes may also be a beneficial metric since it often occurs in conjunction with disordered eating (Cook et al., 2015). Nevertheless, research concerning eating disorders in the elite female endurance athlete population is limited, especially among Olympic-caliber populations.

Conclusion

In brief, eating disorders have the highest mortality rate of any mental health condition and should be treated accordingly (Harris & Barraclough, 1998). Disordered eating in athletes can contribute to an array of negative consequences including RED-S and negative performance effects (Joy et al., 2016). One-third of participants in this study reported an ED demonstrating the prevalence of eating disorders in athletes,

specifically in the elite female endurance athlete population. Many factors contribute to the development of an ED, including body dissatisfaction, perfectionism, caloric restriction, compulsive exercise, and striving for a particular weight before competitions to enhance performance. This study found elite female endurance athletes who reported an ED to have higher prevalence of weight dissatisfaction and food restriction when compared to athletes that did not report ED. It should also be noted that the majority (68%) of the athletes in this study reported consciously restricting or reducing their food intake at least a few times per year. While energy restriction may have been related to weight periodization, less than one-third of participants reported striving to achieve a particular race weight.

Prevention and early detection of disordered eating in athletes is vital for addressing the high prevalence of EDs among this at-risk population. Health and wellness should be emphasized over thinness ideals, and amenorrhea as "a normal part of training" should be refuted (Wells et al., 2020). Dieting is a primary risk factor for EDs, and should be avoided unless necessary for specific performance goals (Sundgot-Borgen & Torstveit, 2010; Wells et al., 2020). Dieting and weight periodization cannot realistically be fully eliminated from an athlete's training regimen, but they should be implemented mindfully (Wells et al., 2020). Frequent weighing, body composition testing, and team weigh-ins have been found to have negative effects on athletes (Wells et al., 2020). Ackerman et al. (2020) states that body composition assessments for performance purposes may be implemented in mature elite athletes with positive self-body image, but should be limited in collegiate level athletes and avoided completely in young developing athletes. Providing thorough education on dieting, disordered eating,

negative physiological and performance outcomes associated with LEA and the female athlete triad is one way to increase awareness among athletes (L. L. Folscher et al., 2015; Wells et al., 2020). Referring athletes to a registered sports dietitian nutritionist when disordered eating is detected is important for accurate assessment and treatment (Sundgot-Borgen & Torstveit, 2010). Finally, additional research focused on studying disordered eating among elite female endurance athletes is warranted, as they appear vulnerable to a dangerous combination of risk factors associated with eating disorders.

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