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Comparing Calculated and Perceived Energy Needs in Collegiate Student-Athletes

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COMPARING CALCULATED AND PERCEIVED ENERGY NEEDS IN COLLEGIATE STUDENT-ATHLETES

by
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ABSTRACT

LYNDSEY REED: Comparing Calculated Energy Needs and Perceived Caloric Needs in Collegiate Student-Athletes
(Under the direction of Melinda Valliant)

The purpose of this study was to evaluate NCAA student-athletes' level of knowledge related to their energy needs. The participants were 75—42 male and 33 female—NCAA Division I student-athletes enrolled at the University of Mississippi (UM) from a variety of sports. In-person data collection took place at UM Athletics facilities by sports registered dietitians during team talks. The names of the athletes were used to find their pre-existing calculated energy, resting metabolic rate (RMR) and total energy expenditure (TEE) using the Nelson equation and the appropriate activity factor. Questionnaire and RMR/TEE data were analyzed and compared to assess knowledge related to energy needs on rest and active days.

A statistically significant difference ($p < 0.05$) was found in both the perceived non-training day caloric needs versus RMR, as well as the perceived training day caloric needs versus TEE relationships ($p = < .001$). The perceived non-training day needs of both sexes was greater than their calculated RMR. Female and male participants reported their training day needs lower than that of their TEE. Student-athletes with prior knowledge reported greater perceived non-training day energy needs compared to their RMR and perceived training day needs to be below their TEE. There was a statistically significant difference ($p = < .001$) between sport and perceived training needs as well as sport and TEE. No significance was found for the student-athletes year in school. In conclusion, this investigation highlighted the lack of understanding student-athletes have of their caloric needs on both training and non-training days, but showed sports nutrition education and prior knowledge could have a positive impact on their understanding of their energy needs.

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LIST OF ABBREVIATIONS

RMR	Resting metabolic rate
EA	Energy availability
BodPod/ADP	Air displacement plethysmography
TEE	Total energy expenditure
CSSD	Certified Specialist in Sports Dietetics
LEA	Low energy availability
RED-S	Relative energy deficiency in sport
DXA/DEXA	Dual-energy X-ray absorptiometry
BMD	Bone mineral density
FFM	Fat-free mass
FM	Fat-mass
LBM	Lean body mass
BSI	Bone stress injury

INTRODUCTION

Resting metabolic rate is the amount of energy the body requires to function while at rest and it accounts for around 60-70% of daily energy expenditure (Balci et al. 2021). Total energy expenditure includes energy expended through RMR, the thermic effect of food, and physical activity together (Heydenreich et al. 2017). To begin understanding how much energy is needed, it makes sense to explore how much is needed to support the body at rest, its most basic level of need. The literature suggests that athletes have poor sports nutrition knowledge which includes how much energy is needed at rest and to fuel activity. The issue of insufficient sports nutrition knowledge in athletes has also been highlighted as an area of need within the literature (Andrews et al. 2016; Kimmel et al. 2019; Klein et al. 2021; Manning et al. 2021; Serhan et al. 2022). Collegiate athletes should know what their bodies need to perform on a regular basis which begins with understanding the energy that is required at rest.

The lack of sport nutrition knowledge could have a profound impact on the health and performance of athletes (Debnath et al. 2019). To aid in student-athlete education, sports dietitians should emphasize the importance of adequate energy intake for an athlete and the negative implications of being in an energy deficient state (Sale, & Elliott-Sale 2019; Edama et al. 2021; Fahrenholtz et al. 2018; Peterson 2018; Torstveit et al. 2018). Energy availability (EA) is the “amount of ingested energy remaining to support basic bodily functions and physiological processes, including growth, immune function, locomotion, and thermoregulation, once the energy needed for exercise has been utilized" (Sale & Elliott-Sale 2019). Having a negative energy balance occurs when an individual's energy expenditure exceeds their energy intake. Remaining in a state of negative energy balance will result in the loss of body mass placing them at greater risk for injury (Jordan et al. 2020; Zabriskie et al. 2019). Educating athletes on consuming adequate energy with foods is essential to avoid being in a negative energy balance and therefore high-risk state. Given the concerns regarding energy deficiencies in student-athletes, the primary purpose of this study is to evaluate NCAA student-athletes perception of energy needs on training and non-training days compared to their calculated RMR and TEE.

REVIEW OF LITERATURE

Performance & Health

An athlete's diet plays a significant role in fueling physical activity. The purpose of an athlete's diet should be to fulfill the energy demands of their training and activity, to aid in quick recovery between workouts, to optimize adaptations to training, and to maintain a healthy status (Fritzen et al. 2019). An athlete's needs depend on their body composition, genetics, and the demands of their sport. According to a 2019 study, there was a significant correlation between the aerobic capacity of an athlete and their nutrition knowledge and practices, which could impact their performance (Debnath et al. 2019). Additionally, the authors concluded a positive correlation between calorie intake and VO_2 max which further certifies the need for adequate energy intake to support optimal athletic performance (Debnath et al. 2019; American Dietetic Association and American College of Sports Medicine, 2000; American Dietetic Association, 2009). Essentially, if an athlete has an adequate understanding of sports nutrition and their needs and puts that information into practice, they are far more likely to perform and execute the physical demands of their sport at a near optimal level.

Sport Nutrition Knowledge

The relationship between an athlete's sports nutrition knowledge and performance is a difficult and contradictory area of research. Inadequate sports nutrition knowledge was a commonly reported in the literature. Andrews et al. 2016 conducted a study on nutrition knowledge which concluded the mean sports nutrition knowledge score for the student-athletes was 56.9% which was considered inadequate (mean < 75%). In some cases, the low nutrition knowledge scores on the questionnaire directly correlated to poor reported intake and nutrition habits.

A study conducted on nutrition knowledge at the Division III level, concluded that their results were in line with most others in the literature, showing the athletes had inadequate nutrition knowledge (Klein et al. 2021). These authors suggest that despite the low knowledge scores on their sport nutrition evaluations, the resources these institutions have may mask the negative implications of their poor knowledge since they are given access to dietitians and a wide array of nutrition resources (Klein et al. 2021). Institutions that focus on and prioritize nutrition education and resources may have a lot more available to their student athletes than some others. To further support the typical findings in the literature, an article including Division I HBCU student athletes reported noticeably poor nutrition knowledge coupled with low energy consumption (Manning et al. 2021). There is also the question of how willing student-athletes are to use the resources available. Additionally, a cross-sectional survey conducted on 384 student athletes agreed with the literature and reported, the student-athletes sports nutrition knowledge scores overall were 63.54% which is inadequate based off the score mean of <75% (Serhan et al. 2022).

To contradict most nutrition knowledge studies in the literature, Guadagni et al. (2019) assessed Division I athletes through a survey and concluded the majority fell into the high nutrition knowledge category. Another study by Debnath et al. (2019), also reported most athletes scored in the high nutrition knowledge category. However, there are application limitations to this study since its participants were 14–17-year-old athletes involved specifically in team sports. Keeping the focus of the current study on student athletes at the collegiate level, most of the literature contradicts these findings. It can be difficult to directly compare the results of these studies as they use somewhat different means of measuring and assessing sports nutrition knowledge.

Nutrition Resources

As previously mentioned, while nutrition knowledge was associated with better performance, some studies indicated that quality nutrition resources and material presented other issues. Moreover, athletes reported their top three primary sources of nutrition information as social media, coaches, and athletic trainers which showed a lack of use and exposure to reliable sources (Klein et al. 2021). When reputable sources were used, nutrition knowledge scores were higher. Klein et al. also reported previous college-level nutrition courses as having a significant positive association with higher total sport nutrition knowledge as well as carbohydrate and hydration knowledge (Klein et al. 2021). While those with prior nutrition education scored better on knowledge assessments, this does not necessarily translate to their intake. Dietitians should not assume most athletes have taken a nutrition course, let alone completed one recently or specific enough to help them understand their needs as an athlete.

Authors that investigated Mid-American Conference (MAC) softball players asked their participants to indicate the likelihood of using different resources to obtain nutrition information. The results suggested the players were most likely to use a physician, followed by an athletic trainer, then college nutrition/health courses, and a dietitian ranked third and fourth out of the ten options (Hornstrom et al., 2011). The authors noted that in this specific study, the two least likely sources of information were coaches and academic journals. It is understandable that the average person and athlete would likely not take the time to read academic journals to find the best sources of information. However, it is interesting that dietitians were not higher on the ranking for sources of nutrition information. This could be a similar situation to Kimmel et al. (2019) who surveyed 127 student-athletes and concluded that only 8% demonstrated adequate sport nutrition knowledge. The study also revealed that less than half of the student-athletes were aware the university had a Registered Dietitian who was also a Certified Specialist in Sports Dietetics (CSSD) (Kimmel et al. 2019). If student-athletes are unaware of the resources they have available to support their dietary needs and nutrition, then it would only make sense they rely on athletic training and other medical staff.

Furthermore, a study on mid-major Division I athletes indicated the primary sources of nutrition knowledge were magazines, athletic trainers, friends, and coursework (Andrews et al 2016). Heaney et al. (2011) continues to support the use of outside resources for nutrition information and education as the authors listed the reported sources; coaches, athletic trainers, sport dietitians, nutritionists, sport scientists, and medical practitioners, school, books, sport-specific magazines, mass media, and the internet. Athletic training staff seems to be one of the more repetitive sources of information, perhaps since they are a frequent point of medical contact for college athletes.

Sex Differences

Sex differences pertaining to nutrition knowledge had highly contradictory outcomes throughout the literature. Guadagni et al. (2019) assessed the nutrition knowledge base of NCAA Division I college athletes and evaluated sex differences. The participants included 128 athletes from eight different sports; 42 scored low knowledge, 24 in medium knowledge, and 62 in high knowledge. When evaluating the sex differences, the males scored significantly lower on the survey questions overall while those who fell into the high nutrition knowledge category were mostly female (Guadagni et al. 2019). In a systematic review by Heaney et al. (2011), it was found that the athletes' knowledge scores were equal to or better than that of non-athletes. Moreover, when it was found statistically significant, females' knowledge was greater than males' (Heaney et al. 2011).

On the other hand, Andrews et al. (2016) reported no significant differences between the sexes. Both sexes scored similarly on their sports nutrition knowledge assessment and were considered to have inadequate knowledge. One study collected more specific data on the different aspects of nutrition knowledge and whether the males versus females scored differently. According to Klein et al. (2021), no significant sex differences were found for total sport nutrition knowledge, carbohydrate, protein, fat, or weight management categories. However, there was a significant difference reported between males and females for hydration knowledge, with females scoring higher than males. Whether or not there was a difference reported between the knowledge scores of the sexes, there seems to be no common explanations for the outcomes either way. This is an area that may need further attention in the future to better understand why there may be differences. When it comes to the specific knowledge areas within sports nutrition, there may be underlying reasons behind why one sex outscores the other.

Energy Intake

The relationship between the actual energy intake of athletes and their knowledge assessment is somewhat unclear in the literature. A study by Heaney et al. in 2011, clearly stated inconclusive results pertaining to the relationship between nutrition knowledge and its effect on dietary intake being unclear. There are a multitude of factors that lie in between what an athlete's knowledge level is and implementing this knowledge into practice. For example, the results from Noronha et al. (2020) indicated the main barriers for the athletes' healthy eating were the lack of willpower and a busy lifestyle. Interestingly, the athletes scored with low levels of nutrition knowledge, however, nutrition knowledge was positively correlated with a better dietary intake of some nutrients (Noronha et al. 2020). Moreover, some athletes may be unintentionally putting themselves at risk for insufficient energy intake due to subconscious undereating as a result of a lack of awareness or knowledge related to the volume of energy they burn or how much they might adjust their intake to accommodate their exercise (Cook & Dobbin, 2022).

Despite the lack of clarity between knowledge and intake, the literature does contain data about intake in athletes in general. Manning et al. (2021) conducted a study which concluded that in combination with poor nutrition knowledge, the energy intake of most athletes was inadequate. Another study by Shriver et al. in 2013 evaluated the intake and dietary habits of collegiate female athletes and compared them to sports nutrition recommendations and produced similar outcomes to the previous study. These outcomes indicated that overall energy and specifically carbohydrate intakes were recorded below the minimum recommendations (Shriver et al. 2013). Only about 9% of the athletes in this study met the minimum requirements for their energy intake needs, 75% of participants did not meet minimum carbohydrate requirements, most did not obtain a regular breakfast intake, and less than 20% regularly maintained adequate hydration status (Shriver et al. 2013). Practical and effective nutrition interventions to aid athletes in at least meeting their minimum intake requirements are necessary to bring these numbers up.

To add, Zabriskie et al. (2019) conducted a study on energy status and body composition in collegiate women's lacrosse players at the NCAA Division II level. Data was collected through dietary intake recorded by the athletes and physical activity was recorded using monitors were worn by the athletes during the off-season, pre-season, and in-season play. Pre-season training resulted in the highest energy expenditures; however, athletes' caloric, carbohydrate, and protein intakes did not change during the different seasons (Zabriskie et al 2019). Self-reports from the athletes resulted in a moderate negative energy balance and low energy availability (LEA) at each measurement period. Caloric and macronutrient intake was low according to both recorded expenditure and athlete recommendations (Zabriskie et al 2019). This study aligns with the literature in that in general, the majority of athletes are below the necessary recommendations and are not adequately adjusting their intake for the more intense parts of their training. Educating on needs and adjusting to the fluctuations of pre-, mid-, and post-season needs and demands are of utmost importance to supporting proper health for performance.

Energy Deficiencies & Negative Impacts

To provide insights into how a negative energy balance can impact an athletes' health and performance, a study 2021 by Heikura et al., explains how even just 4-5 days of low energy availability can impair many of the body systems. Furthermore, Peterson (2018) studied Division I athletes and their EA and relative energy deficiency in sport (RED-S). The purpose of this study was to examine the relationships between EA, eating disorder risk, body composition, and stress. Bone mineral density (BMD) and body composition were assessed using dual-energy X-ray absorptiometry (DXA). EA was calculated and categorized into low, reduced, and adequate EA. The participants included 81 participants, 38 males and 43 females. Over half of males (68%) and females (58%) had low or reduced EA (Peterson 2018). Even in this relatively small sample, the study indicates there is an EA concern and student-athletes need to have increased awareness and education.

Torstveit et al. (2018) researched male endurance athletes with suppressed and normal resting metabolic rates to find if energy deficient endocrine markers would be associated within the same day of being energy deficient. Participants' RMR was measured through a ventilated hood and they were categorized as suppressed or normal. The study found that athletes with suppressed RMR showed greater hourly energy deficits and were in a deficit of >400 kcal for a greater period than those of a normal RMR (Torstveit et al. 2018). The RMR suppressed athletes who spent more time in energy deficient states also showed higher levels of cortisol and a lower testosterone:cortisol ratio (Torstveit et al. 2018). Since the conclusion of this study found that there was an association between RMR and catabolic markers and energy deficiency, the outcome helps support the background of this research. Further, there is an importance in knowing and understanding an individual's RMR, especially for athletes as they may unknowingly put themselves at greater risk for being energy deficient. This article supports the idea that having a suppressed RMR and being in an energy deficient state can have catabolic implications. The low testosterone:cortisol ratio measured in these athletes is indicative of poor or insufficient recovery following exercise.

The LEA experienced by some athletes can have adverse effects on bone, including acute bony injuries and longer-term reduced bone mass and strength (Sale & Elliott-Sale 2019). To add, another study concluded that in active females' markers of bone resorption and decreased bone formation can occur even with short-term LEA (Papageorgiou et al. 2017). Barrack et al. (2014) found in their study observing bone stress injuries (BSI) in collegiate athletes, that the athletes categorized as moderate and high risk, had a higher likelihood of sustaining a BSI. The authors stated these metabolic bone markers that are associated with LEA are less well known in the male population (Papageorgiou et al. 2017). Especially for active females, the risk of bone injury and breakdown increases while in an energy deficit state. Supporting bone health is immensely important in being able to sustain long term activity and performance, particularly for high level weight bearing athletes who compete and train for very long periods of time.

Female Athletes

Recognizing the impact of being in a LEA state is important for all athletes and medical support staff. For female athletes, it is paramount for them to understand the complications they are putting themselves at risk for, in comparison to their male counterparts. Female athletes who exercise and compete without adequate energy intake to sustain performance, put themselves at risk for RED-S and reproductive alterations (De Souza et al. 2019). These issues can come from a combination of LEA, menstrual dysfunction, and low bone mineral density (Scheid et al. 2018). A 2021 study by Edama et al., clarified the relationship between the female athlete triad risk assessment score and the sports injury rate in female college athletes. Amenorrhea, LEA, and BMD data were collected, and the cumulative risk assessment was defined. In swimming, significantly more athletes were in the low-risk category than in the moderate and high-risk categories and in long-distance sports, significantly more athletes were in the moderate-risk category than in the low and high-risk categories (Edama et al. 2021). In the moderate and high-risk categories, significantly more athletes were in the injury group and significantly more athletes at moderate and high-risk categories had bone stress fractures and bursitis than athletes at low risk (Edama et al. 2021). The results of this study help support the importance of adequate energy intake in supporting health and decreasing the injury risk in athletes. In female athletes, the collective damage that being in a LEA state can have on menstrual cycles and bone density is evidenced well in the literature.

A study by Fahrenholtz et al. (2018) looked at energy deficiency and reproductive function in female endurance athletes. The purpose was to compare female athletes with normal menstruation to those with menstrual dysfunction and their same-day 24-hour EA and balance. They found women who experienced menstrual dysfunction spent more time in a catabolic state than women of normal menstrual functioning (Fahrenholtz et al., 2018). Moreover, the researchers concluded the within-day energy deficiency was associated with metabolic complications. Since there is not enough energy provided through intake and food, the body results in breaking down body tissue. This catabolic state is what ultimately puts athletes at risk for injury and dysfunction (Fahrenholtz et al., 2018; Barrack et al. 2014).

A 2018 study on female athletes found that trabecular-rich (categorized as bone stress injury of pelvis, femoral neck, sacrum, and/or calcaneus) bone stress injury is associated with LEA and independently associated with low BMD (Holtzman et al. 2018). Due to these findings, the authors concluded trabecular bone stress injuries may serve as a clinical indicator for further bone health evaluation and assessment for LEA, including eating disorders/disordered eating (Holtzman et al. 2018). Using the data from this study, athletic trainers and sports dietitians may be able to flag athletes who have experienced previous bone stress injuries for further evaluation. The athletes in these categories may need assistance in observing if they are trying to train and compete in a low energy available state, therefore placing themselves at higher risk of these injuries.

Energy Expenditure

To provide some insight specifically about RMR, Jagim et al. (2019) published a study comparing sex differences and identifying predictors of RMR in Division III NCAA athletes. The participants included 68 male and 48 female athletes who were assessed via indirect calorimetry to determine RMR and the use of air displacement plethysmography to measure fat-mass (FM) and fat-free mass (FFM). Once adjusted for body mass and FFM, male and female athletes' differences between RMR in males and females were not significant (Jagim et al. 2019). What is most important from this research is that body mass was the strongest predictor of RMR. An athlete's increased muscle mass or LBM will cause an increase in their energy needs, especially when taken into account with their high levels of physical activity. As athletes transition from high school to college sports, they may experience body composition changes. Athletes may not be knowledgeable on how to adjust for these changes, therefore, putting themselves at risk for inadequate intake.

The Nelson equation is a predictive equation which uses a person's gender, age, height, and weight as well as their measured FM and FFM to calculate their RMR. This equation has tendencies to produce RMR more accurate values to those produced by indirect calorimetry in males and to slightly overpredict RMR for females (Lindsey et al. 2021). To calculate TTE, the RMR value that was produced by the Nelson equation is multiplied by a physical activity factor to account for caloric energy expended depending on the level of activity that person participates in (Body Composition Lab, 2022). Indirect calorimetry is a common method for assessing RMR and is considered more accurate than most predictive equations (Siew & Liu 2019). However, due to limited availability of a metabolic cart, time, and costs of using indirect calorimetry, the predictive Nelson equation was best fit for the current study. The purpose of this research was to evaluate current perceptions and levels of knowledge in NCAA student-athletes related to their calculated energy needs.

METHODS

Participants

Student-athletes were recruited from a variety of sports from a University in Mississippi. They were recruited via email, group messages, or guided in-person with a QR code by a team sport dietitian at the University's athletic facilities and fueling stations. Exclusion criteria were athletes under the age of 18 years old or those that chose not to consent. Participants were asked to review and sign consent forms and voluntarily complete a questionnaire. This research was approved by the University of Mississippi Institutional Review Board (protocol #23x-145).

Procedures

Participants were asked to complete a questionnaire (see Appendix A) that contained six questions that included demographic information and three questions about their perception of caloric intake and prior education related and health and sports nutrition. Further, the participants were also asked not to share answers or use outside resources when answering the questionnaire. After the completion of the questionnaire, pre-existing energy need data were matched to questionnaire results. The data was coded, de-identified, and prepared for statistical analysis.

Statistical Analysis

IBM SPSS software version: 28.0.0.0 was used to perform all statistical analysis tests. The statistical significance value for this study is set at $p < 0.05$. Descriptive statistics were conducted to determine participant characteristics (mean ± SD; frequency). A one sample t-test was used to determine the relationships between the student-athletes' perceived non-training day needs and their calculated RMR, as well as training day needs and their calculated TEE. Independent t-tests were used to look at the differences between sex, prior knowledge, and student-athletes' perceived outcomes. A Kruskal Wallis H test was used to evaluate the statistics and further significance of the relationship between what year in school the student-athletes were in and their perceived outcomes. Additionally, the relationship between the different sports the student-athletes participate in and how they may have impacted the outcomes on perceived training day needs/TEE, the Kruskal-Wallis H test was used to evaluate this relationship. While an ANOVA test was inappropriate to use on this data set due to its parametric assumptions, a post hoc test allowed further breakdown of the differences between sports. One student-athlete had to be removed from the data set to run the post hoc since this athlete only represented one sport.

RESULTS

Participants

One hundred and two student-athletes from ten different sports responded to the questionnaire, 49 were male and 53 were female. Of the 102 respondents, 75 had previously calculated RMR/TEE data and completed the questionnaire; 42 (56%) were male and 33 (44%) were female. In terms of the variety of sports for the 75 participants, the breakdown was as follows: 16 (21.3%) baseball; 15 (20%) football; 14 (18.6%) track and field/cross country; 7 (9.3%) golf; 6 (8%) soccer; 5 (6.7%) rifle; 5 (6.7%) softball; 4 (5.3%) volleyball; 2 (2.7%) tennis; and 1 (1.3%) basketball. Sixty (80%) reported "yes" to having taken a college-level health or nutrition course or meeting with a Sports Dietitian, leaving 15 (20%) who said they have not. The final piece of demographic data collected was related to what year they were in school. There were 9 (12%) were freshman; 16 (21.3%) sophomores; 21 (28%) juniors; 28 (37.3%) seniors; and 1 (1.3%) was a graduate student.

Perceived Energy Needs vs. Calculated Needs

Table 1 shows the comparison of perceived needs of student-athletes on non-training and training days compared to calculated needs of RMR and TEE via the Nelson equation, respectively. There was a significant difference (p-value < .001) found in both non-training versus RMR as well as training versus TEE relationships.

Table 1: Perceived Non-Training Day Needs versus RMR

N = 75	Mean ± SD	Mean Difference (Calories)	p-value
Perceived Non-Training (Calories)	2319 ± 887	Perceived > RMR Difference = 509	< .001
RMR (Calories)	1810 ± 476		
	RMR = Resting metabolic rate		

Table 2: Perceived Training Day Needs versus TEE

N = 75	Mean ± SD	Mean Difference (Calories)	p-value
Perceived Training (Calories)	3105 ± 1209	TEE > Perceived Difference = 323	< .001
TEE (Calories)	3428 ± 1007		
	TEE = Total energy expenditure		

Sex Differences

Sex differences were found when comparing their perceived needs to their calculated needs. Table 2 shows the comparison of the differences between males' and females' knowledge of energy needs. On the perceived non-training day needs, females had a mean difference of 590 calories compared to their calculated RMR, with their perceived needs being greater. The males had a mean difference of 444 calories with perceived non-training day calories also being greater than their RMR. Opposing results were found when comparing the males and females perceived training day needs to their calculated TEE. The female participants reported their training day needs through the questionnaire as lower than that of their TEE, as did the males.

Table 3: Male versus Female Perceived Non-Training Day Needs versus RMR

N = 75 (49 Male; 53 Female)	Male (Mean ± SD)	Female (Mean ± SD)	p-value
Perceived Non-Training (Calories)	2587 ± 917	1978 ± 727	< .001
RMR (Calories)	2143 ± 348	1388 ± 198	
Mean Difference (Calories)	Perceived > RMR 444	Perceived > RMR 590	
	RMR = Resting metabolic rate		

Table 4: Male versus Female Perceived Training Day Needs versus TEE

N = 75 (49 Male; 53 Female)	Male (Mean ± SD)	Female (Mean ± SD)	p-value
Perceived Training (Calories)	3619 ± 1270	2450 ± 726	< .001
TEE (Calories)	4083 ± 831	2595 ± 425	
Mean Difference (Calories)	TEE > Perceived 464	TEE > Perceived 145	
	TEE = Total energy expenditure		

Prior Knowledge

The student-athletes who reported having prior knowledge showed a mean difference of 646 calories higher than that of their calculated RMR. The difference between their perceived training day needs and TEE was closer with a mean difference of 155 calorie overestimation. The outcomes for those that reported not having prior knowledge showed much closer values of perceived non-training day needs and RMR, with a mean difference of 41 calorie overestimation. However, when looking at their perceived training day needs and TEE, there was a mean underestimation difference of 997 calories compared to calculated TEE. Perceived non-training and training day needs showed a statistical significance ($p = .020$, $p = .048$, respectively) in relation to prior knowledge. Student-athletes with prior knowledge had perceived non-training day mean of 590 calories greater than those without prior knowledge. Similarly, regarding perceived training day needs, the prior knowledge group estimated calories to be 690 greater than the group with no prior knowledge. RMR and TEE did not have statistical significance (p = 0.483, p = .605, respectively) in relation to the student-athletes' prior knowledge.

Table 5: Prior Knowledge & Perceived Non-Training Day Needs versus RMR

N = 75 (60 Yes; 15 No)	Yes - Prior Knowledge (Mean ± SD)	No - Prior Knowledge (Mean ± SD)	p-value
Perceived Non-Training (Calories)	2437 ± 841	1847 ± 938	p = .020
RMR (Calories)	1791 ± 498	1888 ± 380	p = .483
Mean Difference (Calories)	Perceived > RMR 646	RMR > Perceived 41	
	RMR = Resting metabolic rate		

Table 6: Prior Knowledge & Perceived Training Day Needs versus TEE

N = 75 (60 Yes; 15 No)	Yes - Prior Knowledge (Mean ± SD)	No - Prior Knowledge (Mean ± SD)	p-value
Perceived Training (Calories)	3243 ± 1181	2553 ± 1201	p = .048
TEE (Calories)	3398 ± 1049	3550 ± 8367	p = .605
Mean Difference (Calories)	TEE > Perceived 155	TEE > Perceived 997	
	TEE = Total energy expenditure		

Sport Participation & Academic Year

There was a statistically significant association between sport and perceived training needs, $X^2(9) = 29.85$, p = < .001. Similarly, sport and TEE resulted in a statistically significant difference, $X^2(9) = 56.65$, p = <.001. The post hoc test revealed some statistically significant differences between sports for perceptions of non-training day needs. Baseball showed significant differences in their means compared to soccer which had a mean difference of 1,503 calories less than baseball (p-value = .003), golf with mean difference of 338 calories less than baseball (p-value =.032), and rifle with a mean difference of 383 calories less than baseball (p-value = .012). There was statistical significance established between two sets of sports for perceptions of training day needs.

Soccer and football had a mean difference of 1,733 calories, with football being greater (p-value = .020), while football also had a greater difference than rifle with mean difference of 1,837 calories (p-value =.022).

No statistical significance was determined by the Kruskal Wallis H test was run to determine relationships between the student-athletes' academic year and perceived needs and calculated needs. There was no significance found between the student-athlete's academic year in school and their perceived non-training day needs $X^2(4) = 3.955$, $p = .412$ or their RMR $X^2(4) = 5.789$, $p = .215$. Additionally, there was also no significance and therefore relationship associated between their academic year in school with their perceived training day needs $X^2(4) = 1.253$, $p = .869$ or their TEE $X^2(4) = 4.275$, $p = .370$.

DISCUSSION

The aim of this study was to evaluate NCAA student-athletes' level of nutrition knowledge related to the energy they utilize at rest and during training. This population of student-athletes' perceived non-training day energy needs were higher than that of the student-athletes RMR while their training day needs were lower than their TEE. The student-athletes' reported their non-training (rest day) needs as a mean of 509 calories higher than their RMR. Since RMR is a measure of the minimum needs a person should have to function at a basic level, this amount is not adequate to support optimal recovery and rest. Bytomski (2018) explains how an athletes RMR should be multiplied by a physical activity level to calculate their approximate needs for the a given day. Even on a rest day, an athletes RMR can be multiplied by a low factor to support rest and recovery. Based off this evidence from Bytomski in 2018, the mean difference of 509 calories would likely not be enough of a difference to support most of these athletes on a non-training day. To further expand on these findings, the current study also found the student-athletes' perceived training day needs to be lower than their TEE. These outcomes align with both the lack of sound sports nutrition knowledge and inadequate energy intake of many student-athletes that has previously been stated within the literature (Andrews et al. 2016; Klein et al. 2021; Manning et al. 2021; Serhan et al. 2022; Shriver et al. 2013; Zabriskie et al 2019).

The outcomes of the sex variable when evaluating their perceived and calculated needs showed that females had a greater perceived difference in energy compared to RMR than males. Since the female mean difference was greater than the male, their perceived energy was somewhat closer to actual estimated needs to support recovery on a non-training day. This outcome supports some of the literature in that females reported better nutrition knowledge scores (Guadagni et al. 2019; Heaney et al. 2011). However, overall, the literature remains inconsistent on differences between male and female nutrition knowledge levels. These inconsistencies align with the outcomes in this study in that both sexes' perceived training day needs were lower than their calculated TEE. Student-athletes who reported having prior knowledge had perceived needs for non-training and training days higher than those who did not report having prior knowledge.

The participants with prior knowledge show a better understanding of their needs. Although, while having prior knowledge did make a difference in having a more adequate understanding of needs, there is still an overall deficit in understanding, which means more education is necessary. Perceived needs for non-training were much closer to their actual RMR and there was a greater difference in their perceived training day needs and TEE, with TEE much higher. These outcomes may be indicative that student-athletes who have taken a college-level health or nutrition course or met with a sports dietitian have a better understanding of their needs than those who have not. The lack of significance for academic year in school indicates the sport nutrition knowledge level of a senior is no different from that of a freshman.

The differences established for non-training day needs between baseball and soccer, golf, and rifle is due to the differences in both sex and demands of the sports. This is similar to the differences in training day needs for football in comparison to soccer and rifle. Since baseball and football are male sports and the others are female sports, the energy needs are going to be higher since male RMR/TEE are greater than the same values for females. Additionally, the physical demands of football and baseball will require greater energy needs compared to the demands of sports such as golf and rifle (Kasper et al. 2022). Soccer had a large mean difference from baseball and football compared to the mean differences between rife with football and baseball. Considering the demands of a soccer player compared to the demands of the athletes who participate in rife, the soccer players should have greater demands (Mara et al. 2015). The mean differences in training day needs for soccer players compared to football players was 1,733 calories, while rifle to football players was 1,837 calories. On non-training day needs, soccer players had a mean difference of 1,503 calories compared to baseball players while rifle only had a mean difference of 383 calories. This may highlight an area of need for rifle and soccer player especially. Further research into these discrepancies may be needed to know which group has a greater misunderstanding of their energy needs and therefore may require a more intense educational intervention.

The importance and clinical application of this data is in knowing the knowledge level of these student-athletes so that sport nutrition professionals can fill the gaps and provide information to fit their needs. In this study, these student-athletes do not have an adequate understanding of their energy needs. Whether this gap comes from not knowing how much energy they are utilizing or not understanding how to fulfill their caloric needs, it places them at risk for being in a LEA or RED-S state (Metz 2022; Williams et al. 2019). There is a better understanding of caloric needs for those that have prior knowledge, so sports dietitians should continue to build upon student-athletes' current knowledge. Using the information from this study, sports dietitians can help athletes understand their needs better on a sport-specific and personal level, to keep them from under-fueling. Furthermore, helping athletes to find sound resources for sport nutrition information would be beneficial to keep the material they are consuming evidence-based and fit for their sport and individual demands.

In terms of building upon this research and the current literature, it would be valuable to assess the actual intake of more student-athletes to grasp the differences in nutrition knowledge versus nutrition practice. A 2021 study found when looking at nutrition knowledge and practices in student-athletes they found that athletes were not skipping meals and before and after workouts or practice (Klein et al. 2021). The translation between knowledge and practice would be valuable to understand when working with athletes. Adding to the prior knowledge piece of the current study could help sports dietitians better understand what nutrition education methods translate best to implementing changes in student-athletes nutrition practices. Furthermore, a study by Jagim et al. in 2021 included information assessing the socioeconomic impacts and barriers to obtaining adequate amounts or appropriate food choices to support sport performance. There could be a multitude of reasons why student-athletes are unable to fuel themselves properly for sports. The direction of future research should aim to understand this rationale so that health care professionals, sports dietitians, and universities can utilize their resources to support their student-athletes' needs.

Strengths & Limitations

A strength of the present study is the potential clinical applicability due to the real-world nature of the participants versus a tightly controlled laboratory study. The results should be generalizable to any Division I institution with student-athletes of this age range and sport participation. Additionally, gathering data via questionnaire versus an in-person interview may have allowed the subjects to feel more comfortable stating they had no prior nutrition knowledge, as well as avoiding manipulation of caloric values due to fear of being judged. While some student-athletes may be comfortable discussing caloric intake, for others it may be a sensitive subject. Due to the high statistical significance with respect to perception versus reality regarding caloric needs and sex differences, sports dietitians may use this information to increase awareness for themselves and their athletes, potentially reducing rates of LEA/RED-S and related sequelae.

The questionnaire was created by the main researcher and while it required simple binary yes or no answers or estimating a simple single numeric value (caloric needs), the questionnaire was not validated nor pilot test/retested for reliability. Additionally, the student-athletes may have had knowledge from sources other than the options provided and therefore could have been missed. There was also not an attempt to determine if any prior knowledge was accurate, however, if we are truly concerned with finding out what real world athletes know this is an accurate representation of that. Another limitation is that indirect calorimetry may have been a more accurate way to measure RMR and TEE values. As stated in the review of the literature, there is some inaccuracy in the ability of the Nelson equation to accurately assess predictions of RMR, especially in the female population.

CONCLUSIONS

Sports nutrition is a key component in supporting a student-athlete's health and performance. The current study highlighted the lack of understanding student-athletes had of their caloric needs on both training and non-training days. Female athletes were only slightly more accurate with their non-training day needs in comparison to their RMR than males, both sexes underestimated their training day needs. Student-athletes with prior knowledge reported non-training and training day values higher than those who did not have prior knowledge. This means the prior knowledge group showed a better understanding of their needs in comparison to those without prior knowledge. Furthermore, there was no relationship between the student-athletes' academic year in school and their caloric comparisons. Efforts to understand where the gaps in both sports nutrition knowledge and practices should be made to enhance support and provide reliable resources.

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APPENDIX A

Questionnaire:

Please do not share answers or use outside resources (internet) to answer questions.

1. Name

2. Are you 18 years or older?
    a. If not, please do not complete this questionnaire.

3. What sport do you participate in?

4. How many calories do you think you need on a non-training (rest/off) day?

5. How many calories do you think you need on a typical practice day?

6. Have you taken a college-level health or nutrition course or met with a Sports Dietitian?