Spring 2022

A Comparison of Dietary Intake in Female College Volleyball Players Before and During the COVID-19 Pandemic

Justine Nuckols
Western Washington University, nuckolj@wwu.edu

A Comparison of Dietary Intake in Female College Volleyball Players Before and During the COVID-19 Pandemic

By

Justine Nuckols

Accepted in Partial Completion
of the Requirements for the Degree
Master of Science

ADVISORY COMMITTEE

Dr. Lorrie Brilla

Dr. Dave Suprak

Dr. Jun San Juan

GRADUATE SCHOOL

David L. Patrick, Dean

A Comparison of Dietary Intake in Female College Volleyball Players Before and During the COVID-19 Pandemic

A Thesis
Presented to
The Faculty of
Western Washington University

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

by
Justine Nuckols
May 2022

Abstract

Context: There is little evidence on the comparison of dietary intake in female college volleyball players before and during the Covid-19 pandemic. Because of the pressures athletes face to perform, it is important to monitor how athletes respond to adversity. Diet is important to consider when analyzing the overall health of athletes.

Objective: To investigate the effects of a global pandemic on kilocalorie intake and macronutrient consumption in collegiate female volleyball players.

Design: Subjects were invited to provide two diet health questionnaires about dietary intake before and during the pandemic. The questionnaires were the same.

Setting: An internet link to the survey with a username and password was sent via email in secure OneDrive Shared File.

Participants: A total of 15 female collegiate volleyball participated in the study.

Main Outcome Measures: Survey questions addressed habitual dietary intake before and during the pandemic. Total kilocalorie consumption and macronutrient consumption were analyzed and compared.

Results: Players consumed 1539 kilocalories per day before the pandemic. During the pandemic there was a kilocalorie intake of 1400 kilocalories per day (p= 0.33798; d=0.17). Players consumed 209 grams of carbohydrates (CHO) before the pandemic and 171 grams during the pandemic (p=0.01204; d=0.36). Before the pandemic, the amount of CHO consumed was 3.12 g/kg. During the pandemic, this intake decreased to 2.63 g/kg. Before the pandemic 116 grams of sugar were consumed each day; during the pandemic only 77 grams of sugar were consumed (p=0.00010; d=0.60).

Conclusions: This study shows CHO consumption in college volleyball players during the pandemic had a significant decrease compared to before the pandemic. Collegiate female athletes are still struggling to meet adequate carbohydrate consumption needed for competition and training before and during the pandemic. Reinforcing proper dietary habits may lead to better sport performance.

Key Words: kilocalorie intake, macronutrient consumption, volleyball players, Covid-19 pandemic

Word Count: 305

Acknowledgements

I would like to take the opportunity to thank the faculty of the Kinesiology department at Western Washington University for all the support and encouragement throughout the last couple of years. A special thank you to my committee members Dr. Lorrie Brilla, Dr. Dave Suprak, and Dr. Jun San Juan. Thanks to their commitment and guidance I was able to complete my thesis.

I also would like to give a special thank you to my parents, Carl and Maria Nuckols. They have always encouraged me in all my endeavors and pushed me to be the best version of myself. I could not have done this without their support.

Table of Contents

List of Tables and Figures

An important component in the success of athletes begins with adequate energy intake to support caloric expenditure and contribute to maintenance and improvement in strength, endurance, muscle mass, and health.[1]. Inadequate energy intake relative to energy expenditure can reduce athletic performance and reverse the benefits associated with exercise.[2–4] To enhance optimal performance and recovery from exercise, recommendations have been given on amount and types of food for certain types of athletes.[2]

Energy intake of athletes involved in moderate levels of intense training, such as elite volleyball players (i.e., 2-3 h/day. 5-6 times/week), has been recommended to be 50-80 kcal $kg^{-1}\cdot day^{-1}$. Specific macronutrient recommendations are 1.6-1.8 g kg^{-1} day^{-1} for protein, 5-8 g kg^{-1} day^{-1} for carbohydrates, and fat intake comprising 20-35% of total kilocalories to meet the demands of performance.[5] Volleyball is a high-intensity, predominantly anaerobic sport based activity. Due to the long volleyball game duration, the human body relies on CHO as its main energy source.[6] Physical performance and the fatigue incurred by athletes in anaerobic sports are partially dependent on carbohydrate (CHO) reserves accumulated in the body and availability during physical loads.[7,8] Volleyball is a high-intensity game requiring speed and large muscle groups for jumping, spiking, blocking, and digging. These high-intensity actions can occur in short bouts every 30 seconds of play over a total period of 30-180 minutes.[10] Athletes who include high repetitions with a moderate to high level of intensity will deplete greater concentrations of glycogen than athletes performing lower intensity repetitions. [9]

Even with nutritional recommendations, athletes still struggle with consuming adequate amounts and types of energy. When assessing the diet quality of college athletes, females tend to have a better diet quality than males.[11,12] Specifically, in one study examining dietary habits in college athletes, participants had diets that were high in solid fats, alcohol, and added sugar. Their diets were also high in sodium and low in fiber and fruit.[11] A number of barriers to healthy eating have been described by college athletes such as lack of time for food preparation, inadequate cooking skills, financial limitations, and difficult living arrangements.[13,14] Several investigations have shown that female and male athletes have failed to compensate for increased energy demands for training and competition.[15–19] Most athletes, particularly female, struggle with meeting adequate CHO recommendations, while increasing their fat intake.[5,6,20–22]

Many factors can play a role in dietary habits associated with athletes including ability to perform, demands of weight category related sports, and aesthetic of a particular body image. However, some dietary habits acquired by athletes to achieve goals can have negative consequences. Eating disorders are especially common in sports where weight has a significant effect on performance. In endurance runners it is desirable to have a high lean body mass and low body fat mass to achieve a high power to weight ratio. Sports that require horizontal or vertical movements, like running or gymnastics, have considered excess fat mass on the body as a disadvantage that increases energy demands.[23] Athletes in weight category sports, like wresting and boxing, will not be able to compete if their weight is above the limit in their category. In sports like diving and gymnastics, aesthetic quality is attached to a particular body composition that is promoted and encouraged in competitors.[23–25] Anorexia Nervosa and Bulimia Nervosa are two common eating disorders that have been observed in athletes.[24] The prevalence of eating disorders is significantly higher in male and female elite athletes than non-athletic males and females.[23] Females who suffer from eating disorders are at risk for the female athlete triad, which refers to the interrelationship between energy availability, menstrual function, and bone mineral density. This triad may have clinical manifestation that includes eating disorders, functional hypothalamic amenorrhea, and osteoporosis.[26]. Athletes who are "at risk" for an eating disorder frequently report more menstrual irregularity and sustained more bone injuries during their college career.[27] Disordered eating and irregular menses is commonly associated with increased risk of injury in young athletes.[28–30] While female athletes have a higher rate of disordered eating than male athletes,[11] male athletes are not immune to disordered eating that can potentially cause long term metabolic problems.[31] The existence of all elements in the female athlete triad is not essential due to high variability in incidence for each one, which can lead to underdiagnoses.

In 2014 relative energy deficiency in sport (RED-S) was introduced, meeting the need for a more holistic approach.[32] RED-S occurs when energy expenditure exceeds energy intake, creating an energy deficiency. This can result in health issues such as; weight changes, amenorrhea or menstrual irregularities, hypoglycemia, changes in eating behaviors, excessive exercising, and body image issues.[33]

Life alternating events that cause stress, anxiety, depression, and injury play a significant role in the development of dietary habits. Recently a life alternating event of CoV-19/SARS-CoV-2 (COVID-19) has struck globally and has changed many lives. COVID-19 is a highly pathogenic virus that is causing infection and even death around the world. In the United States, restricted government rules and quarantining protocols were put in place to try and contain the spread of the virus. Because of these restrictions, athletics and sporting events were prohibited or extremely modified and regulated. Recent studies have emerged analyzing the effect of COVID-19 on changes in diet and physical activity.[37–42] With the dramatic impact this virus has had on athletics from adolescents to professional athletes, it is worth analyzing the effects of COVID-19 on the nutritional health of athletes who lost seasons or training periods due to the virus. Not eating enough kilocalories can seriously impact an athlete's ability to train effectively and has the potential to trigger an eating disorder. Fueling with CHO is important to increase time to fatigue and prevent athletic injuries caused by fatigue.

Studies that investigate the effect of nutrition and diet on health in populations need accurate methods to assess. Self-administered food frequency questionnaires (FFQ) ask respondents about the frequency and portion size of typically consumed foods.[43] Diet History Questionnaire (DHQIII) is used by researchers, clinicians, and educators to assess food and dietary intakes. The nutrient and food group database is based on compilation of a 24-hour dietary recall data from the National Health and Nutrition Examination Surveys (NHANES).

Not much is known on how COVID-19 has altered dietary eating patterns in Americans, let alone college athletes. Because of the pressures athletes face to perform it is important to understand how they respond to adversity, which can include changes in dietary patterns. Monitoring changes in dietary patterns is useful in injury and eating disorder prevention, as well as sport performance. The purpose of this study is to investigate the effects of a global pandemic on kilocalorie intake and macronutrient consumption in collegiate female volleyball players'.

METHODS

Participants

Data were obtained from collegiate volleyball players competing at a Division II level at Western Washington University and junior college level at Whatcom Community College. The Western Washington University volleyball team was ranked third nationally heading into the 2019 fall season. Whatcom Community College volleyball was ranked first in the north region standings heading into the 2019 fall season. Permission was requested from all head coaches from the teams involved in the study for athlete participation. A total of 32 volleyball players were eligible for participation;15 agreed to participate. Ages of subjects ranged from 18-22 years old. Prior to the study, all participants signed a consent form in accordance and approved by the local Institutional Review Board for the protection of Human Participants. Age, height, and weight was voluntarily given by participants through the questionnaire (Table 1). Data were collected from the athletes' current mid-pandemic season, and compared to the previous season, pre-pandemic (Table 2).

Participants	N=15
Sex	Female
	Mean ± SD
Age (years)	19.5 ± 1.2
Height (cm)	170.7 ± 7.3
Weight (kg)	67.4 ± 7.7

Table 1. Participant demographics.

Games Played	
Pre-Pandemic	Mid-Pandemic
30	11
Season Length (months)	
3.5	1

Table 2. Number of games played and season length.

Instrumentation

Participants completed two food frequency questionnaires. All surveys were administered through email to adhere with COVID-19 guidelines and safety protocols. The Diet History Questionnaire (DHQIII) that was administered is used by researchers, clinicians, and educators to assess food and dietary intakes. The nutrient and food group database is based on compilation of national 24-hour dietary recall data from the National Health and Nutrition Examination Surveys (NHANES) conducted from 2007-14. Findings from DHQ evaluation studies show that this tool provides nutrient estimates similar to most comprehensive FFQs (Subar, 2003; Thompson, 2002; Subar, 2001). Pictures of portion sizes were provided to enhance the accuracy of quantity. DHQ III consists of 135 food and beverage line items and 26 dietary supplement questions. Some line items for foods and beverages have additional questions that allow for final assignment to items in the nutrient and food group database leading to 263 foods and beverages listed in the database.

Procedure

Two food frequency questionnaires were sent via email to participants. The questionnaire had athletes estimate their usual intake of many nutrients and food groups. There were clear instructions attached to the questionnaire to ensure it was filled out as accurately and thoughtfully as possible. Pictures and portion sizes were provided to ensure accuracy of quantity sizes. Athletes were instructed to fill out one food frequency questionnaire regarding their overall diet from last season, pre-pandemic. The second food frequency questionnaire included their diet from the current season, mid-pandemic. The two food frequency questionnaires, pre-pandemic and mid-pandemic, were compared to analyze any changes in dietary habits.

Statistical Analysis

The DHQ III was used to perform the primary analysis of comparing habitual food intake pre-pandemic and mid-pandemic in female collegiate volleyball players. Paired t-tests were conducted through Microsoft Excel (2018) to compare macronutrient and kilocalorie consumptions before the pandemic and mid pandemic. Significance was established at a p-value <0.05. The effect size was calculated by finding the mean difference between the groups and dividing by the pooled standard deviation. Following Cohen d's guidelines effect size was defined as 0.2 as small, 0.5 as medium, and 0.8 as large (Cohen, 1992).

Results

All participants in the study were female collegiate volleyball players at a Division II university or community college. The number of games played before the COVID-19 pandemic was 30 games over a three-and-a-half-month span. During the pandemic, athletes played a condensed season of 11 games over a one-month span. Players consumed 1539 kilocalories per day before the pandemic, with 56% of those calories from CHO, 32% from fats, and 13% from protein (Table 3). During the pandemic there was not a significant decrease in kilocalorie intake, players consumed 1400 kilocalories per day (p=0.33798; d=0.17). Results showed 49% of total kilocalorie intake from CHO, 36% from fats, and 15% from protein (Table 3). Players consumed 49 grams of protein before the pandemic and 51 grams of protein during the pandemic (p= 0.86724; d=0.03). The amount of fat consumed pre-pandemic was 56 grams compared to 57 grams during the pandemic (p= 0.87681; d=0.03). The significant change in macronutrient consumption was in CHO. Players consumed 209 grams of CHO before the pandemic and 171 grams during the pandemic (p= 0.01204; d=0.36). Total daily sugar intake also decreased significantly during the pandemic compared to before Covid-19. Before the pandemic 116 grams of sugar were consumed each day; during the pandemic only 77 grams of sugar were consumed (p = 0.00010; d=0.60). Before the pandemic 67% of total sugars were added sugars and 61% during the pandemic (p=0.00016; d=0.66).

	Before Pandemic	Mid-Pandemic
Total Daily Energy (kcals)	1539.3 ± 781.8	1400.6 ± 892.5
Total Daily Protein (g)	49.4 ± 35.3	50.6 ± 39.2
% Kcals from Protein	12.72%	14.82%
Total Daily Fat (g)	55.8 ± 33.9	57.1 ± 44.5
% Kcals from Fat	31.64%	36.63%
Total Daily CHO (g)*	209.4 ± 105.1	171.3 ± 108.4
Kcals from CHO*	55.85%	49.01%
Total Daily Sugar (g)*	116.5 ± 65.7	76.9 ± 65.4
Added Sugars by Total* Sugars (g)	78.3 ± 45.6	46.9 ± 49

Table 3. Total daily kilocalorie and macronutrient consumptions before and during the pandemic Mean ± SD (* indicates significant).

Discussion

The main purpose of this study was to compare the dietary intake of female collegiate volleyball players before the COVID-19 pandemic to their eating patterns that were developed during the middle of the pandemic. CHO consumption had a significant decrease during the pandemic. Literature has shown that most athletes, particularly female, struggle with eating adequate CHO recommendations.[5,6,20–22] Current research explains that 50-60% of energy substrate utilization during 1-4 hours of continuous exercise at 70% of VO_{2Max} is derived from CHO.[9] During the pandemic, calories from CHO dropped about 7% compared to before the pandemic. The percentage decrease may not seem drastic, but with female athletes already struggling to maintain adequate CHO intake it can be damaging to sport performance. In a study assessing dietary intakes and eating habits of female college athletes, results showed that energy and CHO intakes were below the recommended amount, with only 9% of participants meeting their energy and CHO needs, and 75% failing to consume the minimum amount of CHO required to support training.[15] In the current study, only 47% of participants met the minimum recommendations of CHO intake needed for training.

Volleyball players perform an intense intermittent activities that recruits large masses of muscle. When combined with short rest periods, these types of activities can decrease glycogen stores by 24-40%. It is recommended that an intake of 5-10 g kg^{-1} day^{-1} is needed to maintain glycogen stores for these types of athletes.[1] In this study, before the pandemic, the amount of CHO consumed by female volleyball players was 3.12 g/kg. During the pandemic, this number decreased to 2.63 g/kg. Female college volleyball players were failing to meet the necessary CHO intake for training and competition before the pandemic began, and deficiency was exacerbated during the pandemic. When power athletes are below the recommended CHO value needed for training and competing, it decreases the reserves available to utilize during play and decreases the time to fatigue. This decrease in reserves may seriously impact players' performance or put them at risk for injury.[4]

Total daily sugar intake also decreased during the pandemic. Before the pandemic 116 grams of sugar were consumed each day; during the pandemic, only 77 grams of sugar were consumed. This finding is consistent with a study conducted in Spain for the general population. Research indicated that during the pandemic the studied population adopted healthier dietary habits by decreasing the intake of fried foods, snacks, fast foods, red meat, pastries, or sweet beverages and increasing Mediterranean diet foods like olive oil, vegetables, fruits, and legumes.[40,41] The consumption of sweet snacks also decreased compared to the production of homemade desserts. [42] In this study, the decrease in daily sugar intake could also contribute to the decline in CHO consumption. A study analyzing the effects of COVID-19 on collegiate student athletes' health found that the average number of meals consumed each day stayed the same, but females reported consuming less food and perceived increased healthfulness in their diets.[48] Excessive sugar consumption has also been shown to reduce the hypothalamic-pituitary adrenal (HPA) axis. The HPA plays a role in regulating stress. Following consumption, hormones are released to reduce the feelings of stress, which also increase the desire for comfort foods.[49] Stressors of college athletes can come in many forms such as playing time, injuries, discontentment with coaching style, poor academic performance, relationships with teammates, and their win and loss record.[50] One study conducted on college athletes measured stress, anxiety, and depression during the Covid-19 pandemic. The results showed symptoms of anxiety, depression, and stress were not elevated among most college athletes.[51] It is possible that with having altered volleyball seasons that did not result in regular season standings, there was no increase in stressors. This lack of stressors could explain the decrease in sugar consumption.

Dietary fat intake did not change significantly pre-pandemic at 32% to 36% during the pandemic. The amount of fats consumed pre-pandemic was 56 grams compared to 57 grams during the pandemic. It is possible that the slightly higher dietary fat intake compromised the amount of CHO and sugar consumed by athletes.

Although there was not a significant change in kilocalorie consumption before the pandemic to mid-pandemic, the kilocalorie intake was still below the recommended amount for volleyball players in each time period. Elite volleyball players can expend 600-1200 kilocalories or more per hour of exercise.[1,2] Data from this study shows that before the pandemic, athletes were only consuming 1550 calories a day. During the pandemic, kilocalorie intake decreased. The current recommendations for energy intake range from 44 to 50 kcal kg^{-1} day^{-1}.[1,2] In the current study, 22.8 kcal kg^{-1} day^{-1} were consumed before the pandemic. During the pandemic, consumption decreased to 20.8 kcal kg^{-1} Energy consumption of fewer than 2,000 kilocalories per day has been identified as “low energy intake,” and cannot support the high physical and nutritional demands of female athletes.[15] According to this definition, 73% of the athletes consumed less than 2,000 $kcal^{-1}$ day^{-1} before the pandemic and would be considered “low energy intake”. During the pandemic, 87% of the athletes consumed less than 2,000 kca^{-1} day^{-1}. Female athletes typically consume less than 2000 $kcal \cdot day^{-1}$ during training and competition, not enough to support recommendations to maintain optimal muscle glycogen stores.[26,35] Decreased amount of kilocalories over time could significantly reduce strength and endurance performance, and compromise the immune, endocrine, and/or musculoskeletal systems.[3,4,7] Reduced energy availability should be further investigated, especially as athletes start to return to a more normal training regime and competitions.

Dietary intake could have changed for numerous reasons: limited access to certain foods or restaurants, limited travel for competition, more free time to cook meals at home, trying new diets. This information is important in considering how athletes are fueling their bodies while training and competing. Adequate kilocalories and CHO consumption are important for athletes' performance. Sports physicians, nutritionists, and athletic trainers should be aware of these changes and how they can potentially impact an athlete's overall health, training, and recovery.

Limitations

There are several limitations in the study conducted. The study is limited by the utilization of a relatively small sample of athletes. The study is very specific to female collegiate volleyball players and did not include males or athletes from different sports. Of the 31 female college volleyball players at Whatcom Community College and Western Washington University, 15 chose to participate. Participation in the study could have also been limited by survey access. Email was not considered secure enough to distribute surveys. In order to secure the identities of these athletes secure OneDrive folders were shared with participants to access the survey. This included extra steps that may have deterred athletes away from participating in the study. The length of the survey could have also decreased participation, completing both surveys took about 90 minutes. Nine athletes also chose to opt-out of the study to protect their physical and mental health due to prior eating disorders or discomfort with sharing personal dietary information.

Anthropometric data for each athlete before the pandemic and during the pandemic was not collected. Due to COVID-19 restrictions, this study had to be conducted online to ensure the safety of the athlete's health and protect them from potential exposures. Therefore, height and weight measurements were provided by participants and not physically measured. Measuring anthropometric data from before the pandemic and mid pandemic could have been insightful in determining the effects of dietary changes that occurred during the pandemic.

The DHQ III was the only tool implemented for collecting habitual dietary intake before and during the pandemic. Implementing a 3-day food record was attempted, but participation was lacking and was ultimately discarded after very few records were returned. Having 3-day food records would have been useful for the assessment of macronutrient and kilocalories consumption. Another limitation with using the DHQ III as the only tool is that athletes to had rely on memory to remember what their eating habits consisted of before the pandemic.

Conclusions

The results of the study show the importance of evaluating dietary intakes and eating habits of female college athletes during life-altering events. The female volleyball players who participated showed a significant decrease in CHO intake during the COVID-19 pandemic compared to their usual habitual intake before the pandemic. Sugar consumption also significantly decreased during the pandemic than before. Altered seasons due to the pandemic caused a shorter season length decreasing the total amount of games played compared to a regular season. During a regular reason 30 games were played over a course of 3.5 months. With a condensed season, 11 games were played in one month. Even though their total amount of games decreased, they had fewer breaks between games and the level of competition stayed the same. Female collegiate volleyball players still did not meet CHO recommendations. Adequate CHO consumption is essential for energy reserves during practice or competition to prevent a decrease in time to fatigue. CHO is a volleyball players main source of energy. With the study showing a decrease in CHO consumption during the pandemic, it is important that players start increasing CHO in their diet for practice and competition as seasons start to resume normally. Although the kilocalorie decrease in athletes was not statistically significant, as players resume normal training regimes, athletes must increase kilocalorie intake, so it does not affect their energy level, performance, and time to fatigue.

Works Cited

1. Raffaelli C, Milanese C, Lanza M, Zamparo P. Water-based training enhances both physical capacities and body composition in healthy young adult women. *Sport Sci Health*. 2016;12(2):195-207. doi:10.1007/s11332-016-0275-z

2. ACSM, ADA. Nutrition and athletic performance : position statement. *Med Sci Sport Exerc*. 2009;Special Co:709-731. doi:10.1249/MSS.0b013e318190eb86

3. Mercader I, Gonz J. Resilience, anxiety, stress ,depression and eating. *Nutrients* 2020;12(8):2045. doi:10.3390/nu12082405

4. Bonci L. Supplements: Help, harm, or hype? how to approach athletes. *Curr Sports Med Rep*. 2009;8(4):200-205. doi:10.1249/JSR.0b013e3181ae9ae8

5. Mielgo-Ayuso J, Zourdos MC, Calleja-González J, Urdampilleta A, Ostojic SM. Dietary intake habits and controlled training on body composition and strength in elite female volleyball players during the season. *Appl Physiol Nutr Metab*. 2015;40(8):827-834. doi:10.1139/apnm-2015-0100

6. Papadopoulou S. Impact of energy intake and balance on the athletic performance and health of top female volleyball athletes. *Med Sport J Rom Sport Med Soc*. 2015;11(1):2477. https://www.researchgate.net/publication/271209270

7. Kerksick CM, Kulovitz M. Requirements of energy, carbohydrates, proteins and fats for athletes. 1st Ed. Cambridge, MA: Academic Press; 2013. doi:10.1016/B978-0-12-396454-0.00036-9

8. Burke LM. Fueling strategies to optimize performance: Training high or training low? *Scand J Med Sci Sport*. 2010;20(SUPPL. 2):48-58. doi:10.1111/j.1600-0838.2010.01185.x

9. Kerksick CM, Arent S, Schoenfeld BJ, et al. International society of sports nutrition position stand: Nutrient timing. *J Int Soc Sports Nutr*. 2017;14(1):1-21. doi:10.1186/s12970-017-0189-4

10. Valliant MW, Pittman H, Wenzel RK, Garner BH. Nutrition education by a registered dietitian improves dietary intake and nutrition knowledge of a NCAA female volleyball team. *Nutrients*. 2012;4(6):506-516. doi:10.3390/nu4060506

11. Webber K, Stoess AI, Forsythe H, Kurzynske J, Vaught JA, Adams B. Diet quality of collegiate athletes. *College Stud J*. 2015;49(2):251-256. https://content.ebscohost.com/ContentServer.asp?T=P&P=AN&K=103235382&S=R&D=a9h&EbscoContent=dGJyMMTo50SeqLU4y9f3OLCmsEqepq9Ssq%2B4SrCWxWXS&ContentCustomer=dGJyMPGusk%2BzprdNuePfgeyx44Dt6fIA

12. Hull M V., Jagim AR, Oliver JM, Greenwood M, Busteed DR, Jones MT. Gender differences and access to a sports dietitian influence dietary habits of collegiate athletes. *J Int Soc Sports Nutr*. 2016;13(1):1-16. doi:10.1186/s12970-016-0149-4

13. Heaney S, O'Connor H, Naughton G, Gifford J. Towards an understanding of the barriers

to good nutrition for elite athletes. *Int J Sports Sci Coach*. 2008;3(3):391-401. doi:10.1260/174795408786238542

14. Rockwell MS, Nickols-Richardson SM, Thye FW. Nutrition knowledge, opinions, and practices of coaches and athletic trainers at a Division I University. *Int J Sport Nutr*. 2001;11(2):174-185. doi:10.1123/ijsnem.11.2.174

15. Shriver LH, Betts NM, Wollenberg G. Dietary intakes and eating habits of college athletes: Are female college athletes following the current sports nutrition standards? *J Am Coll Heal*. 2013;61(1):10-16. doi:10.1080/07448481.2012.747526

16. Vargas SL, Kerr-Pritchett K, Papadopoulous C, Bennet V. Dietary habits, menstrual health, body composition, and eating disorder risk among collegiate volleyball players: A descriptive study. *Int J Exerc Sci*. 2013;6(1):52-62. http://digitalcommons.wku.edu/ijes/vol6/iss1/7/

17. Loucks AB, Kiens B, Wright HH. Energy availability in athletes. *J Sports Sci*. 2011;29(SUPPL. 1). doi:10.1080/02640414.2011.588958

18. Hoogenboom BJ, Morris J, Morris C, Schaefer K. Nutritional knowledge and eating behaviors of female, collegiate swimmers. *N Am J Sports Phys Ther*. 2009;4(3):139-148. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC2953338

19. Cole CR, Salvaterra GF, Davis JE, et al. Evaluation of dietary practices of national collegiate athletic association division I football players. *J Strength Cond Res*. 2005;19(3):490-494. doi:10.1519/14313.1

20. Clark M, Reed DB, Crouse SF, Armstrong RB. Pre- and post-season dietary intake, body composition, and performance indices of NCAA division I female soccer players. *Int J Sport Nutr Exerc Metab*. 2003;13(3):303-319. doi:10.1123/ijsnem.13.3.303

21. Nepocatych S, Balilionis G, O’Neal EK. Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin J Sport Sci Med*. 2017;6(2):57-65. doi:10.26773/mjssm.2017.09.008

22. Hassapidou MN, Manstrantoni A. Dietary intakes of elite female athletes in Greece. *J Hum Nutr Diet*. 2001;14(5):391-396. doi:10.1046/j.1365-277X.2001.00307.x

23. Sundgot-Borgen J, Torstveit MK. Aspects of disordered eating continuum in elite high-intensity sports. *Scand J Med Sci Sport*. 2010;20(SUPPL. 2):112-121. doi:10.1111/j.1600-0838.2010.01190.x

24. Currie A. Sport and eating disorders - Understanding and managing the risks. *Asian J Sports Med*. 2010;1(2):63-68. doi:10.5812/asjsm.34864

25. Anne LB. Low energy availability in the marathon and other endurance sports. *Sport Med*. 2007;37(4-5):348-352. doi: 10.2165/00007256-200737040-00019. PMID: 17465605.

26. Nattiv A, Loucks AB, Manore MM, Sanborn CF, Sundgot-Borgen J, Warren MP. The female athlete triad. *Med Sci Sports Exerc*. 2007;39(10):1867-1882.

doi:10.1249/mss.0b013e318149f111

27. Beals KA, Manore MM. Disorders of the female athlete triad among collegiate athletes. *Int J Sport Nutr Exerc Metab*. 2002;12(3):281-293. doi:10.1123/ijsnem.12.3.281

28. Thein-Nissenbaum JM, Rauh MJ, Carr KE, Loud KJ, McGuine TA. Menstrual irregularity and musculoskeletal injury in female high school athletes. *J Athl Train*. 2012;47(1):74-82. doi:10.4085/1062-6050-47.1.74

29. Rauh MJ, Nichols JF, Barrack MT. Relationships among injury and disordered eating, menstrual dysfunction, and low bone mineral density in high school athletes: A prospective study. *J Athl Train*. 2010;45(3):243-252. doi:10.4085/1062-6050-45.3.243

30. Rauh MJ, Barrack M, Nichols JF. Associations between the female athlete triad and injury among high school runners. *Int J Sports Phys Ther*. 2014;9(7):948-958. https://pubmed.ncbi.nlm.nih.gov/25540710/

31. Chatterton JM, Petrie TA. Prevalence of disordered eating and pathogenic weight control behaviors among male collegiate athletes. *Eat Disord*. 2013;21(4):328-341. doi:10.1080/10640266.2013.797822

32. Coelho AR, Cascais MJ. The female athlete triad / relative energy deficiency in sports (RED-S). *Rev. Bras. Ginecol. Obstet*. 2021;43(05). doi: 10.1055/s-0041-1730289

33. Conviser JH, Tierney AS, Nickols R. Assessment of athletes with eating disorders: Essentials for best practice. *J Clin Sport Psychol*. 2018;12(4):480-494. doi:10.1123/jcsp.2018-0012

34. Torstveit MK, Fahrenholtz IL, Lichtenstein MB, Stenqvist TB, Melin AK. Exercise dependence, eating disorder symptoms and biomarkers of relative energy deficiency in sports (RED-S) among male endurance athletes. *BMJ Open Sport Exerc Med*. 2019;5(1):1-8. doi:10.1136/bmjsem-2018-000439

35. Putukian M. The psychological response to injury in student athletes: A narrative review with a focus on mental health. *Br J Sports Med*. 2016;50(3):145-148. doi:10.1136/bjsports-2015-095586

36. Sundgot-Borgen, J. Risk and trigger factors for the development of eating disorders in female elite athletes. *Med & Sci in Sport & Exerc*. 1994;26(4), 414–419. https://doi.org/10.1249/00005768-199404000-00003

37. Mattioli A V., Sciomer S, Cocchi C, Maffei S, Gallina S. Quarantine during COVID-19 outbreak: Changes in diet and physical activity increase the risk of cardiovascular disease. *Nutr Metab Cardiovasc Dis*. 2020;30(9):1409-1417. doi:10.1016/j.numecd.2020.05.020

38. Górnicka M, Drywień ME, Zielinska MA, Hamułka J. Dietary and Lifestyle Changes During COVID-19 and the Subsequent Lockdowns among Polish Adults : PLifeCOVID-19 Study. *Nutrients*. 2020;12(8):2324. doi:10.3390/nu12082324

39. Sidor A, Rzymski P. Dietary choices and habits during COVID-19 lockdown: Experience

from Poland. *Nutrients*. 2020;12(6):1-13. doi:10.3390/nu12061657

40. Rodríguez-Pérez C, Molina-Montes E, Verardo V, et al. Changes in dietary behaviours during the COVID-19 outbreak confinement in the Spanish COVIDiet study. *Nutrients*. 2020;12(6):1-19. doi:10.3390/nu12061730

41. Di Renzo L, Gualtieri P, Pivari F, et al. Eating habits and lifestyle changes during COVID-19 lockdown: An Italian survey. *J Transl Med*. 2020;18(1):1-15. doi:10.1186/s12967-020-02399-5

42. Bracale R, Vaccaro CM. Changes in food choice following restrictive measures due to Covid-19. *Nutr Metab Cardiovasc Dis*. 2020;30(9):1423-1426. doi:10.1016/j.numecd.2020.05.027

43. Haftenberger M, Heuer T, Heidemann C, Kube F, Krems C, Mensink GBM. Relative validation of a food frequency questionnaire for national health and nutrition monitoring. *Nutr J*. 2010;9(1):1-9. doi:10.1186/1475-2891-9-36

44. Mandracchia F, Llauradó E, Tarro L, et al. Potential use of mobile phone applications for self-monitoring and increasing daily fruit and vegetable consumption: A systematized review. *Nutrients*. 2019;11(3):1-16. doi:10.3390/nu11030686

45. Engel MG, Kern HJ, Brenna JT, Mitmesser SH. Micronutrient gaps in three commercial weight-loss diet plans. *Nutrients*. 2018;10(1):1-11. doi:10.3390/nu10010108

46. Block G, Coyle LM, Hartman AM, Scoppa SM. Revision of dietary analysis software for the Health Habits and History Questionnaire. Am J Epidemiol 1994;139:1190-1196. doi:10.1093/oxfordjournals.aje.a116965

47. Ortega RM, Perez-Rodrigo C, Lopez-Sobaler AM. Métodos de evaluación de la ingesta actual: Registro o diario dietético. *Nutr Hosp*. 2015;31:38-45. doi:10.3305/nh.2015.31.sup3.8749

48. Chandler AJ, Arent MA, Cintineo HP, Torres-McGehee TM, Winkelmann ZK, Arent SM. The Impacts of COVID-19 on collegiate student-athlete training, health, and well-being. *Transl J Am Coll Sport Med*. 2021;6(4):1-11. doi:10.1249/tjx.0000000000000173

49. Jacques A, Chaaya N, Beecher K, Ali SA, Belmer A, Bartlett S. The impact of sugar consumption on stress driven, emotional and addictive behaviors. *Neurosci Biobehav Rev*. 2019;103(March):178-199. doi:10.1016/j.neubiorev.2019.05.021

50. Holden SL, Forester BE, Williford HN, Reilly E. Sport locus of control and perceived stress among college student-athletes. *Int J Environ Res Public Health*. 2019;16(16). doi:10.3390/ijerph16162823

51. Sanborn V, Todd L, Schmetzer H, Manitkul-Davis N, Updegraff J, Gunstad J. Prevalence of covid-19 anxiety in division i student-athletes. *J Clin Sport Psychol*. 2021;15(2):162-176. doi:10.1123/jcsp.2020-0057

52. von Rosen P, Frohm A, Kottorp A, Fridén C, Heijne A. Too little sleep and an unhealthy diet could increase the risk of sustaining a new injury in adolescent elite athletes. *Scand J Med Sci Sport*. 2017;27(11):1364-1371. doi:10.1111/sms.12735

53. Kreider RB, Wilborn CD, Taylor L, et al. ISSN exercise and sport nutrition review: Research and recommendations. *J Int Soc Sports Nutr*. 2010;7:1-43. doi:10.1186/1550-2783-7-7

54. Deldicque L, Francaux M. Recommendations for healthy nutrition in female endurance runners: An update. *Front Nutr*. 2015;2(May):1-7. doi:10.3389/fnut.2015.00017

55. Brun JF, Malatesta D, Sartorio A. Maximal lipid oxidation during exercise: A target for individualizing endurance training in obesity and diabetes? *J Endocrinol Invest*. 2012;35(7):686-691. doi:10.3275/8466

56. Matsuda T, Kato H, Suzuki H, Mizugaki A, Ezaki T, Ogita F. Within-day amino acid intakes and nitrogen balance in male collegiate swimmers during the general preparation phase. *Nutrients*. 2018;10(11). doi:10.3390/nu10111809

57. Monirujjaman M, Ferdouse A. Metabolic and physiological roles of branched-chain amino acids. *Adv Mol Biol*. 2014;2014:1-6. doi:10.1155/2014/364976

58. Knechtle B, Mrazek C, Wirth A, et al. Branched-chain amino acid supplementation during a 100-km ultra-marathon-A randomized controlled trial. *J Nutr Sci Vitaminol (Tokyo)*. 2012;58(1):36-44. doi:10.3177/jnsv.58.36

59. Stamler J, Elliott P, Dennis B, et al. INTERMAP: Background, aims, design, methods, and descriptive statistics (nondietary). *J Hum Hypertens*. 2003;17(9):591-608. doi:10.1038/sj.jhh.1001603

60. Tarnopolsky M. Protein requirements for endurance athletes. *Eur J Sport Sci*. 2004;4(1):1-15. doi:10.1080/17461390400074102

61. Burke LM, Ross ML, Garvican-Lewis LA, et al. Low carbohydrate, high fat diet impairs exercise economy and negates the performance benefit from intensified training in elite race walkers. *J Physiol*. 2017;595(9):2785-2807. doi:10.1113/JP273230

62. Kerksick CM, Kreider RB, Willoughby DS. Intramuscular adaptations to eccentric exercise and antioxidant supplementation. *Amino Acids*. 2010;39(1):219-232. doi:10.1007/s00726-009-0432-7

63. Jeukendrup A. A step towards personalized sports nutrition: Carbohydrate intake during exercise. *Sport Med*. 2014;44(SUPPL.1). doi:10.1007/s40279-014-0148-z

64. Phillips SM. Protein requirements and supplementation in strength sports. *Nutrition*. 2004;20(7-8):689-695. doi:10.1016/j.nut.2004.04.009

65. Wales NS. A low-carbohydrate ketogenic diet reduces body mass without compromising performance in powerlifting and olympic weightlifting athletes. *J Strgth & Con Res.* 2018;32(12):3373-3382. doi: 10.1519/JSC.0000000000002904

66. Paoli A, Grimaldi K, D'Agostino D, et al. Ketogenic diet does not affect strength performance in elite artistic gymnasts. *J Int Soc Sports Nutr*. 2012;9:1-9. doi:10.1186/1550-2783-9-34

67. McSwiney FT, Wardrop B, Hyde PN, Lafountain RA, Volek JS, Doyle L. Keto-adaptation enhances exercise performance and body composition responses to training in endurance athletes. *Metabolism*. 2018;81(December):25-34. doi:10.1016/j.metabol.2017.10.010

68. Burke LM, Hawley JA. Effects of short-term fat adaptation on metabolism and performance of prolonged exercise. *Med Sci Sports Exerc*. 2002;34(9):1492-1498. doi:10.1097/00005768-200209000-00015

69. Hinton PS, Sanford TC, Davidson MM, Yakushko OF, Beck NC. Nutrient intakes and dietary behaviors of male and female collegiate athletes. *Int J Sport Nutr Exerc Metab*. 2004;14(4):389-405. doi:10.1123/ijsnem.14.4.389

70. Baranauskas M, Stukas R, Tubelis L, et al. Nutritional habits among high-performance endurance athletes. *Med*. 2015;51(6):351-362. doi:10.1016/j.medici.2015.11.004

71. Drenowatz C, Eisenmann JC, Carlson JJ, Pfeiffer KA, Pivarnik JM. Energy expenditure and dietary intake during high-volume and low-volume training periods among male endurance athletes. *Appl Physiol Nutr Metab*. 2012;37(2):199-205. doi:10.1139/H11-155

72. Sundgot-Borgen J, Torstveit MK. Prevalence of eating disorders in elite athletes is higher than in the general population. *Clin J Sport Med*. 2004;14(1):25-32. doi:10.1097/00042752-200401000-00005

73. Wade TD. Epidemiology of eating disorders: Creating opportunities. *Int J Eat Disord.* 2007;(September):27-30. doi:10.1002/eat

74. Greenleaf C, Petrie T, Carter J, Reel J. Female collegiate athletes: Prevalence of eating disorders and disordered eating behaviors. *J Am Coll Heal*. 2009;57(5):489-496. doi:10.3200/JACH.57.5.489-496

75. Wells EK, Chin AD, Tacke JA, Bunn JA. Risk of disordered eating among division I female college athletes. *Int J Exerc Sci*. 8(3):256-264. https://europepmc.org/article/MED/27293502?msclkid=72e10142cee411ecbc49c5c6f12b3246

76. Tenforde AS, Barrack MT, Nattiv A, Fredericson M. Parallels with the female athlete triad in male athletes. *Sport Med*. 2016;46(2):171-182. doi:10.1007/s40279-015-0411-y

77. Arthur-Cameselle J, Quatromoni P. Factors related to the onset of eating disorders in female athletes. *Sport Psychol*. 2010;25:1-17. https://sites.bu.edu/nutritionalepilab/files/2017/03/01-Arthur-1-17.pdf

78. Papadopoulou SK. Rehabilitation nutrition for injury recovery of athletes: The role of macronutrient intake. *Nutrients*. 2020;12(8):1-17. doi:10.3390/nu12082449

79. Weiss MR. Psychological aspects of sport-injury rehabilitation: A developmental

perspective. *J Athl Train*. 2003;38(2):172-175. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC164909/

80. Reinking MF. Exercise-related leg pain in female collegiate athletes: The influence of intrinsic and extrinsic factors. *Am J Sports Med*. 2006;34(9):1500-1507. doi:10.1177/0363546506287298

81. Ammar A, Brach M, Trabelsi K, et al. Effects of COVID-19 home confinement on eating behaviour and physical activity: Results of the ECLB-COVID19 international online survey. *Nutrients*. 2020;12(6). doi:10.3390/nu12061583

82. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires – a review. *Public Health Nutr*. 2002;5(4):567-587. doi:10.1079/phn2001318

83. Block G, Hartman AM, Dresser CM, Carroll MD, Gannon J, Gardner L. A data-based approach to diet questionnaire design and testing. *Am J Epidemiol*. 1986;124(3):453-469. doi:10.1093/oxfordjournals.aje.a114416

84. Block G, Coyle LM, Hartman AM, Scoppa SM. Revision of dietary analysis software for the health habits and history questionnaire. *Am J Epidemiol*. 1994;139(12):1190-1196. doi:10.1093/oxfordjournals.aje.a116965

85. Livingstone MBE, Robson PJ, Wallace JMW. Issues in dietary intake assessment of children and adolescents. *Br J Nutr*. 2004;92(S2):S213-S222. doi:10.1079/bjn20041169

86. Storey KE, Mccargar LJ. Reliability and validity of Web-SPAN, a web-based method for assessing weight status, diet and physical activity in youth. *J Hum Nutr Diet*. 2012;25(1):59-68. doi:10.1111/j.1365-277X.2011.01181.x

Literature Review

Introduction

An important component in the success of athletes begins with adequate energy intake to support caloric expenditure and contribute to maintenance and improvement in strength, endurance, muscle mass, and health. [2,7] A well-designed diet that has an adequate amount and proportions of macronutrients will help promote peak performance. Inadequate energy intake relative to energy expenditure can reduce athletic performance and reverse the benefits associated with exercise.[2–4] When there is a limited amount of energy, it can cause the body to break down fat and lean tissue to be used as fuel for the body. If there is inadequate blood glucose levels, fatigue and perception of exertion will increase and reduce performance.[2,7] Eventually, this could significantly reduce strength and endurance performance and compromise the immune, endocrine, and musculoskeletal systems. [3,4,52]

Nutritional Recommendations for Endurance Athletes

Endurance athletes raise their aerobic capacity to overcome intensive and long-lasting physical loads. Depending on training schedule and the exercise intensity of an endurance athlete, research shows hourly caloric expenditure in the range of 600-1200 $kcal \cdot hour^{-1}$. Estimated energy needs of these athletes are in the range of 50-80 $kcal\ kg^{-1} \cdot day^{-1}$. [7,53] For female endurance athletes, the minimal energy requirement has been set to 45 $kcal \cdot kg^{-1}$ fat free mass per day plus the amount needed for physical activity. An athlete of 50 kg having a fat percentage of 15% and a fat free mass of 42.5 kg, the energy available should be above 1900 $kcal \cdot day^{-1}$. Energy expenditure of 500-600 kcal during their sport would increase the daily total energy intake to 2400-2500 kcal.[54] To delay onset of fatigue in endurance activity, repletion of kilocalories may be necessary during training sessions that last longer than 60 to 90 minutes.[7]

Physical performance and the fatigue incurred by athletes in aerobic training are partially dependent on carbohydrate reserves accumulated in the body and availability during physical loads.[7,8] Currently, the recommended carbohydrate (CHO) intake for athletes is 6-10 $g\ kg^{-1}\ day^{-1}$.[2,9] As exercise intensity increases, so does the reliance on carbohydrates for energy. Current research has shown that 50-60% of energy substrate utilization during 1-4 hours of continuous exercise at 70% of VO_{2max} is derived from carbohydrates (CHO). As endurance training continues the energy expenditure does not change, but the reliance on CHO decreases and switches to lipids.[9] Increased lipid oxidation results from the depletion of glycogen storages when exercise exceeds one hour or when an exercise has been performed at high intensity.[55] Adequate CHO intake is necessary for adequate glycogen concentration. Increasing glycogen stores within the muscle will help CHO availability during exercise, and therefore performance.[1,9]

Optimal performance is also reliant upon the balance of proteins found within skeletal muscles; studies indicate that absolute requirements exist for essential amino acids to maximize muscle protein synthesis.[7] Because protein is also oxidized as an energy source at ~4.4% or 10% of total exercise-induced energy expenditure, they have to be replaced by dietary protein intake.[56] Branch chain amino acids (BCAAs) have diverse physiological and metabolic roles. Supplementation of BCAAs promotes protein synthesis and reduces break down.[57] In muscle, BCCAs provide a carbon source of oxidation for production of energy and as a precursor for muscle protein synthesis. Oxidations of BCAAs increases under different physiological conditions to meet energy demand, including starvation.[58] Research has shown that BCAAs supplementation increases lipid oxidation during exercise and helps overcome fatigue.[59] The protein needs of endurance training athletes depends on training intensity, duration, distance, frequency, sex, energy and CHO intake, and current fitness level of the athlete. Protein requirements for men tend to be greater than those for women due to increased protein oxidation. Females oxidize more lipid and less CHO compared to men during exercise.[60] Elite athletes with a high fitness status who perform high volumes of training have increased protein requirements to about 1.6 g kg^{-1} day^{-1}.[2,7,9] Increasing dietary fat is a strategy used by athletes with the rationale to enhance intramuscular triglycerides to improve prolonged exercise performance in endurance athletes.[61] However, recommended requirements are 20-30% of total energy intake.[2,7]

Nutritional Recommendations for Power Athletes

Energy intake and requirements for power athletes differ greatly than those for endurance athletes. Caloric expenditure is more difficult to determine for strength and power athletes because of the variability in high-intensity bursts and power, varying lengths of recovery periods from training and competition, and a greater contribution of eccentric muscle action. [7,62] Caloric recommendations should be determined based on individual needs and goals as well as age, height, and weight.[63] High-intensity activity requires a high level of energy production, followed by periods of rest intervals. This creates periods of high caloric expenditure to periods of recovery. The ability of an athlete to recover between supra-maximal bouts can influence performance during training or competition. The variability in training volume, duration, and recovery periods add complexity for energy needs and recommendations of energy requirements for this type of athletic population. Elite strength and power athletes can expend 600-1200 kilocalories or more per hour of exercise. There is variability with body size, sex, age, amount of muscle mass activated, number of sets and repetitions completed, rest periods, and time the contraction is held. The current recommendations for energy intake range from 44 to 50 kcal kg^{-1} day^{-1}. It must also be considered that some of these athletes hope to induce muscle hypertrophy, requiring more energy. [1,2] Strength and power athletes participating in high repetition exercise at a moderate to high levels of intensity to maximize performance adaptations as well as muscle hypertrophy will deplete glycogen storages faster. Therefore increasing energy intake is advised.[7]

Consuming adequate CHO for strength and power athletes is important for optimal power output and performance.[1] Intense intermittent muscle contractions that last 1-5 minutes, recruit large masses of muscle, combined with short rest periods can decrease glycogen stores by 24-40%.[1] Strength and power athletes who include high repetitions with a moderate to high level of intensity will deplete greater concentrations of glycogen. [9] An intake of 5-10 g kg^{-1} day^{-1} is sufficient to maintain glycogen stores for these types of athletes. [1]

Exercise increases rate of muscle protein synthesis and breakdown. Ingestion of protein alone or in combination with CHO is required to have a net positive protein balance.[64] Regular resistance training invokes additional stress and trauma to the body that require greater protein availability to repair any damage. Increasing protein intake of 1.2-2.0 g kg^{-1} day^{-1} should fulfill the needs of strength and power athletes. [2,7,9,62,] Modifying intake of fat has been considered little for strength and power athletes to help improve performance. Weight class athletes use weight-making strategies to compete in specific weight categories with an optimum power-to-weight ratio. Studies have shown weight loss without energy restriction using diets that reduce CHO intake and increase fat intake.[65–67] There is also evidence that weight loss arises from reductions in fat mass accompanied with reservation of lean mass.[65] However, the majority of studies have indicated that increasing fat intake will favorably impact substrate utilization, but negatively affect performance.[7,61,68] Requirements for fat intake are 20-30% of total energy intake. Diets with less than 20% of total calories from fat do not benefit performance since fat is a source of energy and necessary for the production of fat-soluble vitamins and essential fatty acids.[2,7]

Dietary Habits in College Athletes

When assessing the diet quality of college athletes, females tend to have a better diet quality than males.[11,12] Specifically, in one study examining dietary habits in college athletes, participants had diets that were high in solid fats, alcohol, and added sugar. Their diets were also high in sodium and low in fiber and fruit.[11] Data from a study examining sex differences in diet had 143 male and 240 female student athletes from 10 different collegiate sports participate in a survey consisting of questions on dietary habits. Results showed that 13.69% of athletes consumed fast foods prior to practice or competition, and that consumption was more frequent in men (61.97%) than women (53.33%). They also found that 50.93% reported experiencing hunger during training, practice, or competition, suggesting that there is low energy availability and poor pre-exercise fueling.[12] A number of barriers to healthy eating have been described by college athletes such as lack of time for food preparation, inadequate cooking skills, financial limitations, and difficult living arrangements.[13,14]

Several investigations have shown that female and male athletes have failed to compensate for increased energy demands for training and competition.[15–19] Most athletes, particularly female, struggle with eating adequate CHO recommendations, while increasing their fat intake.[5,6,20–22] In a study assessing dietary intakes and eating habits of female college athletes, results showed that energy and CHO intakes were below the recommended amount, with only 9% of participants meeting their energy needs, and 75% failed to consume minimum amount of CHO that is required to support training. A majority of the participants reported no regular breakfast and 36% consumed less than five meals a day. [15] Female athletes typically consume less than 2000 $kcal \cdot day^{-1}$ during training and competition, not enough to support recommendations to maintain optimal muscle glycogen stores. [5,16] Nepocatych et al[21] performed a study on female college basketball and softball players to assess their food intake and body composition over their competitive season. Mean energy intake was significantly lower at the beginning of the season versus the end of it. Macronutrient consumption did not change, but CHO and protein intakes were still below the recommended levels. There was also low intake of fibers and high intake of sodium observed in diets. This trend has been observed in multiple investigations with both male and female athletes.[12,15,69]

In a study analyzing the dietary habits of endurance runners using a 24-hour dietary survey method, 80.8% of endurance athletes had lower than recommended amounts of CHO in their diet, especially females. More than 70% of athletes used higher than recommended levels of fat.[70] This is a common trend found in most endurance athletes. Drenowatz et al[71] reported that male endurance athletes did not change their caloric intake between high volume and low volume training periods despite changes in energy expenditure. He also observed that CHO and fiber were below recommended intakes, while fat intake was above recommendations.

Eating Disorders

Eating disorders are especially common in sports where weight has a significant effect on performance. In endurance runners, leanness is related to performance for physiological reasons.[24] It is desirable to have a high lean body mass and low body fat mass to achieve a high power to weight ratio.

Sports that require horizontal or vertical movements, like running or gymnastics, have considered excess fat mass on the body as a disadvantage. Excess fat increases energy demands and can negatively affect performance.[72] Weight category sports like wresting and boxing will not be able to compete if their weight is above the limit in their category. In sports like diving and gymnastics, aesthetic is attached to a particular body composition that is promoted and encouraged in competitors.[23–25]

Anorexia Nervosa and Bulimia Nervosa are two common eating disorders that have been observed in athletes.[24] Anorexia Nervosa is defined as the refusal to maintain body weight at or above minimally normal level for age and height. Bulimia is more common and consists of recurrent episodes of binge eating with recurrent compensatory behavior. “Binge eating” refers to eating an unusually large amount of food in a short period of time while also experiencing a loss of control.[73] Sundgot and Torstveit[72] showed that the prevalence of eating disorders is significantly higher in male and female elite athletes than non-athletic males and females.

The female athlete triad refers to the interrelationship between energy availability, menstrual function, and bone mineral density. This triad may have clinical manifestation that includes eating disorders, functional hypothalamic amenorrhea, and osteoporosis.[26] Beals et al.[27] conducted a study on prevalence and relationship between the disorders of the triad in college athletes that participate in aesthetic, endurance, or team/anaerobic sports. Out of 425 female athletes from different universities, 2-3% reported a clinical diagnosis of AN or BN, about 15% indicated an “at risk” behavior for disordered eating, while 31% reported menstrual irregularity. Athletes who were “at risk” for an eating disorder frequently reported more menstrual irregularity and sustained more bone injuries during their college career.[27] Disordered eating and irregular menses is commonly associated with increased risk of injury in young athletes.[28–30] Studies on collegiate female volleyball players collected data on body composition, nutritional habits, eating disorder risk, and menstrual health.[29,35,51-52] Half of the participants were considered “At-Risk” for an eating disorder, all participants consumed an inadequate amount of calories needed for predicted energy expenditure, and below the recommended CHO and protein intake values.[16,5,74] Another study assessed the risk of disordered eating between female athletes in lean and non-lean sports. The results indicated that lean sports (sports that emphasize body composition; swimming, cross country, volleyball, cheerleading) exhibit a higher risk for disordered eating compared to those in non-lean sports (softball, basketball, soccer, golf).[75]

While female athletes have a higher rate of disordered eating than male athletes,[11] male athletes are not immune to disordered eating that can potentially cause long term metabolic problems.[31] In a survey of college male athletes, the most common form of weight control was dieting. Males who participated in weight-controlled sports had the highest rate of dieting.[31] While dieting is helpful for weight loss, it is important that athletes consume all the required nutrients to prevent long term health effects.[31,76]

Injuries and Diet

Injuries are common in athletes and psychological response to injury can include normal or problematic responses, such as depression, anxiety, or stress. Athletes differ in their response to injury. Some of those responses can include sadness, isolation, irritation, lack of motivation, anger, changes in appetite, sleep disturbance, and disengagement. The response to injury extends from immediately after the injury through post injury, rehabilitation, and return to activity.[35,77]

After injury, some athletes restrict their caloric intake because they feel since they are injured, they 'don't deserve' to eat and can elicit disordered eating.[35] However, an adequate, balanced diet is very important in injury recovery and rehabilitation for athletes.[78] In a study on emotional responses of athletes to injury in college or elite athletes, common responses were disbelief, fear, rage, depression, tension, fatigue, upset stomach, insomnia, and loss of appetite.[79] In a study examining stimulus factors in the development of eating disorders in elite female athletes, reported that eating disorders occurred at the time of injury or illness when they were unable to train at high levels.[36] Disordered eating was higher among injured female athletes than non-injured female athletes that participated in an eating disorder questionnaire.[29] This is in agreement with multiple studies of injured college athletes. [27,80]

Pandemic Related Dietary Changes in General Population

CoV-19/SARS-CoV-2 (COVID-19) is a highly pathogenic virus that is causing a global pandemic with high numbers of deaths and infected people. To contain the infection of the virus, the government has enforced restrictions on outdoor activities and even a collective quarantine on the population. Recent studies have emerged analyzing the effect of COVID-19 on changes in diet and physical activity.[37–42] Quarantine has been associated with stress and depression leading to an unhealthy diet and reduced physical activity. A diet poor in fruit and vegetables is frequent during isolation.[37,81]

A survey among Polish adults on dietary and lifestyle changes during the lockdowns found that 34% of respondents increased food consumption with 33% in confectionary and 18% in alcohol intake. Conversely, 24% increased water intake, 37% showed decrease in fast food intake, and 48% increased consumption of homemade meals.[38,39] A similar study conducted in Spain found that during the pandemic the studied population adopted healthier dietary habits by decreasing the intake of fried foods, snacks, fast foods, red meat, pastries, or sweet beverages and increasing Mediterranean diet foods like olive oil, vegetables, fruits, and legumes.[40,41]

In Italy, an analysis of food consumption during quarantine based on data from information resources in consumer goods and retail plus shopper market data was performed. There was an increase in consumption of canned food products, pasta, flour, eggs, milk, and frozen foods. There was also a strong reduction in sales of fresh fruit and vegetables. The sales of sweet snacks also decreased compared to the production of homemade desserts. The products used for home preparation of pizza, bread, and cake had a significant increase.[42]

Diet Analysis

Many studies investigate the effect of nutrition and diet on health in many populations, so accurate methods to assess are needed. Self-administered food frequency questionnaires (FFQ) ask respondents about the frequency and portion size of typically consumed foods.[43] FFQs measure usual intake over a middle or long-term period, which is relevant for the survey to objectively monitor usual eating behavior. In comparison to other assessment methods, FFQs are relatively inexpensive, easy, and quick to administrate.[82] Since 1982, Block Questionnaires have been developed using a data-base approach to questionnaire design. They use large representative national dietary surveys, such as the Nation Health and Nutrition Examination Survey (NHANES), to inform the selection of foods or physical activities that are required, as well as applying appropriate portion sizes and nutrient composition to apply. The 2005 Block FFQ is a full-length questionnaire designed to estimate usual and customary intake of a wide array of nutrients and food groups. It takes about 30-40 minutes to complete and is intended for either self or interviewer administration. The food list was developed from NHANES 1999-2002 dietary recall data; the nutrient database was developed from the USDA Food and Nutrient Database for Dietary Studies, version 1.0. A series of "adjustment" questions provide greater accuracy in assessing fat and carbohydrate intake. Individual portion size is asked for each food and pictures are provided to enhance the accuracy of quantification.[46] Multiple studies are used as standard references related to the development of Block FFQ to validate this method of data collection and used to determine which foods to include in the FFQ.[83,84]

Dietary records or food diaries is another tool that is used among dietary assessment methods for an individual's current diet for their interest and validity. It is a prospective, open-ended survey method to collect data about the foods and beverages consumed over a specified time frame. These records can be used to estimate current diet of individuals and population groups, as well as identifying groups that are at risk of inadequacy.[47] The main advantage of diet records is the potential it has to collect accurate quantitative information of food consumed by an individual. Because of the quality of the dietary data, diet records are considered to the gold standard of dietary methods and is often used as a reference in calibration or validation studies using other less involved and less expensive methods.[47] Reporting errors are likely for food intake data, however, 3-day food records are still used to assess diet and produce estimates of nutrient inadequacy.[85] The 3-day food records require participants to record all foods and beverages consumed over the three days, which includes one weekend day to account for variability. It is important to instruct participants on how to correctly complete a food record, using food models, pictures, sample records, and example portion sizes. To reduce error and maximize accuracy and completeness, it is helpful to review food records with participants following data collection. The interviewer can check for completeness, clarify items and serving sizes, and remind the participant of any foods or beverages that may have been forgotten.[86]

Mobile technologies are a valid tool for dietary self-monitoring. There are several basic web journaling and mobile applications that allow users to set weight loss goals, collect daily calorie target chart data to reflect trends over time, and record food consumption and exercise levels.[44] Some of those apps include MyFitnessPal© (2009-2020 MyFitnessPal, Inc, San Francisco, CA, USA), InsideTracker© (2009-2020 Segterra, Inc, Cambridge, MA, USA), and Cronometer© (2011-2020, Cronometer.com, Revelstoke, BC, Canada). Cronometer is a web-based nutrition and biometric tracking application that features data on over 60 nutrients and contains more than 7,500 foods in its databases.[87] Cronometer is a useful tool for nutrient analysis because of its large food database including the U.S. Department of Agriculture (U.S. DA) National Nutrient Database for Standard Reference.[45]

Summary

Adequate energy intake and macronutrient consumption is an important component in the health and success of athletes. Without proper diets, athletes put themselves at risk for health issues, eating disorders, and injury. Changes in dietary habits can be caused by numerous things such as performance reasons, body image, injury, and life-changing events. Little is known on how COVID-19 has changed dietary habits in Americans, let alone college athletes. With government restrictions in place, athletes are unable to participate in training or competition for an extended period. Because of the pressures athletes face to perform it is important to understand how they respond to this kind of adversity. Monitoring changes in dietary patterns is useful in injury and eating disorder prevention, as well as sport performance. The purpose of this study is to investigate the effects of a global pandemic on kilocalorie intake and macronutrient consumption in endurance and power athletes at the collegiate level.

REFERENCES

1. Raffaelli C, Milanese C, Lanza M, Zamparo P. Water-based training enhances both physical capacities and body composition in healthy young adult women. *Sport Sci Health*. 2016;12(2):195-207. doi:10.1007/s11332-016-0275-z

2. ACSM, ADA. Nutrition and Athletic Performance : Position Statement. *Med Sci Sport Exerc*. 2009;Special Co:709-731. doi:10.1249/MSS.0b013e318190eb86

3. Mercader I, Gonz J. Resilience , Anxiety , Stress , Depression and Eating. Published online 2020:1-11.

4. Bonci L. Supplements: Help, harm, or hype? how to approach athletes. *Curr Sports Med Rep*. 2009;8(4):200-205. doi:10.1249/JSR.0b013e3181ae9ae8

5. Mielgo-Ayuso J, Zourdos MC, Calleja-González J, Urdampilleta A, Ostojic SM. Dietary intake habits and controlled training on body composition and strength in elite female volleyball players during the season. *Appl Physiol Nutr Metab*. 2015;40(8):827-834. doi:10.1139/apnm-2015-0100

6. Papadopoulou S. Impact of energy intake and balance on the athletic performance and health of top female volleyball athletes. *Med Sport J Rom Sport Med Soc*. 2015;11(1):2477.

7. Kerksick CM, Kulovitz M. *Requirements of Energy, Carbohydrates, Proteins and Fats for Athletes*. Elsevier Inc.; 2013. doi:10.1016/B978-0-12-396454-0.00036-9

8. Burke LM. Fueling strategies to optimize performance: Training high or training low? *Scand J Med Sci Sport*. 2010;20(SUPPL. 2):48-58. doi:10.1111/j.1600-0838.2010.01185.x

9. Kerksick CM, Arent S, Schoenfeld BJ, et al. International society of sports nutrition position stand: Nutrient timing. *J Int Soc Sports Nutr*. 2017;14(1):1-21. doi:10.1186/s12970-017-0189-4

10. Valliant MW, Pittman H, Wenzel RK, Garner BH. Nutrition education by a registered dietitian improves dietary intake and nutrition knowledge of a NCAA female volleyball team. *Nutrients*. 2012;4(6):506-516. doi:10.3390/nu4060506

11. Webber K, Stoess AI, Forsythe H, Kurzynske J, Vaught JA, Adams B. Diet quality of collegiate athletes. *J Nutr Educ Behav*. 2004;36(3):135-139.

12. Hull M V., Jagim AR, Oliver JM, Greenwood M, Busteed DR, Jones MT. Gender differences and access to a sports dietitian influence dietary habits of collegiate athletes. *J Int Soc Sports Nutr*. 2016;13(1):1-16. doi:10.1186/s12970-016-0149-4

13. Heaney S, O'Connor H, Naughton G, Gifford J. Towards an Understanding of the Barriers to Good Nutrition for Elite Athletes. *Int J Sports Sci Coach*. 2008;3(3):391-401. doi:10.1260/174795408786238542

14. Rockwell MS, Nickols-Richardson SM, Thye FW. Nutrition knowledge, opinions, and practices of coaches and athletic trainers at a Division I University. *Int J Sport Nutr*. 2001;11(2):174-185. doi:10.1123/ijsnem.11.2.174

15. Shriver LH, Betts NM, Wollenberg G. Dietary intakes and eating habits of college athletes: Are female college athletes following the current sports nutrition standards? *J Am Coll Heal*. 2013;61(1):10-16. doi:10.1080/07448481.2012.747526

16. Vargas SL, Kerr-Pritchett K, Papadopoulous C, Bennet V. Dietary Habits, Menstrual Health, Body Composition, and Eating Disorder Risk Among Collegiate Volleyball Players: A Descriptive Study. *Int J Exerc Sci*. 2013;6(1):52-62. http://digitalcommons.wku.edu/ijes/vol6/iss1/7/

17. Loucks AB, Kiens B, Wright HH. Energy availability in athletes. *J Sports Sci*. 2011;29(SUPPL. 1). doi:10.1080/02640414.2011.588958

18. Hoogenboom BJ, Morris J, Morris C, Schaefer K. Nutritional knowledge and eating behaviors of female, collegiate swimmers. *N Am J Sports Phys Ther*. 2009;4(3):139-148. http://www.ncbi.nlm.nih.gov/pubmed/21509109%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC2953338

19. Cole CR, Salvaterra GF, Davis JE, et al. Evaluation of dietary practices of National Collegiate Athletic Association Division I football players. *J Strength Cond Res*. 2005;19(3):490-494. doi:10.1519/14313.1

20. Clark M, Reed DB, Crouse SF, Armstrong RB. Pre- and post-season dietary intake, body composition, and performance indices of NCAA division I female soccer players. *Int J Sport Nutr Exerc Metab*. 2003;13(3):303-319. doi:10.1123/ijsnem.13.3.303

21. Nepocatych S, Balilionis G, O’Neal EK. Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin J Sport Sci Med*. 2017;6(2):57-65. doi:10.26773/mjssm.2017.09.008

22. Hassapidou MN, Manstrantoni A. Dietary intakes of elite female athletes in Greece. *J Hum Nutr Diet*. 2001;14(5):391-396. doi:10.1046/j.1365-277X.2001.00307.x

23. Sundgot-Borgen J, Torstveit MK. Aspects of disordered eating continuum in elite high-intensity sports. *Scand J Med Sci Sport*. 2010;20(SUPPL. 2):112-121. doi:10.1111/j.1600-0838.2010.01190.x

24. Currie A. Sport and eating disorders - Understanding and managing the risks. *Asian J Sports Med*. 2010;1(2):63-68. doi:10.5812/asjsm.34864

25. Anne LB. Low Energy Availability in the Marathon and other Endurance Sports. *Sport Med*. 2007;37(4-5):348-352.

26. Nattiv A, Loucks AB, Manore MM, Sanborn CF, Sundgot-Borgen J, Warren MP. The female athlete triad. *Med Sci Sports Exerc*. 2007;39(10):1867-1882. doi:10.1249/mss.0b013e318149f111

27. Beals KA, Manore MM. Disorders of the female athlete triad among collegiate athletes. *Int J Sport Nutr Exerc Metab*. 2002;12(3):281-293. doi:10.1123/ijsnem.12.3.281

28. Thein-Nissenbaum JM, Rauh MJ, Carr KE, Loud KJ, McGuine TA. Menstrual irregularity and musculoskeletal injury in female high school athletes. *J Athl Train*. 2012;47(1):74-82. doi:10.4085/1062-6050-47.1.74

29. Rauh MJ, Nichols JF, Barrack MT. Relationships among injury and disordered eating, menstrual dysfunction, and low bone mineral density in high school athletes: A prospective study. *J Athl Train*. 2010;45(3):243-252. doi:10.4085/1062-6050-45.3.243

30. Rauh MJ, Barrack M, Nichols JF. Associations between the female athlete triad and injury among high school runners. *Int J Sports Phys Ther*. 2014;9(7):948-958. http://www.ncbi.nlm.nih.gov/pubmed/25540710%0Ahttp://www.pubmedcentral.nih.gov/articleren

der.fcgi?artid=PMC4275199

31. Chatterton JM, Petrie TA. Prevalence of Disordered Eating and Pathogenic Weight Control Behaviors Among Male Collegiate Athletes. *Eat Disord*. 2013;21(4):328-341. doi:10.1080/10640266.2013.797822

32. Coelho AR, Cascais MJ. The Female Athlete Triad / Relative Energy De fi ciency in Sports (RED-S) A tríade da atleta feminina / dé fi cit energético relativo no. Published online 2021.

33. Conviser JH, Tierney AS, Nickols R. Assessment of athletes with eating disorders: Essentials for best practice. *J Clin Sport Psychol*. 2018;12(4):480-494. doi:10.1123/jcsp.2018-0012

34. Torstveit MK, Fahrenholtz IL, Lichtenstein MB, Stenqvist TB, Melin AK. Exercise dependence, eating disorder symptoms and biomarkers of Relative Energy Deficiency in Sports (RED-S) among male endurance athletes. *BMJ Open Sport Exerc Med*. 2019;5(1):1-8. doi:10.1136/bmjsem-2018-000439

35. Putukian M. The psychological response to injury in student athletes: A narrative review with a focus on mental health. *Br J Sports Med*. 2016;50(3):145-148. doi:10.1136/bjsports-2015-095586

36. Risk_and_trigger_factors_for_the_development_of.3 (1).pdf.

37. Mattioli A V., Sciomer S, Cocchi C, Maffei S, Gallina S. Quarantine during COVID-19 outbreak: Changes in diet and physical activity increase the risk of cardiovascular disease. *Nutr Metab Cardiovasc Dis*. 2020;30(9):1409-1417. doi:10.1016/j.numecd.2020.05.020

38. Górnicka M, Drywień ME, Zielinska MA, Hamułka J. Dietary and Lifestyle Changes During COVID-19 and the Subsequent Lockdowns among Polish Adults : PLifeCOVID-19 Study. *Nutrients*. 2020;12(8):2324.

39. Sidor A, Rzymski P. Dietary choices and habits during COVID-19 lockdown: Experience from Poland. *Nutrients*. 2020;12(6):1-13. doi:10.3390/nu12061657

40. Rodríguez-Pérez C, Molina-Montes E, Verardo V, et al. Changes in dietary behaviours during the COVID-19 outbreak confinement in the Spanish COVIDiet study. *Nutrients*. 2020;12(6):1-19. doi:10.3390/nu12061730

41. Di Renzo L, Gualtieri P, Pivari F, et al. Eating habits and lifestyle changes during COVID-19 lockdown: An Italian survey. *J Transl Med*. 2020;18(1):1-15. doi:10.1186/s12967-020-02399-5

42. Bracale R, Vaccaro CM. Changes in food choice following restrictive measures due to Covid-19. *Nutr Metab Cardiovasc Dis*. 2020;30(9):1423-1426. doi:10.1016/j.numecd.2020.05.027

43. Haftenberger M, Heuer T, Heidemann C, Kube F, Krems C, Mensink GBM. Relative validation of a food frequency questionnaire for national health and nutrition monitoring. *Nutr J*. 2010;9(1):1-9. doi:10.1186/1475-2891-9-36

44. Mandracchia F, Llauradó E, Tarro L, et al. Potential use of mobile phone applications for self-monitoring and increasing daily fruit and vegetable consumption: A systematized review. *Nutrients*. 2019;11(3):1-16. doi:10.3390/nu11030686

45. Engel MG, Kern HJ, Brenna JT, Mitmesser SH. Micronutrient gaps in three commercial weight-loss diet plans. *Nutrients*. 2018;10(1):1-11. doi:10.3390/nu10010108

46. Questionnaires and Screeners – Assessment & Analysis Services – NutritionQuest.

47. Ortega RM, Perez-Rodrigo C, Lopez-Sobaler AM. Métodos de evaluación de la ingesta actual: Registro o diario dietético. *Nutr Hosp*. 2015;31:38-45. doi:10.3305/nh.2015.31.sup3.8749

48. Chandler AJ, Arent MA, Cintineo HP, Torres-McGehee TM, Winkelmann ZK, Arent SM. The Impacts of COVID-19 on Collegiate Student-Athlete Training, Health, and Well-Being. *Transl J Am Coll Sport Med*. 2021;6(4):1-11. doi:10.1249/tjx.0000000000000173

49. Jacques A, Chaaya N, Beecher K, Ali SA, Belmer A, Bartlett S. The impact of sugar consumption on stress driven, emotional and addictive behaviors. *Neurosci Biobehav Rev*. 2019;103(March):178-199. doi:10.1016/j.neubiorev.2019.05.021

50. Holden SL, Forester BE, Williford HN, Reilly E. Sport locus of control and perceived stress among college student-athletes. *Int J Environ Res Public Health*. 2019;16(16). doi:10.3390/ijerph16162823

51. Sanborn V, Todd L, Schmetzer H, Manitkul-Davis N, Updegraff J, Gunstad J. Prevalence of covid-19 anxiety in division i student-athletes. *J Clin Sport Psychol*. 2021;15(2):162-176. doi:10.1123/jcsp.2020-0057

52. von Rosen P, Frohm A, Kottorp A, Fridén C, Heijne A. Too little sleep and an unhealthy diet could increase the risk of sustaining a new injury in adolescent elite athletes. *Scand J Med Sci Sport*. 2017;27(11):1364-1371. doi:10.1111/sms.12735

53. Kreider RB, Wilborn CD, Taylor L, et al. ISSN exercise and sport nutrition review: Research and recommendations. *J Int Soc Sports Nutr*. 2010;7:1-43. doi:10.1186/1550-2783-7-7

54. Deldicque L, Francaux M. Recommendations for Healthy Nutrition in Female Endurance Runners: An Update. *Front Nutr*. 2015;2(May):1-7. doi:10.3389/fnut.2015.00017

55. Brun JF, Malatesta D, Sartorio A. Maximal lipid oxidation during exercise: A target for individualizing endurance training in obesity and diabetes? *J Endocrinol Invest*. 2012;35(7):686-691. doi:10.3275/8466

56. Matsuda T, Kato H, Suzuki H, Mizugaki A, Ezaki T, Ogita F. Within-day amino acid intakes and nitrogen balance in male collegiate swimmers during the general preparation phase. *Nutrients*. 2018;10(11). doi:10.3390/nu10111809

57. Monirujjaman M, Ferdouse A. Metabolic and Physiological Roles of Branched-Chain Amino Acids. *Adv Mol Biol*. 2014;2014:1-6. doi:10.1155/2014/364976

58. Knechtle B, Mrazek C, Wirth A, et al. Branched-chain amino acid supplementation during a 100-km ultra-marathon-A randomized controlled trial. *J Nutr Sci Vitaminol (Tokyo)*. 2012;58(1):36-44. doi:10.3177/jnsv.58.36

59. Stamler J, Elliott P, Dennis B, et al. INTERMAP: Background, aims, design, methods, and descriptive statistics (nondietary). *J Hum Hypertens*. 2003;17(9):591-608. doi:10.1038/sj.jhh.1001603

60. Tarnopolsky M. Protein requirements for endurance athletes. *Eur J Sport Sci*. 2004;4(1):1-15. doi:10.1080/17461390400074102

61. Burke LM, Ross ML, Garvican-Lewis LA, et al. Low carbohydrate, high fat diet impairs exercise

economy and negates the performance benefit from intensified training in elite race walkers. *J Physiol*. 2017;595(9):2785-2807. doi:10.1113/JP273230

62. Kerksick CM, Kreider RB, Willoughby DS. Intramuscular adaptations to eccentric exercise and antioxidant supplementation. *Amino Acids*. 2010;39(1):219-232. doi:10.1007/s00726-009-0432-7

63. Jeukendrup A. A step towards personalized sports nutrition: Carbohydrate intake during exercise. *Sport Med*. 2014;44(SUPPL.1). doi:10.1007/s40279-014-0148-z

64. Phillips SM. Protein requirements and supplementation in strength sports. *Nutrition*. 2004;20(7-8):689-695. doi:10.1016/j.nut.2004.04.009

65. Wales NS. A l -c k d r b m w c p p o w a. 2018;32(12):3373-3382.

66. Paoli A, Grimaldi K, D'Agostino D, et al. Ketogenic diet does not affect strength performance in elite artistic gymnasts. *J Int Soc Sports Nutr*. 2012;9:1-9. doi:10.1186/1550-2783-9-34

67. McSwiney FT, Wardrop B, Hyde PN, Lafountain RA, Volek JS, Doyle L. Keto-adaptation enhances exercise performance and body composition responses to training in endurance athletes. *Metabolism*. 2018;81(December):25-34. doi:10.1016/j.metabol.2017.10.010

68. Burke LM, Hawley JA. Effects of short-term fat adaptation on metabolism and performance of prolonged exercise. *Med Sci Sports Exerc*. 2002;34(9):1492-1498. doi:10.1097/00005768-200209000-00015

69. Hinton PS, Sanford TC, Davidson MM, Yakushko OF, Beck NC. Nutrient intakes and dietary behaviors of male and female collegiate athletes. *Int J Sport Nutr Exerc Metab*. 2004;14(4):389-405. doi:10.1123/ijsnem.14.4.389

70. Baranauskas M, Stukas R, Tubelis L, et al. Nutritional habits among high-performance endurance athletes. *Med*. 2015;51(6):351-362. doi:10.1016/j.medici.2015.11.004

71. Drenowatz C, Eisenmann JC, Carlson JJ, Pfeiffer KA, Pivarnik JM. Energy expenditure and dietary intake during high-volume and low-volume training periods among male endurance athletes. *Appl Physiol Nutr Metab*. 2012;37(2):199-205. doi:10.1139/H11-155

72. Sundgot-Borgen J, Torstveit MK. Prevalence of Eating Disorders in Elite Athletes Is Higher Than in the General Population. *Clin J Sport Med*. 2004;14(1):25-32. doi:10.1097/00042752-200401000-00005

73. Wade TD. Epidemiology of Eating Disorders : Creating Opportunities. 2007;(September):27-30. doi:10.1002/eat

74. Greenleaf C, Petrie T, Carter J, Reel J. Female collegiate athletes: Prevalence of eating disorders and disordered eating behaviors. *J Am Coll Heal*. 2009;57(5):489-496. doi:10.3200/JACH.57.5.489-496

75. Wells EK, Chin AD, Tacke JA, Bunn JA. Risk of Disordered Eating Among Division I Female College Athletes. *Int J Exerc Sci*. 8(3):256-264. http://www.ncbi.nlm.nih.gov/pubmed/27293502%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4882473

76. Tenforde AS, Barrack MT, Nattiv A, Fredericson M. Parallels with the Female Athlete Triad in Male Athletes. *Sport Med*. 2016;46(2):171-182. doi:10.1007/s40279-015-0411-y

77. Arthur-Cameselle J, Quatromoni P. Factors Related to the Onset of Eating Disorders in Female Athletes. *Sport Psychol*. 2010;25:1-17.

78. Papadopoulou SK. Rehabilitation nutrition for injury recovery of athletes: The role of macronutrient intake. *Nutrients*. 2020;12(8):1-17. doi:10.3390/nu12082449

79. Weiss MR. Psychological Aspects of Sport-Injury Rehabilitation: A Developmental Perspective. *J Athl Train*. 2003;38(2):172-175.

80. Reinking MF. Exercise-related leg pain in female collegiate athletes: The influence of intrinsic and extrinsic factors. *Am J Sports Med*. 2006;34(9):1500-1507. doi:10.1177/0363546506287298

81. Ammar A, Brach M, Trabelsi K, et al. Effects of COVID-19 home confinement on eating behaviour and physical activity: Results of the ECLB-COVID19 international online survey. *Nutrients*. 2020;12(6). doi:10.3390/nu12061583

82. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires – a review. *Public Health Nutr*. 2002;5(4):567-587. doi:10.1079/phn2001318

83. Block G, Hartman AM, Dresser CM, Carroll MD, Gannon J, Gardner L. A data-based approach to diet questionnaire design and testing. *Am J Epidemiol*. 1986;124(3):453-469. doi:10.1093/oxfordjournals.aje.a114416

84. Block G, Coyle LM, Hartman AM, Scoppa SM. Revision of dietary analysis software for the health habits and history questionnaire. *Am J Epidemiol*. 1994;139(12):1190-1196. doi:10.1093/oxfordjournals.aje.a116965

85. Livingstone MBE, Robson PJ, Wallace JMW. Issues in dietary intake assessment of children and adolescents. *Br J Nutr*. 2004;92(S2):S213-S222. doi:10.1079/bjn20041169

86. Storey KE, Mccargar LJ. Reliability and validity of Web-SPAN, a web-based method for assessing weight status, diet and physical activity in youth. *J Hum Nutr Diet*. 2012;25(1):59-68. doi:10.1111/j.1365-277X.2011.01181.x

87. Davidson A. CRON-O-Meter: Track nutrition count calories. *Cronometer*. Published online 2016. https://cronometer.com/

Appendix A

Journal of Athletic Training

Journal Guidelines to Author:

Meridian.allenpress.com/DocumentLibrary/NATA/2020_JAT_Authors'_Guide.pdf

Citation example provided by Journal of Athletic Training Authors Guide

Wright CJ, Nauman, SL, Bosh JC. Wobble-board balance intervention to decrease symptoms and prevent re-injury in athletes with chronic ankle instability: an exploration case series. *J Athl Train.* 2020;55(1):42-48.