Effects of Sports Nutrition Counseling on Rating of Perceived Fatigue and Diet Patterns

Case Study

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Abstract

Introduction: Collegiate cross-country runners have poor dietary intakes and are at increased risk for injury. Fatigue is one outcome used to predict risk of injury, and improvement in dietary intakes such as increased carbohydrate consumption may result in reduced fatigue. Other factors such as academic stress, sleep, and muscle mass also contribute to fatigue in athletes.
Methods: Nutrient intake, perceived fatigue, sleep quality, and changes in body composition were assessed for nine cross-country athletes before and after receiving sports nutrition counseling. As this is a case series type design, these data, along with notes from nutrition counseling, were analyzed for trends with a focus on energy intake, carbohydrate intake, and factors that impact day-to-day fatigue.
Results: Participants (n=9) had minimal changes in perceived fatigue, sleep quality, and body composition during the study. Most participants met estimated requirements for energy (106%) and protein (150%) but only consumed 70% of estimated carbohydrate needs. Participants made an effort to increase carbohydrate intake and reported reduced fatigue on long runs after increasing carbohydrates.
Conclusions: Nutrition counseling from a registered dietitian can help to improve timing and quality of carbohydrates. Nutrition may improve peripheral fatigue experienced by athletes, but other factors impacting central fatigue should be assessed when reporting overall fatigue in athletes.

Key Words: running, energy, endurance

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Introduction

Collegiate athletes are documented to have limited nutrition knowledge and inadequate intakes compared to estimated needs.[1] As a result, athletes are at risk for injury, disordered eating, and metabolic risk.[1] Additionally, performance of athletes is diminished with poor dietary habits. One significant contributor to fatigue in athletes is lack of adequate carbohydrate intake.[2,3] The recommendations for personalized nutrition vary based on each athlete and their individualized goals for performance.[2,3] Sports nutrition counseling can help improve athletes' performance, but more research is needed to link nutrition interventions with performance outcomes, such as fatigue.[4]

While nutrition is a key factor in fatigue, other lifestyle elements play a significant role. Sleep disturbance has been shown to lower performance and running speed[5], with even partial sleep disturbances causing increases in heart rate, perceived exertion, and a decrease in peak oxygen consumption.[6] Similarly, academic stress has been highly correlated with increased fatigue, decreased energy levels, and lower sleep quality.[7,8] These lifestyle factors paired with poor nutritional intake can lead to an increase in mental (central fatigue) and physical fatigue (peripheral fatigue).[10] Furthermore, high training loads in competitive settings can elevate both fatigue and injury risk, and cause a decrease in lean mass toward the end of the season which has been associated with higher injury rates in other sports such as soccer and rugby.[11]

Athletic performance, therefore, is a combination of many variables. The purpose of this study was to examine the effects of nutrition counseling on perceived fatigue of collegiate cross-country runners and to evaluate common lifestyle factors that contribute to fatigue.

Methods

Participants

Participants included in the study were over the age of 18 and a member of a division I men's and women's cross-country team at a midwestern university. They were recruited at an in-person team meeting and sent an email with details of the study during the Fall of 2024. Participants were given personal ID codes to maintain confidentiality throughout the duration of the study. The study was approved by the Institutional Review Board.

Protocol

An initial survey was sent to participants where they provided consent to participate and entered demographic data including age, sex, race, ethnicity, self-reported height and weight, and years of participation in the sport of running. They were also sent a link to a seven-day food recall, a link to another survey to report fatigue and lifestyle factors contributing to fatigue, and personal ID codes to use for survey and food recalls. Food recalls, fatigue, and sleep surveys were completed by each participant before they went to sleep each night for seven sequential days, including weekends. Survey data collection was completed three times, during week one (Pre), week five (Mid), and week 10 (Post).

To assess fatigue, the rating of fatigue (ROF) scale[12] was used; runners were given instructions on how to interpret and use the scale prior to completion. The runners completed the scale at the end of the day, which represents a blend of both central and peripheral fatigue. The ROF scale is an 11-point numerical scale ranging from 0-10 (0=not fatigued, 10=total fatigue and exhaustion).

Sleep was measured using the validated Single-Item Sleep Quality Scale (SQS).[13] This scale is an 11-point numerical scale ranging from 0-10, where 0=terrible and 10=excellent. The SQS allows participants to report their sleep quality over the last seven days, so this scale was completed on the final day of each data collection week.

Food recalls were recorded via the Automated Self-Administered 24-Hour Dietary Assessment Tool (ASA24). These recalls were done through participant self-entry and reviewed by the researcher at the end of each week. If there were discrepancies, the researcher would follow-up with the participant for clarification. [14] This online tool has been validated to produce similar results to a multiple pass 24-hour recall and accurately determine nutrient intakes when compared to recovery biomarkers.[15]

Body composition was measured via Bioelectrical Impedance Analysis (BIA) (Inbody 230)[16] during week one (Pre) and week 10 (Post) of the study. Prior to testing, participants were instructed to avoid eating and drinking at least two hours before the test, avoid strenuous exercise the morning of, to remain standing upright for at least five minutes, and to be adequately hydrated.

The participants met with the researcher, who was also a registered dietitian (RD), to receive sports nutrition counseling in a private room on campus or via Zoom. Each participant received sports nutrition counseling from the same RD a total of three times throughout the season (week 2, week 4, and week 8). Notes were recorded electronically. The nutritional recommendations given were based on current guidelines and best practices for sports nutrition. See Figure 1 for a full timeline of study.

Statistical Analysis

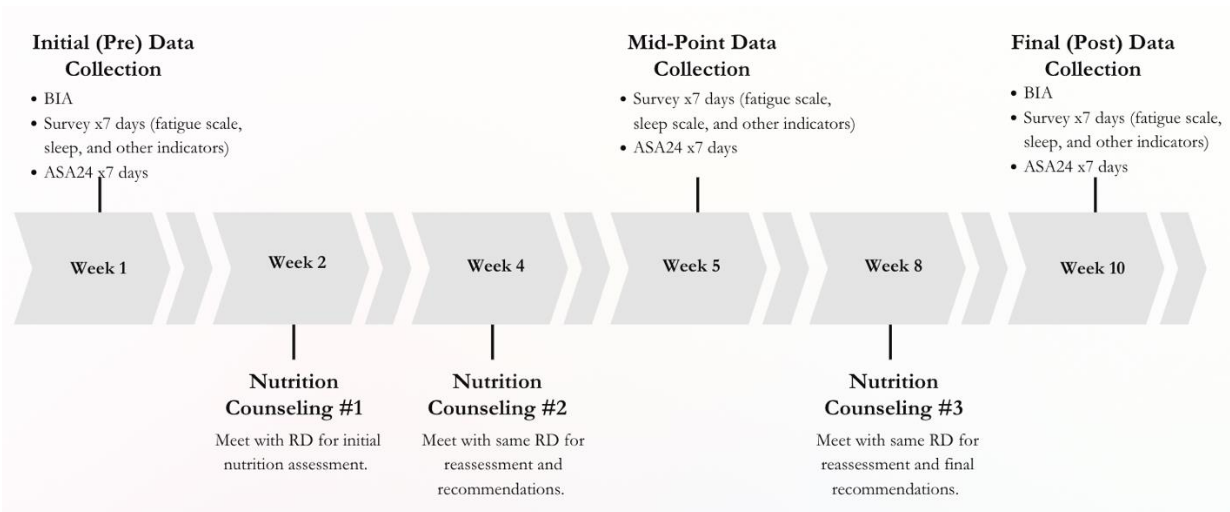
Food recalls were analyzed using ASA24 software. Totals for energy intake, carbohydrate intake, and protein intake were averaged for each week (pre, mid, post). Actual intake of energy, fluids, carbohydrates, and protein were compared to estimated needs to determine if the athlete met requirements across the three time points. Estimated energy requirements (EER) were calculated using Mifflin St. Jeor with a physical activity factor of 2.0 to account for vigorous endurance training. Carbohydrate estimated needs were calculated using a factor of 9g/kg for moderate to vigorous endurance training. Protein needs were estimated using a factor of 1.4g/kg. Fluid needs were assessed using formula 1ml/kcal.

Fatigue and sleep scale survey responses were averaged across subjects for each week of data collection and compared across all three time points. The number of participants in the study was too small for statistical analysis, so these data were analyzed for trends. The electronic notes from the counseling sessions were categorized using thematic coding across researchers. Two researchers independently reviewed the data and identified repeated and/or related key words, phrases, and/or concepts. The responses were narrowed down to three common themes.

Results

Nine athletes (female n=5; male n=4) were enrolled in the study with an average age of 19.2 ± 0.84 yrs. Figure 1 provides information regarding when data was collected, and when nutrition counseling sessions took place. Table 1 provides information regarding participant characteristics.

Figure 1. Timeline of data collection and nutrition counseling intervention.



As shown in Table 2, eight out of the nine participants were meeting recommendations for energy intake at the beginning of the study with total energy intakes averaging 110% of estimated needs. Similar results were found for energy intake at the end of the study with total actual energy intakes averaging about 106% of estimated needs. Only one out of the nine participants met goals for carbohydrate intake with total carbohydrate intakes averaging to 70% of estimated needs at the beginning of the study.

As seen in Table 3, minimal changes in body composition occurred. Changes in body composition were within the range of acceptable error for the method utilized.

ROF had minimal changes from the beginning to the end of study for both males and females. Pre-ROF mean for females was 4.3 ±1.49 and Post-ROF mean was 3.7 ± 0.96. The males were similar, with mean Pre-ROF being 3.7 ± 1.12 and mean Post-ROF being 3.6 ± 0.98. These ratings of fatigue are low on the scale, with women's ROF being slightly higher than males.

Sleep quality also showed minimal changes. Pre-SQS mean values for females were 5.4 ± 1.3 and Post-SQS mean values were 6.2 ± 1.3. Means for males were slightly higher than females, with Pre-SQS being 6.8 ± 0.5 and Post-SQS being 7 ± 0.82. The sleep quality for women was on average in the 'fair' category. Men displayed higher sleep quality averages in the 'good' category.

The three themes that emerged in reference to nutrition interventions were: fueling during long runs, increasing electrolyte intake during the day, and consuming a bedtime snack to help with recovery. There was only one theme from the follow-up sessions with the athletes, which was that they experienced improved energy in the long runs.

Table 1. Participant characteristics. All athletes had healthy BMIs and ran competitively in high school.

Participant	Age (Years)	Height (cm)	Weight (kg)	BMI (Kg/M²)	Years of Competitive Running
Female					
A	20	162.6	54.5	20.6	11
B	20	172.7	63.6	21.3	8
C	19	167.6	59.1	21	10
D	19	177.8	65.9	20.8	8
E	18	167.6	54.5	19.4	11
Mean (SD)	19.2 (0.84)	169.7 (5.78)	59.5 (5.19)	20.6 (0.73)	9.6 (1.52)
Male					
F	23	180.3	64.1	19.7	18
G	20	177.8	69.1	20.3	10
H	20	170.2	65.9	22.7	7
I	18	177.8	67.7	21.4	7
Mean (SD)	20.3 (2.06)	176.5 (4.38)	66.7(2.17)	21.0 (1.32)	10.5 (5.20)

Table 2. Estimated energy requirement and estimated carbohydrate needs versus actual intake.

		Pre	**Mid**	**Post**		**Pre**	**Mid**	**Post**
Participant	EER[A] (Kcal/Day)	Actual Energy Intake[B] (%EER)	Actual Energy Intake[B] (%EER)	Actual Energy Intake[B] (%EER)	Est. Carb Requirement (g)[C]	Average Carb Intake (g) (%ECR)[D]	Average Carb Intake (g) (%ECR)[D]	Average Carb Intake (%ECR)[D]
Female								
A	2591	3452 (133.2)	2951 (113.9)	2737 (105.6)	491	450 (91.6)	411 (83.7)	361 (73.5)
B	2900	1749 (60.3)	2714 (93.6)	2640 (91.0)	572	253 (44.2)	348 (60.8)	350 (61.2)
C	2735	3122 (114.1)	3245 (118.6)	2760 (100.9)	531	389 (73.3)	374 (70.4)	308 (58.0)
D	2999	3334 (111.2)	3993 (133.1)	3361 (112.1)	594	419 (70.5)	468 (78.8)	386 (65.0)
E	2684	2810 (104.7)	2297 (85.6)	2513 (93.6)	491	365 (74.3)	309 (63.0)	340 (69.2)
Male								
F	3316	3516 (106.0)	2880 (86.9)	2882 (86.9)	576	226 (39.2)	323 (56.1)	328 (56.9)
G	3404	3321 (97.6)	3445 (101.2)	3929 (115.4)	621	336 (54.1)	378 (60.9)	345 (55.6)
H	3245	3070 (94.6)	3970 (122.3)	3682 (113.5)	594	382 (64.3)	505 (85.0)	425 (71.5)
I	3407	5719 (167.8)	5515 (161.9)	4696 (137.8)	612	725 (118.5)	684 (111.8)	549 (90.0)
Total Avg. %EER and Avg. Carb Intake (g) (%ECR)		110.0	113.0	106.3		393.8 (70)	422.2 (74.5)	376.8 (66.7)

[A]Estimated Energy Requirement (EER) = RMR (10 x weight [kg] + 6.24 x height [cm] -5 x age [years] – 161) x activity factor of 2.0 (rounded to the nearest kcal)
[B]Average of seven-day intake
%EER= (Actual Kcal Intake / EER) x 100
[C]Est. Carb Requirement= (9g x weight [kg]) (rounded to the nearest gram)
% Est. Carb Requirement (ECR) = (Actual Carb Intake / Estimated Carb Needs) x 100

Table 3. BIA results in pre and post nutrition counseling.

Participant	Pre Weight (lbs)	Post Weight (lbs)	%Weight Change^{A}	Pre SMM (lbs)	Post SMM (lbs)	%Muscle Change^{A}	Pre PBF (%)	Post PBF (%)	PBF Change^{B}	Pre TBW (lbs)	Post TBW (lbs)
Female											
A	121	121.9	.74	51.1	50.4	-1.37	22.5	24.7	2.2	68.4	67.1
B	138.9	143.8	3.5	60.5	61.8	2.15	21.4	22.7	1.3	79.4	81.0
C	139.1	134.3	-3.5	65.6	65.3	-0.46	16.6	13.8	-2.8	84.7	84.6
D	147.7	142.4	-3.6	67.8	66.5	-1.92	17.5	16.4	-1.1	89	87
E*	123	124.6	1.3	63.2	61.2	-3.16	8.9	12.3	3.4	82.2	80.3
Average %Change			-0.31			-0.95			0.6		
Male											
F	143.1	143.5	0.3	75.5	74.9	-0.79	7.2	8.1	0.9	97.4	96.8
G	145.1	157	8.2	78.4	77.9	-0.64	5.1	12.9	7.8	101.1	100.2
H	149.9	153.9	2.7	75.8	75.4	-0.53	11.4	14.2	2.8	97.2	96.6
I*	154.3	150.3	-2.6	81.1	81.8	0.86	8.3	5.6	-2.7	103.7	104.3
Average %Change			2.2			-0.3			2.2		

^{A}%Change= ([Post-Pre] / [Pre]) x 100
^{B} PBF Change= Post PBF – Pre PBF
SMM= Skeletal Muscle Mass
PBF= Percent Body Fat
TBW= Total Body Water
BIA error margins may obscure small changes. Changes were within acceptable range of error.

Discussion

Based on baseline data of ASA24 software and athlete experience, we focused on three main recommendations during nutrition counseling: increasing carbohydrate consumption, electrolytes, and recovery overnight. Most athletes needed to increase carbohydrate consumption. This can be seen in Table 3, as only 70% of estimated carbohydrate needs were met on average. Participants were encouraged to increase carbohydrate intake during meals, snack times, and long runs. Athletes reported during counseling sessions increased intake and awareness of carbohydrates. Additionally, a common theme from athlete reports was reduced fatigue during long runs due to carbohydrate intake. Carbohydrate intake may have remained low due to gastrointestinal discomfort after competitions and high-intensity exercise, rapid satiety, and food preferences.

Previous research has found that endurance runners tend to have negative energy balances with total energy expenditure averaging 32.5% and 47.9% of recommended intakes for males and females, respectively.[17] Our findings contradict this as most of the runners were meeting estimated energy needs. Actual energy intakes progressed closer to recommended intakes over the season with consumption being 110% and 106% for weeks 1 and weeks 10, respectively. Protein and fluid intakes exceeded expectations throughout the season for most athletes as well with intakes being about 150% of estimated needs. The high protein intake likely contributed to a positive energy balance more than carbohydrates as athletes were meeting recommended energy intakes but consuming low amounts of carbohydrate.

Although we found from individual meetings that each athlete was making progress with carbohydrate intake, nutrient timing, and recovery, the athletes reported their overall fatigue during the week did not improve. This is shown in the means for males and females as reported fatigue stayed consistent throughout the duration of the study. On an individual level, athletes did have increased fatigue when reporting other contributing factors. Increases in levels of fatigue unrelated to nutrition can be attributed to many other lifestyle factors that collegiate runners experience commonly. The most reported factors were related to academic stress (exams, busy class schedule), sickness, traveling, injury, and menstrual cycle. Many of these athletes experience high levels of academic stress along with high social demands. Much of their time is taken by participation in their sport with training, meetings, travel, and competitions.[9] All of these reported factors contributed to the participants' ratings of fatigue.

Although within the acceptable range of error for the method, there were minimal changes in body composition for the female runners and more increase in %BF for males. Other findings in endurance athletes show significantly more body mass increases in male athletes than female athletes during the season.[18] However, Fess et al.[19], found no significant changes in anthropometric measures for endurance athletes from pre-post season. Similarly, we found SMM did not change across the 10-week period examined in both female and male runners. The minimal changes in body composition and weight in all the participants likely supported our findings of consistent fatigue throughout the study.

Poor sleep has been shown to reduce athletic performance and has been highly correlated with increased fatigue and academic stress.[5,6] However, we found sleep and fatigue changed minimally in most athletes. Poor sleep was reported by a few athletes as a reason for elevated fatigue.

One limitation of this study was that participants reported fatigue at the end of the day. Asking the participants to complete the scale at that time likely caused confusion on the type of fatigue we were asking for. Nutrition can highly impact peripheral fatigue with the preservation of muscle glycogen[23,24]; however central fatigue can be impacted by all the other stressors that are put on athletes and lower physical performance during running.[10,21,22] A suggestion for future studies is to ask participants to complete the fatigue scale after their training session every day, as this would have helped us to gain a better understanding of nutrition's role in peripheral fatigue.

Fatigue is important to assess in athletes, and injury or illness are typically used as indicators of fatigue or overtraining. However, these methods only allow for adjustments after injury has already occurred. Thus, prevention and early assessment are necessary for the success of athletes.

Conclusions

Nutrition plays an important role for cross-country runners to improve peripheral fatigue during training. Although overall energy, protein, and fluid intakes were adequate, carbohydrate intakes of cross-country runners were 30% lower than recommendations in this study. Sessions with a registered dietitian were found to be essential to improving carbohydrate timing and food choices. However, overall fatigue did not improve over the competition season with nutrition counseling. Central fatigue is multifactorial as sleep, stress, and other factors can have a direct impact on reported levels. Therefore, practitioners should broaden their focus beyond training and nutrition to include education and assessment of lifestyle behaviors, such as sleep, stress, and overall health to improve fatigue in athletes during the competitive season.

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