



Original Research

Nutrient Intake of Elite Canadian and American Athletes with Spinal Cord Injury

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ABSTRACT

International Journal of Exercise Science 10(7): 1018-1028, 2017. The nutrient needs of athletes with Spinal Cord Injury (SCI) are dependent on their physiological alterations and training status. Limited research is available regarding dietary intake of elite athletes with SCI and possible nutrient deficiencies. Therefore, the purpose of this study was to examine dietary intake of elite athletes with SCI, and determine dietary intake inadequacies based on the Estimated Average Requirement (EAR) comparisons. Additionally, the average energy and macronutrient (carbohydrate, protein, and fat) intake was compared based on level of injury (C level, T1-T6, T7-T12, Lumbar). A total of 39 athletes with a SCI completed a self-reported 24 hour diet recall in autumn and 27 athletes returned to complete a second data collection period (winter). Nutrient inadequacy was estimated by the proportion of athletes with mean intakes below the EAR through the Research Solutions Food Processor Diet Analysis Software (ESHA). Although Macronutrients for both men and women were within acceptable macronutrient distribution range (AMDR) recommendations, low EAR's for various nutrients were consistently found for both men and women. No significant differences were found for energy or macronutrient intake between groups based on level of lesion. Further research is needed to examine nutrient intake using other methods of dietary assessment and to determine the factors that may lead to nutrient insufficiency among elite athletes with SCI.

KEY WORDS: Performance nutrition, Paralympic, inadequate intake

INTRODUCTION

Current analysis of the dietary patterns and nutrient intake of elite athletes with spinal cord injury (SCI) is limited. Proposed performance nutrition guidelines are available for athletes, however, these recommendations do not address the potential differences in nutrient needs of elite athletes with spinal cord injury (5, 6). Spinal cord injury is damage to any part of the spinal cord or nerves that often results in changes in muscle strength, feeling, and movement

below the level of injury site. The SCI can be complete or incomplete. A complete SCI is associated with complete loss of motor and sensory function below the level of injury, whereas an incomplete SCI may have partial loss of function below the injury level (7). Difficulties in food preparation, shopping and availability to complement intense training regimens is a concern for athletes with SCI. Therefore, examining dietary patterns of elite athletes with SCI is a vital step in developing nutrient recommendations for optimal performance (9).

Although research is limited, the dietary patterns of elite athletes with SCI have been previously examined (4, 8) to determine nutrient inadequacies. Krempien et al. (9) examined the energy intakes of athletes with SCI during a training camp where athletes were provided three-day diet recalls. Intake variations of both macronutrients and micronutrients as reported by the athletes suggested that this group of elite athletes could be at risk for nutrient inadequacies based on dietary recall analysis during peak training and performance season. Three-day diet recalls revealed that most athletes were not meeting the Estimated Average Requirement (EAR) for calcium, magnesium and vitamin D for both men and women. Macronutrient intakes were within acceptable ranges according to the acceptable macronutrient distribution range (AMDR) for carbohydrate (45-65%), protein (10-35%) and fat (20-35%) for all athletes (5).

Comparing EAR and AMDR of able-bodied athletes with elite athletes with SCI has been common practice in this specific group due to the lack of evidence based recommendations for this group and subsequent increased energy and nutrient needs as compared to individuals with SCI who are not elite athletes. Utilizing this standardized method of comparison, against current able-bodied general guidelines for energy and nutrients will provide a baseline for further development and more comparative data for future studies. Remaining within similar protocol guidelines of studies analyzing this specific group of elite athletes is an important aspect to consider when providing additional data and nutritional guidelines for this unique group of elite athletes.

Athletes with SCI have a decreased lean tissue to fat mass ratio, and overall decreased basal metabolic rate (1). However, specific nutrient recommendations are currently lacking, and athletes with SCI may be deficient in key nutrients necessary for optimal performance. Although the total caloric intake recommendations for individuals with SCI are reduced in comparison to individuals without SCI, these athletes are exerting high volumes of energy during training (5). Recommendations for athletes with SCI regarding caloric intake are inconclusive, but due to a reduced metabolic rate as compared to able-bodied athletes, total calories needed for performance is hypothesized to be less in this group of athletes.

Therefore, the purpose of this study was to examine dietary intake of elite athletes with SCI and determine dietary intake inadequacies based on EAR comparisons. This study serves to contribute information relative to the development of dietary recommendations for optimal performance for elite athletes with SCI. Previous studies have examined the dietary intake of athletes with SCI using three day diet records (8, 9), which provide a sound basis for further research and development of dietary guidelines for this population. This study serves to add

to this basis of understanding and improve the available data for creating such guidelines using available 24 hour diet recalls from a training camp taken at two points in different seasons.

METHODS

Participants

In autumn (2014) the diets of 12 Canadian and 27 American elite athletes with SCI were recorded using a self-reported 24-hour diet recall. During the second collection in winter (February, March 2015), due to participant drop out, 7 Canadian and 20 American elite athletes with SCI self-reported 24-hour diet recalls. Two 24 hour diet recalls were employed, once during an autumn training camp and again during a winter training camp to assess nutrient intake instead of three day diet records due to limitations of the training camp and available resources for administration.

Elite athletes with SCI were recruited from *The Canadian Wheelchair Sports Association (CAN)*, and *The United States Olympic Committee Paralympic Programs (US)*. Participating SCI athletes were required to have an impairment of their spinal cord (e.g. spinal cord injury, spina bifida) and were selected from tennis, track, basketball and rugby. Athletes were between the ages of 19 to 47 and consisted of 39 athletes (19 women; and 20 men). Mean weight ($60.0 \pm 13.3\text{kg}$) and height ($165.0 \pm 13.5\text{cm}$) for athletes was collected at the beginning of the first testing period in autumn. In winter athletes were between ages 21 and 47 and consisted of 27 athletes (14 women; and 13 men). Mean weight was evaluated for the second collection period reported weight ($58.8 \pm 12.6\text{kg}$) and height ($164.1 \pm 13.3\text{cm}$) were indicated. No alcohol was consumed during assessment periods.

Protocol

Participants were instructed and provided information relative to quantifying intake for the purpose of diet tracking. This study was approved by the IRB, Human Subjects Review Committee (HSRC) (Project # H14114) by a mid-sized school in the Pacific Northwest. Subjects provided written consent prior to participating in the study. All participants were attending a training camp during both collection periods. The measures provided included information on estimations for serving sizes, reminders to include all ingredients in mixed dishes, and to track everything consumed during each 24 hour period. During each collection period, athletes recorded type, quantity, preparation method, and time of each meal and snack to later be analyzed for calorie (kcal), macronutrient (carbohydrate, fat and protein) and micronutrient (Vitamin B₆, vitamin B₁₂, vitamin C, vitamin D, folate, calcium, iron, magnesium and zinc) values. Athletes were not provided meals during this time and were responsible for individual records of daily intake. Furthermore, it should be noted that athletes were not taking any supplements at the time and the implementation of 24 hour recalls were taken from another study protocol measuring vitamin D intake, therefore limiting the ability of further analysis using a 3 day diet record like in other relative literature. Nutrient inadequacy was estimated by the proportion of athletes with mean intakes below the estimated average requirement (EAR) through the Research Solutions Food Processor Diet Analysis Software (ESHA, Salem,

Oregon 2010). Results were also compared to current recommendations in sports nutrition from the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine (12).

Statistical Analysis

Statistical analysis was conducted after each data collection period using a two tailed t-test (autumn, winter) with Microsoft Excel (2010) to compare macronutrient and micronutrient intake between the autumn and winter. The determination of inadequacy remained as a comparison to the EAR for each athlete based on computation and analysis in ESHA. A One-Way Analysis of Variance Analysis (ANOVA) was conducted to determine difference in total energy (kcal) and macronutrient (carbohydrate, protein and fat) intake relative to level of injury (C level, T1-T6, T7-T12, Lumbar). A Bonferroni post hoc was used in cases where a significant difference was observed. Significant differences between each collection period were used to determine relevance of reports using an alpha level of 0.05 to determine significance.

RESULTS

During autumn a total of 19 women and 20 men completed 24 hour diet recalls. Mean energy intakes were $1,602 \pm 718$ kcal for females and 1893 ± 725 kcal for men, respectively. Estimations (to account for deviations from mean) of average acceptable macronutrient distribution ranges (AMDR) during autumn for men (45% carbohydrate, 22% protein, 35% fat) and women (51% carbohydrate, 16% protein, 37% fat) were primarily within acceptable ranges with the exception of fat intake for the women being above AMDR by 2% (AMDR fat; 20-35%).

Reported mean \pm SD energy and macronutrient intake values for men and women during the autumn and winter are shown in Table 1.

Twelve participants did not complete a second 24-hour diet recall. During the second data collection (February, March 2015), due to participant drop out only 7 Canadian and 20 U.S. athletes completed 24 hour diet recalls. A total of 14 women and 13 men participated during the second winter data collection cycle. Mean energy intakes were $1,463 \pm 844$ kcal for women and 1669 ± 683 kcal for men. Estimations of average macronutrient distribution ranges during winter for men (41% carbohydrate, 18% protein, 37% fat) and women (53% carbohydrate, 20% protein, 36% fat) were primarily within acceptable ranges. Total intake of fat was above AMDR for both men and women during winter but the percent above recommended ranges were still close to AMDR guidelines (20-35% fat). Carbohydrate intake for men was below the acceptable macronutrient range (45-65%).

Protein was within the recommended range for athletes (1.2-2.0g/kg) for both autumn and winter. Average intake of carbohydrates in autumn was 3.5 ± 1.17 g/kg and 3.1 ± 0.8 g/kg in winter, which is considered low for athletes (3-12 g/kg) based on current Academy of Nutrition and Dietetics and American College of Sports Medicine recommendations (12).

Table 1. Mean ± SD macronutrient intake of elite athletes with spinal cord injury.

	Participants		
	All	Men	Women
Autumn	(n = 39)	(n = 20)	(n = 19)
Energy, kcal/day	1767 ± 735	1893 ± 725	1602 ± 718
Carbohydrate, g/day	211 ± 93	215 ± 86	206 ± 100
g/kg	3.5 ± 1.17	3.8 ± 0.9	3.6 ± 0.8
Protein g/day	84 ± 45	102 ± 49	63 ± 25
g/kg	1.4 ± 0.4	1.7 ± 0.2	1.1 ± 0.3
Fat, g/day	70 ± 45	73 ± 45	66 ± 43
Total Sugars g/day	59 ± 34	67 ± 30	50 ± 36
Winter	(n = 27)	(n = 13)	(n = 14)
Energy, kcal/day	1563 ± 777*	1,669 ± 683	1463 ± 844
Carbohydrate, g/day	183 ± 103	172 ± 88	192 ± 115
g/kg	3.1 ± 0.8	2.8 ± 0.5	3.4 ± 1.0
Protein g/day	71 ± 38*	73 ± 48	73 ± 47
g/kg	1.2 ± 0.4	1.3 ± 0.3	1.3 ± 0.4
Fat, g/day	63 ± 38	69 ± 31	58 ± 42

No significant differences were found between men and women. **p* < 0.05, indicating intakes were significantly different between summer and winter collections (Energy intake, Winter).

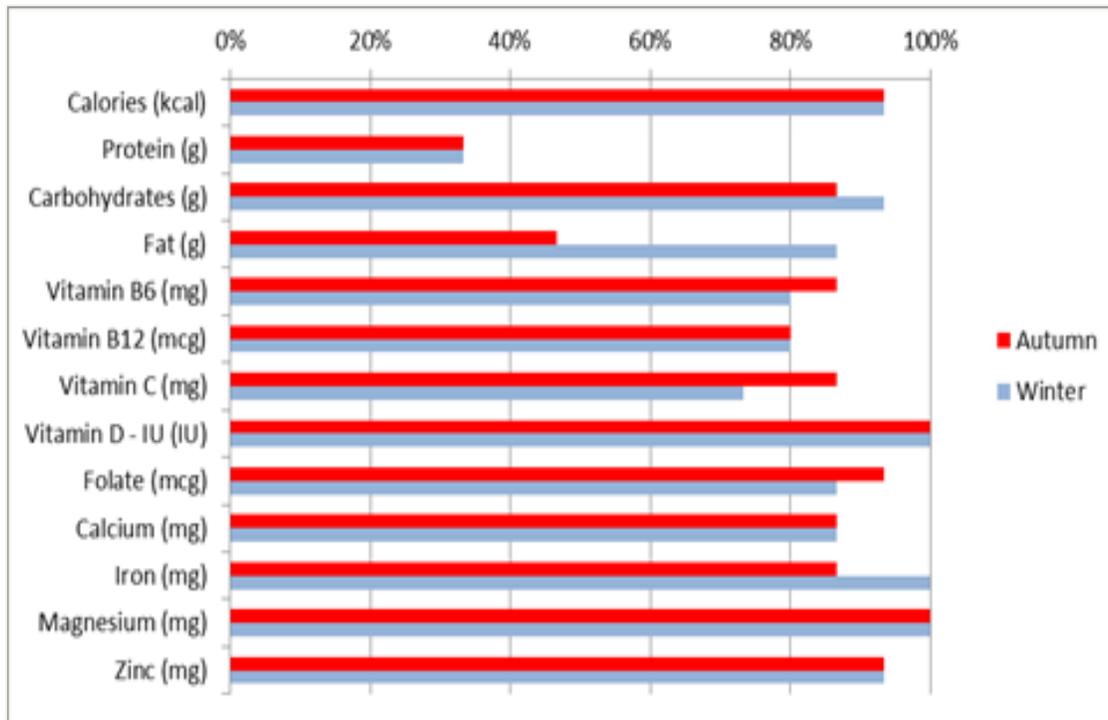


Figure 1. Estimated prevalence of nutrient insufficiencies of elite female athletes with spinal cord injury from self-reported 24 hour recalls during collections 1 (autumn, 2014) and 2 (winter, 2015). Estimations are based on EAR values originating from ESHA (Food Processing Software Analysis systems). Percent score is relevant to EAR percent met to EAR percent not met (insufficient). 100% indicates that 100% of athletes were insufficient in that category.

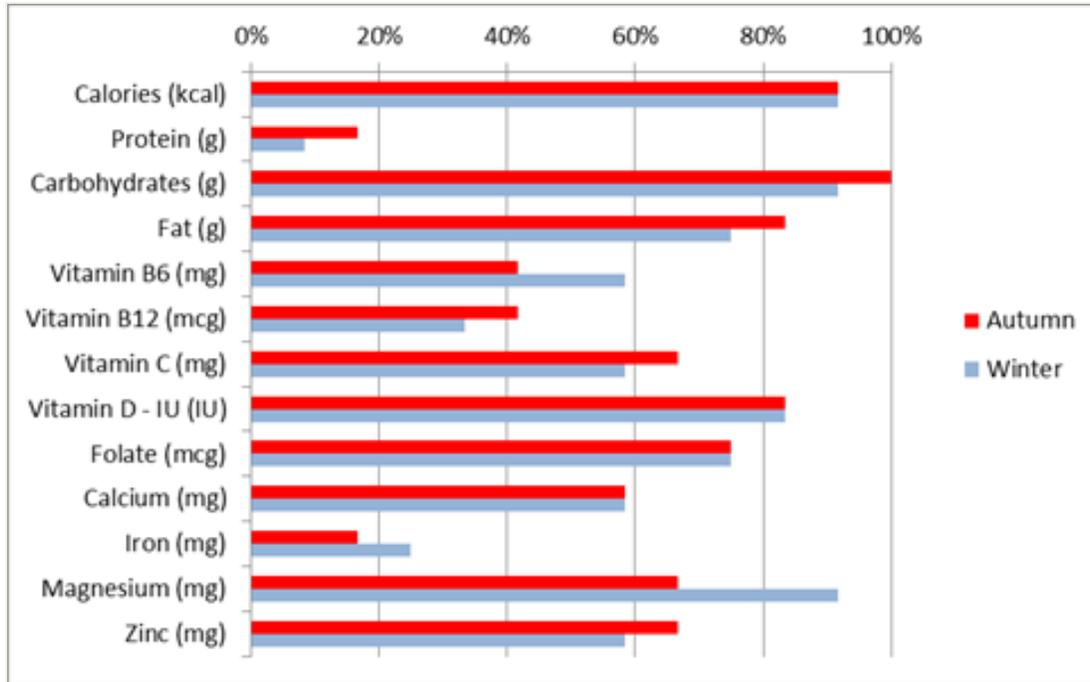


Figure 2. Estimated prevalence of nutrient insufficiencies of elite male athletes with spinal cord injury from self-reported 24 hour recalls during collections 1 (autumn, 2014) and 2 (winter, 2015). Estimations are based on EAR values originating from ESHA (Food Processing Software Analysis systems). Percent score is relevant to EAR percent met to EAR percent not met (insufficient). 100% indicates that 100% of athletes were insufficient in that category.

Mean ± SD macronutrient intake during autumn and winter is displayed in Table 1. Winter mean ± SD micronutrient intake is shown in Figure 1 for women and Figure 2 for men.

Table 2. Mean ± SD micronutrient intake of female athletes with spinal cord injury.

Nutrient, M ± SD	Women	
	(n = 19) Autumn, 2015	(n = 14) Winter, 2015
Vitamin B ₆ (mg)	0.6 ± 0.5	0.8 ± 0.6
Vitamin B ₁₂ (mcg)	1.2 ± 1.4	1.6 ± 1.5*
Vitamin C (mg)	54.1 ± 71.3	62.5 ± 71.5
Vitamin D (IU)	0.5 ± 0.8	0.7 ± 1.1
Folate (mcg)	115.3 ± 86.1	139.7 ± 156.1
Calcium (mg)	541 ± 432	462.3 ± 373.3
Iron (mg)	10.7 ± 6.5	8.3 ± 4.2
Magnesium (mg)	96.2 ± 70.9	89.5 ± 72.4
Zinc (mg)	3.2 ± 2.7	3.8 ± 4.8

*p < 0.01, reported intakes for autumn and winter differed significantly

Returning female athletes did not meet a 60% minimum intake of the EAR in vitamin D, vitamin B₆, vitamin B₁₂, vitamin C, folate, calcium, iron, magnesium and zinc.

Women were more likely to have insufficiencies in most macronutrients with the exception of protein with only 33% of returning women being insufficient compared to EAR values. The consumption of fat also was the only nutrient that was significantly different between collection periods in returning women. Table 2 and Figure 1 represent intake analysis of women during autumn and winter. The prevalence of insufficiency increased 40% in collection 2 (47% collection 1, 87% collection 2). Vitamin D and magnesium EAR values were consistently not met during both collections (100%). Returning women were insufficient (<60% of EAR) in calories, carbohydrate, fat, vitamin B6, vitamin B12, vitamin C, folate, calcium, iron and zinc.

Male athletes showed similar insufficiencies as compared to women in the study. Macronutrient intakes were consistently not met for total calories and carbohydrate intake in both collection periods. Although many nutrients were not met by a large percentage of returning men, more nutrient EAR values were met in comparison to returning women. Table 3 represents mean \pm SD micronutrient intake for men during autumn and winter. Figure 2 depicts nutrient deficiencies in autumn and winter for men. Protein insufficiency occurred in both autumn (17%) and winter (8%). Returning men were insufficient (<60% EAR) in calories, carbohydrate, fat, vitamin D, folate, and magnesium.

Table 3. Mean \pm SD micronutrient intake of male athletes with spinal cord injury.

Nutrient, <i>M</i> \pm <i>SD</i>	Men	
	(<i>n</i> = 20) Autumn, 2014	(<i>n</i> = 13) Winter, 2015
Vitamin B ₆ (mg)	1.7 \pm 1.4	1.4 \pm 1.0
Vitamin B ₁₂ (mcg)	4.6 \pm 4.4	4.2 \pm 3.3*
Vitamin C (mg)	92.9 \pm 109	75.8 \pm 47
Vitamin D (IU)	3.9 \pm 4.7	2.0 \pm 2.6
Folate (mcg)	284.9 \pm 245	251 \pm 341.5
Calcium (mg)	990.8 \pm 589	869.7 \pm 453
Iron (mg)	16.6 \pm 8.17	12.9 \pm 8.8
Magnesium (mg)	294.3 \pm 293.6	195.6 \pm 173.9
Zinc (mg)	9.0 \pm 9.9	10.9 \pm 11.4

**p* < 0.01, reported intakes for autumn and winter differed significantly

Participant intake was also categorized by the location of the injury on the spinal cord (C Level, T1-T6, T7-T12, and Lumbar). Table 4 displays the mean \pm SD energy and macronutrient intake for athletes based on level of injury. A total of 6 athletes did not provide information regarding their injury level for this study; therefore only 33 athletes provided information regarding their level of injury for analysis.

DISCUSSION

Little research has examined the diets of elite athletes with a SCI. The purpose of this study aimed to examine dietary intake of elite athletes with SCI, and determine dietary intake inadequacies based on EAR and current sports nutrition recommendations.

Table 4. Mean nutrient intake of athletes with spinal cord injury categorized by level of injury.

	C Level	T1-T6	T7-T12	Lumbar	P Value
	(n = 9)	(n = 9)	(n = 10)	(n = 5)	
Energy (kcal)	1,662 ± 494	1,731 ± 877	1,883 ± 753	2,059 ± 918	0.81
kcal/kg	26 ± 7.9	28 ± 14	36 ± 14	36 ± 16	
Protein (g/day)	93 ± 51	70 ± 42	87 ± 18	109 ± 59	0.52
g/kg	1.5 ± 0.8	1.1 ± 0.7	2 ± 0.1	1.9 ± 1	
Carbohydrate (g/day)	183 ± 61	223 ± 120	237 ± 117	200 ± 46	0.7
g/kg	2.9 ± 0.9	3.6 ± 1.9	4 ± 2	3.5 ± 0.8	
Fat (g/day)	65 ± 37	64 ± 33	77 ± 47	97 ± 66	0.52
g/kg	1 ± 0.6	1.1 ± 0.6	1 ± 1.1	1.7 ± 1.1	

Not all participants provided level of injury during study participation. *No significant differences ($p < 0.05$) were found between groups.

Energy intake was a major factor in the determination of nutrient adequacy of athletes, as expected for relative intake of foods during each 24-hour dietary recall. Energy intake estimations produced by ESHA using current Dietary Reference Intake (DRI) guidelines provided insight to where these individuals stood in terms of intake, but did not consider their SCI or elite athlete status. This software also is limited to pairing only what is available in the software database to estimates recorded from participants and should be noted when interpreting intake analysis. Calculation of total energy requirements were based on the estimation of activity level, sex, weight and height but due to the limitations of the software utilized a true estimation cannot be concluded in this study.

Past recommendations for energy intake specifically involving this group of athletes has been estimated using indirect calorimetry on paraplegic individuals (2, 3). Results concluded that resting metabolic rate was significantly lower in these individuals as compared to able-bodied individuals. Differences were calculated as upwards of 14%, but when adjusted for fat free mass this difference decreased to only 2%. Taking into consideration this study and others that have examined the differences in metabolic rate in individuals with SCI, it should be noted that an athlete training at an elite status would have altered needs as compared to these studies due to training and recovery. Specifically, this is due to decreased overall muscle recruitment for activity and ultimately decreased muscle mass. Exercise physiology is altered between able bodied and athletes with SCI which has been measured in the effects of VO_{2max} . Decreased stroke output, oxygen uptake and decreased lean muscle tissue influence VO_{2max} of athletes with SCI (10). As a result of these factors combined, decreased metabolic rate has been assumed in this group of athletes.

Current research examining training load and estimation of energy requirements for elite athletes with SCI suggest that based on individual BMR calculations, any athlete who is evaluated as needing less than 1,800 calories per day should consult a registered dietitian due to the increased nutrient needs for training (5).

Although energy intake was below the recommended threshold of 1,800 calories per day, macronutrient distribution ranges for both groups were within acceptable ranges. Fat intake of male athletes exceeded recommendations by 2%, was 4% below recommended percentages of carbohydrate intake and meet protein intake recommendations in winter. Additionally, fat intake for women was above recommendations as well for both autumn and winter while carbohydrate intake was below recommendations. This could suggest that, according to guidelines using AMDR, this elite group could be consuming adequate distribution of nutrients, but due to potential insufficient total energy intake this needs to be further evaluated.

Comparisons of energy intake according to level of injury also provide insight to dietary patterns of athletes with spinal cord injury. Overall, energy intake was similar between groups based on level of injury, but due to the small sample size when divided into groups according to injury, a significant difference was not detected. Differences were observed for fat and protein intake when analyzed according to injury level. Athletes with a lumbar spine injury reported a higher relative intake of fat and protein when compared to other groups, although no significant differences were found. It could be inferred that athletes with a lumbar spine injury may consume additional calorically dense foods high in fat and protein due to the fact that they were primarily involved in track athletics, which has an increased energy demand, but this hypothesis can only be theorized. Supporting this hypothesis is the physiologic alternations that occur following a lumbar spine injury, alterations in metabolism influenced by changes in muscle mass, sympathetic innervation and hormonal influences can occur (6, 12). Lumbar spine injury is considered a paraplegic injury and is described as "impairment or loss of motor and/or sensory function in the thoracic, lumbar or sacral segment of the spinal cord secondary to damage of neural elements within the spinal canal...arm functioning is spared, but, depending on the level of injury, the trunk, legs and pelvic organs may be involved" (11). Considering these aspects associated with a lumbar spine injury, it could be inferred that due to the higher available muscle mass from the effects of the injury, these individuals have a higher resting metabolic rate and therefore need for additional energy as compared to other classifications of SCI. Additional research is needed to adequately determine total nutrient and calorie needs in this specific population and could be a benefit for future studies to explore.

Comparable to current studies involving the analysis of nutrient intake of athletes with SCI, this study produced similar results regarding energy intake. In a similar study evaluating supplementation and intake of athletes with SCI, researchers concluded that based on self-recorded diet intake analysis, this group of elite athletes were not consistently meeting total energy goals and were not meeting specific vitamin and mineral recommendations compared to EAR. Similar to the findings of Krempien et al. (9), despite not meeting standards for energy intake, their intake seem to be balanced and the athletes were consistent in meeting the AMDR criteria (5). Another study examined non-athlete individuals with SCI, and this finding was consistent even when ADMR was utilized to evaluate the distribution of nutrient intake (13). This further suggests that individuals with SCI, specifically athletes, are able to consume

adequate distribution of nutrients but may be at risk for nutrient inadequacies based on differences in total energy needs compared to able-bodied individuals.

Exact measurement of intake is difficult with the use of 24-hour diet recalls. Despite having a registered dietitian instruct athletes on how to document intake accordingly, human error as well as user understanding of portion sizes and overall exposure to intake documentation could have interfered with accurate recording procedures. Optimally, a three-day diet recall would have been more advantageous in estimating inadequate intake for this group of athletes and has been noted for further research. Other factors that could have skewed data to represent a false record of intake are the influence of training schedules, meal availability and timing, sickness, preconceptions of food intake and performance, as well as many other factors (2). Participant drop out during the second collection period also was an unforeseen barrier to collecting data for comparison of autumn and winter dietary intake records.

Total energy intake was low in this group of elite athletes based on current intake guidelines, and consequently total nutrient intake was also low based on EAR comparisons. Overall, this group of elite athletes could benefit from monitoring and evaluation from a registered dietitian throughout training to meet current EAR guidelines. Additional research is needed to determine if this group of elite athletes is consuming adequate distribution of macronutrients, but possibly not an adequate amount and therefore insufficient micronutrients.

It should be noted that it is difficult to determine the adequacy of energy intakes given that energy requirements have yet to be determined for elite athletes with SCI, and solely referencing data used for able-bodied athletes is not appropriate to make a conclusion. This group of athletes did consume adequate meals in compliance with macronutrient distribution ranges, but overall calories need to be increased to meet the EAR for most nutrients in both men and women. The EAR values referenced are specific to able bodied athletes and could be used as guidelines for athletes with SCI, but specific recommendations should be calculated on an individual basis as these values could be above or below the needs of these athletes. It could be advised that consulting with a sports registered dietitian nutritionist would be of benefit to this group of athletes and should be taken into consideration with future nutrition recommendations and nutrition education provided for these athletes. This study provides information regarding dietary intake of elite athletes with SCI. Further research is warranted to determine energy requirements to establish dietary recommendations for elite athletes with SCI in order to adequately represent the intake needs of this group of elite athletes.

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