

Short Report

Influence of Improvements in Snacking Habits on Nutrient Intake and Body Composition Following Online Nutritional Guidance in Male Senior High School Soccer Players

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Abstract

This study investigated how improved snacking habits influence nutrient intake and body composition in male high school soccer players following online nutritional guidance. A 1-year intervention consisting of three online seminars led to significant increases in carbohydrate intake and lean body mass index. However, vitamin and mineral intake declined. These findings show that online nutritional guidance enhances carbohydrate consumption but may require additional strategies to ensure micronutrient adequacy. Further research is needed to optimize online nutritional guidance for adolescent athletes.

1. Introduction

Soccer is an intermittent, high-intensity sport requiring aerobic and anaerobic energy supply, which leads to muscle glycogen depletion post-match. Proper nutritional strategies are critical for optimizing performance and recovery¹⁾. However, inadequate nutrient intake can impair muscle glycogen resynthesis, increase muscle protein breakdown, and negatively impact immune function, bone health, and hormonal balance, increasing the risk of relative energy deficiency in sport (RED-S)²⁾. Adolescent athletes have unique nutritional needs due to their growth and development, making them especially vulnerable to RED-S³⁾.

Implementing nutrition education programs is an effective strategy to enhance athletes' nutritional knowledge and improve dietary habits⁴⁾. With social distancing restrictions limiting in-person interactions, remote nutrition education has emerged as a viable alternative⁵⁾. However, research on its effectiveness, particularly among high school soccer players, remains limited.

This short report presents a pre-post intervention study assessing changes in nutrient intake and body composition among male high school soccer players following online nutritional guidance. Specifically, we examined athletes who improved their snacking habits after a 1-year, three-session online seminar and analyzed the findings.

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2. Methods

2.1 Study design and participants

This study employed a single-arm, pre-post intervention design. Participants were five male first-year high school soccer players (aged 15-16 years) belonging to the same high school soccer club who demonstrated improved snacking behaviors, defined as regularly consuming supplementary meals or eating within 60 min post-exercise after attending an online nutrition seminar.

2.2 Nutritional intervention

The intervention consisted of three online nutrition seminars conducted over 1 year by a registered dietitian specializing in sports nutrition. The seminars were delivered via Zoom in a lecture and question-and-answer format, each lasting up to 40 min, including discussion time. Sessions were held in September 2020, January 2021, and April 2021. The seminar content, detailed in Table 1, covered the importance of supplementary feeding, selection criteria for supplementary foods, appropriate timing and quantity, and the role of carbohydrate intake. General sports nutrition topics, such as balanced meals and the use of supplements, were also discussed. Participants were encouraged to apply the recommendations throughout the study period.

Table 1 Overview of the online nutrition seminars

Date	Topics covered	Key points
Sep 2020	Pre-training and pre-match nutrition	• Role of glycogen as a primary energy source • Importance of carbohydrate intake for optimal energy supply • Recommended pre-exercise snack options • Optimal timing strategies for snack consumption
Jan 2021	Post-training and post-match recovery nutrition	• Necessity of carbohydrate replenishment post-exercise • Role of protein in glycogen resynthesis • Recommended post-exercise snack options • Optimal timing strategies for snack consumption
Apr 2021	Review of pre and post-exercise nutrition	• Summary of glycogen's role in energy supply and recovery • Practical strategies for selecting snacks before and after exercise

2.3 Data collection

Data were collected at two time points to assess changes before and after the intervention: pre-intervention (July 2020) and post-intervention (July 2021).

2.3.1 Nutrient intake

Habitual nutrient intake was evaluated using the Brief-Type Self-Administered Diet History Questionnaire for 15-Year-Olds (BDHQ15y). For energy-yielding nutrients (carbohydrates, protein, and fat), the percentage contribution of each to total energy intake was calculated. Additionally, protein and carbohydrate intake per kilogram of body weight was determined. Intake of nonenergy-yielding nutrients (retinol equivalent, vitamins B₁, B₂, and C, calcium, and iron) and various food groups (grains, tubers, legumes, dark green and yellow vegetables, other vegetables, fruits, fish and shellfish, meat, eggs, dairy products, and fats and oils), were adjusted per 1,000 kcal of energy intake.

2.3.2 Body composition

Height (cm) was measured using a portable stadiometer seca213 (Seca, Hamburg, Germany). Body weight (kg) and body fat percentage (%) were measured using a bioelectrical impedance analysis device RD-

802 (TANITA, Tokyo, Japan). Body fat mass (kg) was calculated by multiplying body weight by body fat percentage. Lean body mass (kg) was derived by subtracting body fat mass from body weight, and the lean body mass index (LBMI; kg/m²) was computed by dividing lean body mass by height squared (m²).

2.4 Statistical analysis

Statistical analyses were performed using SPSS Statistics version 23 (IBM Japan, Tokyo, Japan), with significance set at $p < 0.05$. Descriptive statistics (mean, median, minimum, and maximum values) were calculated, and the Wilcoxon signed-rank test was applied to compare pre and post-intervention data.

3. Results

Table 2 presents changes in nutrient intake before and after the online nutrition seminar. Energy intake exhibited an increasing trend post-intervention ($p = 0.079$). Among energy-yielding nutrients, the carbohydrate energy ratio significantly increased ($p = 0.043$), whereas the protein energy ratio significantly decreased ($p = 0.043$). The fat energy ratio showed a decreasing trend post-intervention ($p = 0.079$).

Table 2 Changes in nutrient intake before and after the online nutrition seminar intervention

Nutrients, Unit	Time point	mean $\pm$ SD		median (Min-Max)		p value
Energy, kcal/day	Pre	2715	$\pm$ 480	2728	(2212-3448)	0.079
	Post	2986	$\pm$ 682	2714	(2400-4146)	
Carbohydrate energy ratio, %	Pre	53.2	$\pm$ 6.7	50.9	(46.3-64.2)	0.043
	Post	59.0	$\pm$ 3.7	58.7	(55.3-64.7)	
Carbohydrate, g/kg/day	Pre	6.2	$\pm$ 1.6	5.6	(5.0-9.1)	0.043
	Post	7.1	$\pm$ 2.0	6.5	(5.8-10.7)	
Protein energy ratio, %	Pre	16.2	$\pm$ 2.3	16.4	(13.0-18.4)	0.043
	Post	14.3	$\pm$ 1.7	14.4	(12.5-16.0)	
Protein, g/kg/day	Pre	1.8	$\pm$ 0.2	1.8	(1.6-2.1)	0.345
	Post	1.7	$\pm$ 0.2	1.7	(1.4-2.1)	
Fat energy ratio, %	Pre	30.6	$\pm$ 5.0	30.8	(22.8-35.5)	0.079
	Post	26.7	$\pm$ 2.7	27.0	(22.8-29.5)	
Retinol equivalent, μ g/1000kcal/day	Pre	370	$\pm$ 82.4	329	(296-502)	0.079
	Post	300	$\pm$ 66.4	307	(220-391)	
Vitamin B ₁ , mg/1000kcal/day	Pre	0.4	$\pm$ 0.1	0.4	(0.4-0.5)	0.686
	Post	0.4	$\pm$ 0.1	0.4	(0.3-0.6)	
Vitamin B ₂ , mg/1000kcal/day	Pre	0.8	$\pm$ 0.1	0.7	(0.7-0.9)	0.225
	Post	0.7	$\pm$ 0.1	0.7	(0.6-0.8)	
Vitamin C, mg/1000kcal/day	Pre	65.9	$\pm$ 23.3	61.6	(44.5-104.6)	0.043
	Post	45.0	$\pm$ 15.0	38.6	(31.6-61.7)	
Calcium, mg/1000kcal/day	Pre	365	$\pm$ 61.2	362	(280-436)	0.043
	Post	281	$\pm$ 38.8	294	(239-327)	
Iron, mg/1000kcal/day	Pre	4.1	$\pm$ 0.4	4.1	(3.7-4.7)	0.043
	Post	3.6	$\pm$ 0.4	3.7	(3.1-4.2)	

Data are presented as mean $\pm$ standard deviation (SD) and median (min-max). Significant differences between pre-intervention (Pre) and post-intervention (Post) were assessed using the Wilcoxon signed-rank test. A p value < 0.05 was considered statistically significant.

Carbohydrate intake per kilogram of body weight significantly increased after the intervention ($p = 0.043$), while protein intake remained unchanged. Among micronutrients, vitamin C, calcium, and iron intake significantly decreased post-intervention ($p = 0.043$), whereas the retinol equivalent showed a decreasing trend post-intervention ($p = 0.079$). No significant changes were observed in vitamin B₁ and B₂ intake before and after intervention.

Table 3 presents variations in food group consumption before and after the online nutrition seminar. Notably, grain intake significantly increased following the intervention ($p = 0.043$). Conversely, the intake of other vegetables—including pale-colored vegetables, mushrooms, seaweeds— and dairy products significantly decreased post-intervention ($p = 0.043$). Additionally, a decreasing trend was observed in green and yellow vegetable intake ($p = 0.079$). No significant changes were detected in the consumption of other food groups before and after intervention.

Table 3 Changes in food group intake before and after the online nutrition seminar intervention

Food groups	Time point	mean $\pm$ SD			median (Min-Max)	p value
Grains	Pre	238	$\pm$	73.5	217 (176-359)	0.043
	Post	289	$\pm$	48.4	282 (248-369)	
Tubers	Pre	9.6	$\pm$	5.5	12.0 (2.1-14.3)	0.500
	Post	9.3	$\pm$	5.7	11.3 (2.4-16.0)	
Legumes	Pre	28.7	$\pm$	9.7	28.2 (15.9-40.2)	0.500
	Post	25.5	$\pm$	6.0	26.5 (18.1-33.9)	
Dark green and yellow vegetables	Pre	51.9	$\pm$	12.0	49.8 (36.6-68.8)	0.079
	Post	38.3	$\pm$	16.5	33.9 (17.6-57.3)	
Other vegetables	Pre	88.9	$\pm$	22.1	81.5 (67.7-121)	0.043
	Post	58.1	$\pm$	11.1	56.0 (42.9-69.4)	
Fruits	Pre	58.7	$\pm$	29.4	49.1 (29.0-101)	0.225
	Post	75.9	$\pm$	49.6	95.8 (8.1-132)	
Fish and shellfish	Pre	36.3	$\pm$	20.6	35.2 (12.6-69.1)	0.500
	Post	26.9	$\pm$	12.7	32.1 (11.8-38.2)	
Meat	Pre	50.0	$\pm$	18.2	49.5 (25.7-74.3)	0.225
	Post	41.3	$\pm$	18.2	38.3 (21.4-71.0)	
Eggs	Pre	30.8	$\pm$	17.5	32.1 (4.3-50.4)	0.225
	Post	29.4	$\pm$	13.8	29.6 (9.3-47.4)	
Dairy products	Pre	126	$\pm$	60.6	110 (65.4-223)	0.043
	Post	84.8	$\pm$	33.8	76.8 (41.0-131)	
Fats and oils	Pre	7.0	$\pm$	2.0	7.0 (4.2-9.6)	0.893
	Post	6.2	$\pm$	3.1	7.2 (1.5-9.6)	

Food group intake is expressed as daily values per 1,000 kilocalories (g/1,000 kcal/day). Data are presented as mean $\pm$ standard deviation (SD) and median (min-max). Significant differences between pre-intervention (Pre) and post-intervention (Post) were assessed using the Wilcoxon signed-rank test. A p value <0.05 was considered statistically significant.

Figure 1 illustrates changes in body composition before and after the intervention using box plots. Median values for height, body weight, and fat-free mass index showed a significant increase post-intervention ($p = 0.043$). However, no significant change was observed in the median body fat percentage before and after intervention.

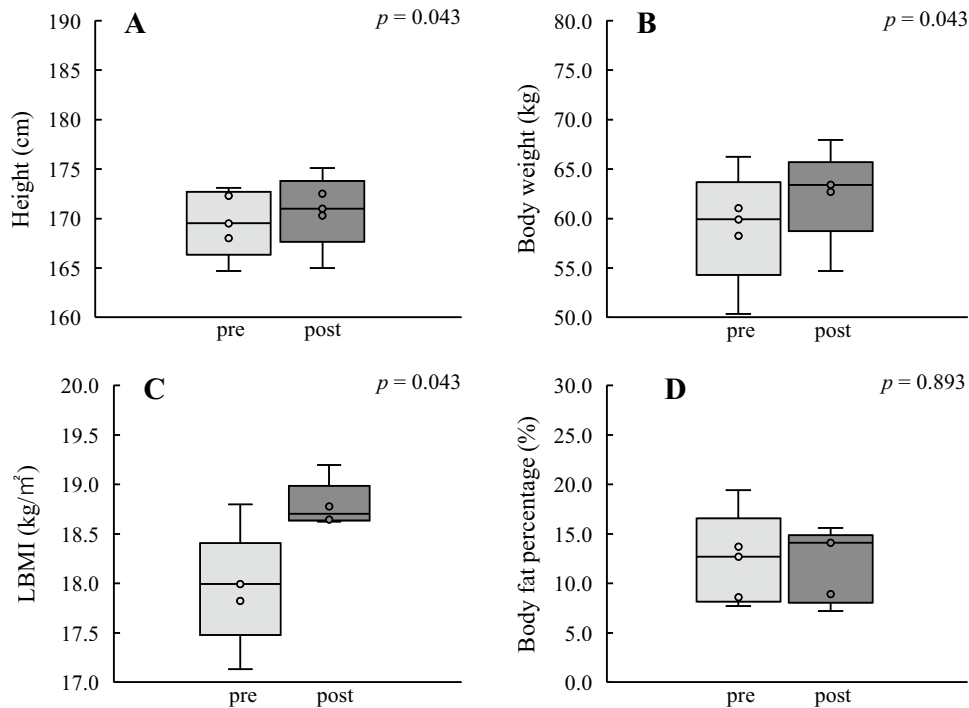


Figure 1 Changes in body composition before and after the online nutrition seminar intervention. (A) Height, (B) body weight, (C) lean body mass index (LBMI), and (D) body fat percentage before and after the intervention are presented. Data visualization includes box plots superimposed on a bee swarm plot. Significant differences between pre-intervention (Pre) and post-intervention (Post) were assessed using the Wilcoxon signed-rank test. A p value <0.05 was considered statistically significant.

4. Discussion

The key finding of this study is the significant increase in carbohydrate intake per body weight, carbohydrate energy ratio, and grain consumption among male high school soccer players who improved their snacking habits through the online nutritional guidance intervention. These findings suggest that the intervention effectively facilitated desirable modifications in carbohydrate intake patterns, particularly an increased intake of staple carbohydrate sources such as rice, bread, and noodles.

The seminar was structured across three sessions, each consistently emphasizing the importance of snacking, appropriate snack selection, optimal timing and portion sizes, and the role of carbohydrates in athletic performance. Participants were encouraged to incorporate carbohydrate-rich snacks such as rice balls, bread, and noodles, particularly before practices and games. This guidance likely reinforced their understanding of the benefits and practical applications of carbohydrate consumption, leading to behavioral changes. These results align with previous studies on high school soccer players^{6,7}, which, despite being conducted in a face-to-face format, also implemented nutrition education at a frequency of three sessions per year. The content of these programs—including recommendations on snacking and carbohydrate intake—bears strong similarities to the present study, and they reported comparable trends in increased energy and carbohydrate intake.

Although this study was limited to subjects who demonstrated improved snacking behavior, the findings suggest that online nutritional guidance can effectively enhance carbohydrate intake among male high school soccer players. Adequate carbohydrate consumption has been shown to improve energy supply efficiency, increase glycogen storage in muscles and the liver, and enhance performance during endurance exercises and high-intensity training^{8,9}. Furthermore, a joint statement from the Academy of Nutrition and Dietetics, Dietitians of Canada (DC), and the American College of Sports Medicine (ACSM) recommends a

carbohydrate intake of 5-7 g/kg of body weight per day for moderate exercise (1 h/day) and 6-10 g/kg for moderate - to high-intensity exercise (1-3 h/day)¹⁰. Additionally, carbohydrate intake is essential not only for supporting training but also for facilitating growth and development in adolescent athletes¹¹. In this study, the average carbohydrate intake per body weight significantly increased from 6.2 ± 1.6 g/kg before the intervention to 7.1 ± 2.0 g/kg post-intervention, aligning with the recommended range of 6-10 g/kg for moderate - to high-intensity exercise. This increase suggests that the online nutrition seminar successfully promoted dietary changes that may support athletic performance and healthy development.

Beyond carbohydrate intake, another noteworthy finding is the significant increase in LBMI among participants who improved their snacking habits. LBMI is strongly correlated with maximal muscle strength and power output¹², which are critical for soccer performance, particularly in terms of aerobic fitness, agility, and explosiveness¹³. However, studies on Japanese university students¹⁴ indicate that LBMI is independent of height and serves as a reliable screening indicator for soccer players¹⁵. The observed increase in LBMI in this study is likely attributable to the increase in carbohydrate intake. Insufficient energy intake can prompt the mobilization of endogenous protein and liver glycogen to regulate blood glucose levels, potentially compromising protein availability for muscle synthesis¹⁶. Conversely, adequate carbohydrate intake reduces amino acid breakdown and promotes a positive nitrogen balance, facilitating muscle development¹⁷. Notably, participants in this study met the ACSM-recommended protein intake of 1.2-2.0 g/kg/day before and after the intervention. The combination of sufficient protein and increased carbohydrate intake likely created a synergistic effect, optimizing protein utilization for muscle synthesis.

However, it is important to acknowledge that an increase in grain consumption may disrupt overall dietary balance, potentially leading to a relative decrease in the intake of other food groups. In this study, a reduction in the consumption of "other vegetables" and "dairy products" was observed, which may have contributed to lower vitamin C, calcium, and iron intake. While the seminar primarily focused on snack-related guidance, vegetables and dairy products are crucial sources of essential micronutrients. Future nutrition education initiatives should adopt a more holistic approach, addressing overall dietary balance to ensure optimal nutrient intake. Additionally, disseminating information to parents and guardians—who play a vital role in meal preparation—could further support the maintenance of a well-rounded diet.

Ethical considerations

Written informed consent was obtained from participants and their parents/guardians following a detailed explanation of the study's purpose, methods, potential benefits and risks, and data confidentiality measures. The study was approved by the Kawasaki University of Medical Welfare Ethics Committee (Approval No. 20-026).

Conflict of interest

The authors declare that there is no conflict of interest.

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