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Evaluation of a randomized nutrition intervention combining nutrition education and cooking workshops on dietary intakes and psychosocial determinants of performance in university football athletes

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Abstract

Although nutrition influences performance, many athletes, including football players, do not meet nutritional requirements for their sport. The objective of this study was to determine the impact of a nutrition intervention combining nutrition education and cooking workshops on nutrition knowledge, intention, and perceived behavioral control in the preparation of healthy meals, dietary intakes, and diet quality in male university football players. Athletes ($n = 23$; age: 22 ± 1 year) were randomly assigned to an intervention (2 h/week) ($n = 13$) or control group ($n = 10$) over three weeks. Questionnaires were completed before (pre), immediately after (post 1), and two months after the intervention (post 2). Dietary intakes and diet quality were evaluated from three web-based 24-h dietary recalls per visit. Mixed linear models for repeated measures with Tukey's post hoc test were performed to determine the effects of the intervention on all outcomes. There was a group by time interaction for nutrition knowledge ($p = 0.002$) that was higher immediately after and two months after the intervention compared to the control group. No differences on other outcomes were observed. Combining nutrition education and cooking workshops improved nutrition knowledge, but did not affect intention and perceived behavioral control in the preparation of healthy meals, dietary intakes, and diet quality in male university football athletes.

Key words: Sports nutrition, nutrition education, cooking workshops, nutrition knowledge, cooking skills

Introduction

In sports such as American football, most studies are directed toward optimizing physical preparation and performance (Fullagar et al. 2017). In a context where the goal of an athlete is to achieve excellence, it is essential to consider other factors that may influence the components of sport performance including psychological preparation and recovery (Battaglia et al. 2014; Schuster et al. 2018). Among these factors, proper nutrition has been found to directly impact athletic performance (Thomas et al. 2016) and to indirectly impact sports performance through psychosocial determinants such as sleep (Doherty et al. 2019) and stress (Khan and Khan 2016) or overall well-being (Conner et al. 2015).

While nutrition is an important factor influencing performance, most football players do not meet nutritional requirements for their sport. Some studies in football players have reported low carbohydrate intakes (Burke et al. 1991; Devlin et al. 2017) and high lipid intakes (Abbey et al. 2017; Burke et al. 1991) when compared to recommendations. Although lacking in variety (Abbey et al. 2017; Burke et al. 1991), the protein consumption of football players is largely sufficient (Abbey et al. 2017; Devlin et al. 2017) and does not justify a high consumption of protein supplements (Abbey et al. 2017). Poor nutrition knowledge and inadequate cooking skills have previously been shown to negatively influence the dietary intakes of athletes (Birkenhead and Slater 2015; Heaney et al. 2008). Two studies that assessed sport nutrition knowledge in football players reported success rates of approximately 50% (Lohman et al. 2019) and 60% (Devlin et al. 2017). In addition, university football players' regular consumption of fast foods at restaurants (Abbey et al. 2017; Jonnalagadda et al. 2001) may suggest a lack of cooking skills at a time where many of them gain independence from their families (Heaney et al. 2008). Therefore, although diet quality is influenced by several determinants, it appears that food choice may depend on nutrition knowledge and cooking skills, among many factors (Birkenhead and Slater 2015). A recent systematic review shows that nutrition education interventions for team sports could improve an athlete's nutrition knowledge and dietary intakes (Sánchez-Díaz et al. 2020). For instance, Rossi et al. (2017) observed an increase in nutrition knowledge that was reflected by improved dietary intakes in response to a nutrition education intervention involving a 90-minute education session and 5 meetings over a 12-week period. However, some studies among athletes or university students that showed an increase in nutrition knowledge did not observe changes in dietary intakes (Levy and Auld 2004; Bernardoa et al. 2018; Heikkilä et al. 2019). Systematic reviews have shown that the inclusion of practical teaching methods such as cooking workshops (Tam et al. 2019) is a key element of effective nutrition interventions (Bentley et al. 2020). Savoie et al. (2015) showed that a nutrition education intervention improves participants' intention to prepare meals, a main precursor of behavioral change. It has been shown that improving nutrition knowledge and cooking skills enhances self-efficacy towards cooking (Bisogni et al. 2005), which is specifically linked to compliance with nutritional recommendations among football players (Gacek 2015). However, to our knowledge, there is a lack of studies examining the effects of a nutrition intervention combining nutrition education and cooking workshops among college football players.

The primary objective of this study was to assess the impact of a nutrition intervention combining nutrition education and cooking workshops on nutrition knowledge, intention, and perceived behavioral control in the preparation of healthy meals, dietary intakes, and diet quality in male university football players. The secondary objective was to assess the impact of the intervention on other psychosocial determinants of performance such as sleep, stress, and well-being.

Methods

Participants

The current study was approved by the Université Laval Research Ethics Board (Approval No. 2018-069/10-05-2018). Participants included volunteer student-athletes at Université Laval who

were members of the Canadian University Football League. Athletes were first contacted on the field through an informative meeting and then via posters displayed in the gym and players' locker rooms. Those interested in the study were invited to an information session describing the study protocol, inclusion criteria, and consent form. The inclusion criteria were being a member of Université Laval's football team for the 2018 winter and summer sessions, having a comprehension of the French language, being available for all activities in the study, being aged between 18–25 years, having a body mass index (BMI) between 18.5 and 40 kg/m^2, having a relatively stable body weight (i.e., variation $\leq$ 4 kg in the two months preceding the study), being in overall good health, and not taking any medications that could affect study outcomes.

Protocol

After providing written informed consent, participants were randomized by the research coordinator to the intervention or control groups using Excel. The intervention group participated in three weekly two-hour sessions divided equally into nutrition education and cooking workshops while the control group did not have an intervention.

Before the beginning of the intervention, participants attended a first visit (pre; week 0) at Université Laval to complete questionnaires and measurements. The same evaluations were performed immediately after the intervention (post 1; week 4), and two months after the intervention (post 2; week 13). At each evaluation visit, participants completed questionnaires assessing their general and sport-specific nutrition knowledge, intention, and perceived behavioral control to prepare healthy meals as well as their sleep quality and duration, stress levels, and overall well-being. Anthropometric measures (i.e., height, weight, and waist circumference) were evaluated at each visit. At each visit, participants completed, on three random days over a period of 2–3 weeks (i.e., two during the week and 1 during the weekend without considering training), a validated, web-based, self-administered 24-h dietary recall assessing dietary intakes and diet quality (Fig. 1).

Intervention group

Participants in the intervention group attended three sessions (1 session per week) that included nutrition education and a cooking workshop over three weeks. The goal of the nutrition education portion was to learn the basic principles of sports nutrition. Through the nutrition knowledge and cooking skills taught, the cooking workshops aimed to improve the ability to prepare quick, balanced, and cost-effective meals. Educational materials and cooking workshops also aimed to influence the intention and perceived behavioral control towards the preparation of healthy meals by adressing

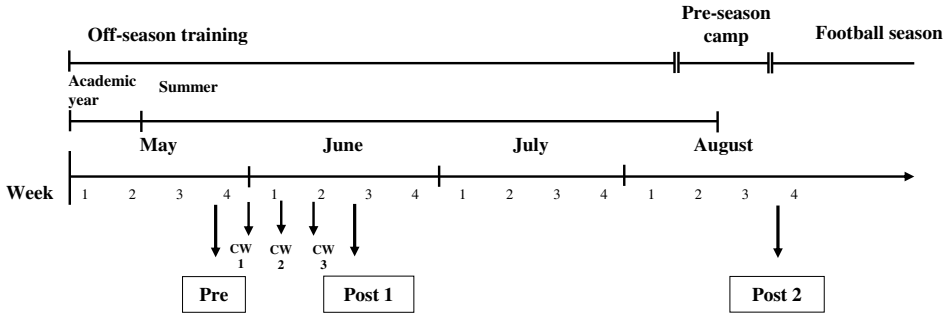

Fig. 1. Study timeline (anthropometric measures, questionnaires and 24-h dietary recalls were assessed at Pre, Post 1 and Post 2. Abbreviation: Cooking workshop (CW)).

common barriers to meal preparation such as time and cost. The cooking workshops integrated specific dietary targets relating to energy, macronutrients, and fluid intakes. The workshops presented their role, sources, and specific recommendations for football players with examples; recommendations before, during, and after physical activity (e.g., a football game); recommendations specific to hydration and discussion about the acute physiological effects of alcohol consumption; and low-cost meal planning tips. Recommendations for protein and carbohydrate consumption provided to the student-athletes were 1.6–1.8 g of protein per kilogram of body weight per day (Tarnopolsky et al. 1992; American College of Sports Medicine, American Dietetic Association and Dietitians of Canada 2000) and 6–8 g of carbohydrate per kilogram of body weight per day (Thomas et al. 2016; Abbey et al. 2017), respectively. These targets were more specific recommendations for sports such as American football. The three sessions were developed by undergraduate nutrition students under the direction of a registered dietitian and nutrition researcher (details of each session are provided in **Table 1**).

Table 1. Overview of each session of the nutrition intervention combining nutrition education and cooking workshops.

Session	Aim	Content of nutrition education and cooking workshops
1	To provide a better understanding and identification of the nutrient needs of football players.	Macronutrient roles Daily macronutrient requirements (6–8 g of carbohydrate/kg of body weight/day and 1.6–1.8 g of protein/kg of body weight/day) Main sources of different macronutrients Typical representation of the athlete's plate Preparation and cooking the following recipes: • Souvlaki pork skewers • Vegetable quinoa • Morning burrito with eggs • Greek pasta salad • Greek yogurt-based sauce • Marinade
2	To provide a better understanding of the role of carbohydrates and proteins during exercise and recovery.	Food and hydration before, during and after training Alcohol Recovery Preparing and cooking the following recipes: • Souvlaki pork skewers • Fruits smoothie • Beef stir-fry with orange and coconut rice • Homemade sports drink
3	To develop autonomy in the planning of a weekly diet.	Tips for grocery shopping and meal planning Basic ingredients for cooking Food preservation Preparing and cooking the following recipes: • Whole chicken • Chicken gratin • Coleslaw • Pokebol with marinated chicken • Chicken broth using chicken bones

Because of a lack of material resources and the size of the kitchen facility, the 13 participants randomized to the intervention group attended each session in two separate groups. Each session was led by a graduate student in kinesiology with training in sports nutrition and a dietetic technician for approximately two hours per session. Each session was conducted as follows: the first part was allocated to nutrition education using a presentation that explained the specific content of the nutrition intervention and provided recipe information such as macronutrient content, meal cost, and duration of recipe preparation. Then, players prepared the recipes and received advice on cutting and cooking techniques and alternatives to recipes.

At the end of the intervention period, participants were invited to redo the recipes at home using the different alternatives offered. To encourage this practice, participants in the intervention group received a cooking guide with all of the contents of the nutrition education and cooking workshops and all the recipes and various alternatives.

Control group

The control group received no intervention. They completed the same questionnaires and anthropometric measurements as the intervention group at the same time points. In addition to the cooking guide, the content of the three nutrition sessions was combined and presented to the control group at the end of the study, but no cooking was performed.

Measurements

Primary outcomes

Nutrition knowledge and intention and perceived behavioral control to prepare healthy meals

A questionnaire consisting of 18 questions was developed to assess nutrition knowledge related to sport nutrition recommendations for football players and their intention and perceived behavioral control towards healthy meal preparation. Of the 18 questions, 13 questions were on nutrition knowledge of which seven were in a true or false format (e.g., (1) The timing of food and drink consumption can influence performance, (2) It is recommended to restrict sodium intake following physical exertion resulting in heavy sweating, (3) The proteins contained in supplements are of better quality than those contained in animal products), while the remaining six were multiple choice questions (e.g., of the following protein sources, identify the complete protein source(s)) (Cronbach's $\alpha = 0.81$). Five questions measured determinants of the Theory of Planned Behavior (TPB): two questions measured intention (Cronbach's $\alpha = 0.93$) and three measured perceived behavioral control (Cronbach's $\alpha = 0.88$) toward preparing healthy meals, with all using a 6-point Likert scale (strongly disagree (−3) to strongly agree (3)). Questions measuring intention and perceived behavioral control were developed using the TPB guidelines (Fishbein and Ajzen 2010; Godin 2012). For example, the following item was used to measure intention: "For the next month, I am determined to cook meals and (or) snacks suited to my training at least twice a week" and the following item was used to measure perceived behavioral control: "If I wanted to, I could cook meals suited to my training in a short time at least twice a week."

Dietary intakes and diet quality

A web-based 24-h dietary recall (R24W) was used to assess dietary intakes over three days and diet quality at all times by automatically calculating energy intake, proportion of macronutrients, and the Canadian Healthy Eating Index 2007 (C-HEI) (Lafrenière et al. 2017). The C-HEI assesses overall diet quality, based on the 2007 Canada's Food Guide, which was implemented at the time of the study ("Eating Well with Canada's Food Guide; Health Canada: Ottawa, ON, Canada," 2007;

Garriguet 2009) and is divided into eight adequacy and three moderation components. All components are reported based on total energy intake and the contribution of between 0 and the maximum potential number of points (5, 10, or 20) for each component, calculated proportionally. Details of the scoring system are provided in Lafreniere et al. (2019). Scores were then summed and used as a measure of diet quality on a 100-point score. The R24W has been shown to be a valid tool to classify participants by level of adherence to the 2007 Canada's Food Guide (Lafreniere et al. 2019).

Secondary outcomes

Other psychosocial determinants of performance

Sleep quality and duration were evaluated using the Pittsburgh Sleep Quality Index questionnaire (Buysse et al. 1989). This questionnaire contains 18 items assessing seven different components of sleep quality (e.g., sleep quality, sleep duration (i.e., hours of sleep), sleep patterns). A lower score reflects better sleep quality. Stress level was examined using the validated French translation of the short version of "The Measure of Psychological Stress" questionnaire (Lemyre and Tessier 2003). This questionnaire contains nine statements allowing each participant to indicate the degree to which each statement has applied to them in the last four to five days on a scale ranging from 1 (not at all) to 8 (extremely). A score below 40 indicates that an individual feels little stress while a score of ≥ 60 represents a problematic stress state. Overall well-being was measured using the validated French translation of the short version of the "Profile of Mood States" (Fillion and Gagnon 1999). The 37 multiple choice questions, ranked on a 5-point Likert scale, ranging from 1 (not at all) to 5 (absolutely), assess mood states (depression, confusion, vigor, tension, anger, fatigue, or total mood disturbance) of the athletes based on their life in general during the previous weeks prior to the study. A higher score indicates a major mood disturbance. Yet, the score may also be negative since it is calculated by subtracting the vigor score from the total of the other states scores.

Anthropometric measurements and sociodemographic information

Body weight was measured with a portable bioimpedance weighing scale and recorded to the nearest 0.1 kg (TANITA, model TBF-310, Tanita Corporation of America, Inc., Arlington Heights, Illinois). Height was obtained using a portable stadiometer and recorded to the nearest 0.1 cm. Waist circumference (WC) was measured with a tape measure and recorded to the nearest 0.1 cm. Two WC measures were taken, and the average was determined thereafterBMI was calculated as the weight (kg) divided by height squared (m^2). Lastly, sociodemographic information such as age, years of football experience, degree and field of study, and whether or not they have participated in one or more nutrition courses in the past was collected with a five-item questionnaire.

Statistical analysis

Statistical analyses were performed using JMP 14.0 statistical software, (SAS Institute, Cary, NC, USA). Based on a previous sport nutrition intervention study from our research team, the objective was to recruit a total of 40 participants to detect significant differences in nutrition knowledge, energy and dietary intakes, diet quality and intention, and perceived behavioral control towards meal preparation (Jacob et al. 2016). Descriptive statistics including *t*-tests or χ^2 analyses were used to compare baseline characteristics between the intervention and control groups. Mixed linear model for repeated measures was performed to assess the effect of group, time, and their interaction on nutrition knowledge, energy and dietary intakes, diet quality, intention, and perceived behavioral control towards meal preparation, sleep duration and quality, stress, and overall well-being. When a group × time interaction was observed, the Tukey's post hoc test was used to identify differences. Data are presented as means ± standard deviations. Statistical significance was considered at $p < 0.05$.

Results

Baseline participant characteristics

In total, 32 football players accepted the invitation to participate in the study, but two players did not meet the inclusion criteria and five others did not have time to participate. While 25 players consented to the project, two participants dropped out due to lack of time, 13 were assigned to the intervention group and 10 to the control group. All the participants in the intervention group attended the three cooking workshops indicating 100% attendance. At the two-month follow-up period (August 2018), one player in the control group withdrew for personal reasons. There were no significant differences in baseline characteristics between the control and intervention groups (Table 2).

Changes in nutrition knowledge and intention and perceived behavioral control to prepare healthy meals

Nutrition knowledge significantly improved in the intervention group and was maintained throughout the intervention compared to the control group (group × time interaction, $p = 0.002$) (Table 3). Accordingly, nutrition knowledge in the intervention group was significantly higher at post 1 and post 2 compared with the control group ($p = 0.0002$ and $p = 0.003$, respectively). The intention and perceived behavioral control to prepare healthy meals in the intervention group did not differ after the intervention in either groups (Table 3).

Table 2. Baseline characteristics.

Variables	Control mean, $n = 10$	Intervention mean, $n = 13$	p
Age[a], y	22 (1)	22 (1)	0.86
Weight[a], kg	102.1 (23.1)	100.5 (24.1)	0.89
Height[a], cm	183.9 (6.1)	179.8 (7.0)	0.30
Body mass index[a], kg/m²	29.9 (5.3)	30.8 (5.6)	0.77
Waist circumference[a], cm	96.9 (15.9)	96.4 (16.1)	0.92
Football experience[a], y	11 (3)	11 (2)	0.67
Field of study[b,c]	—	—	0.56
Social sciences	80 (8)	62 (8)	—
Health sciences	0 (0)	15 (2)	—
Engineering	20 (2)	23 (3)	—
Undergraduate education, year of study[b]	—	—	0.30
Year 1	50 (5)	15 (2)	—
Year 2	20 (2)	54 (7)	—
Year 3	20 (2)	8 (1)	—
Year 4	10 (1)	23 (3)	—
Previous participation in a nutrition course[b]	0 (0)	15 (2)	0.17

[a]Values are means (±SD).
[b]Values are means % (n).
[c]The fields of study have been classified into three categories. Social sciences include education, administration, sports studies, design, consumer science, product development and marketing. Health sciences include pharmacy and kinesiology. Engineering includes civil engineering and geomatics.

Table 3. A comparison of a nutrition intervention to a control group on nutrition knowledge, intention, and perceived behavioral control towards healthy eating habits and psychosocial determinants of performance in male university football players.

	Control mean (SD), $n = 10$			Intervention mean (SD), $n = 10$			p		
Questionnaires (score range)	Pre	Post 1	Post 2	Pre	Post 1	Post 2	Group	Time	Interaction
Nutritional data									
Nutrition knowledge (0 to 13)	8.3 (1.7)	7.5 (1.7)	7.8 (2.4)	8.9 (1.6)	10.8 (1.1)[a,b]	10.5 (1.2)[c,d]	0.0004	0.29	0.002
Intention towards healthy eating habits (−3 to 3)	2.4 (0.9)	2.2 (1.3)	2.1 (1.3)	2.4 (0.9)	2.5 (0.8)	2.4 (1.4)	0.45	0.69	0.70
Perceived behavioral control towards healthy eating habits (−3 to 3)	2.1 (0.9)	1.9 (1.5)	2.4 (0.7)	2.1 (1.6)	2.4 (0.8)	2.1 (1.4)	0.72	0.97	0.60
Pittsburgh Sleep Quality Index									
Sleep duration (h)	8.4 (1.1)	8.2 (1.0)	8.6 (0.8)	7.9 (0.6)	8.8 (1.0)[e]	8.9 (0.8)[f]	0.64	0.04	0.05
Sleep quality (0 to 21)	4.4 (2.7)	4.4 (1.6)	4.6 (2.4)	4.9 (2.0)	4.0 (2.4)	4.7 (2.3)	0.94	0.73	0.77
Measure of psychological stress									
Stress (9 to 72)	27.2 (9.3)	25.6 (10.9)	30.6 (10.8)	27.3 (15.0)	23.2 (9.8)	23.4 (9.7)	0.48	0.23	0.16
Profile of Mood State/well-being									
Depression (0 to 32)	2.5 (1.8)	2.8 (4.6)	4.1 (6.9)	1.8 (2.3)	1.8 (5.5)	1.8 (4.4)	0.45	0.61	0.65
Confusion (0 to 20)	3.4 (3.8)	3.6 (4.1)	3.2 (4.1)	3.1 (3.0)	2.1 (3.2)	1.4 (2.0)	0.37	0.13	0.28
Vigor (0 to 24)	15.6 (4.1)	13.1 (4.6)	12.4 (4.9)[g]	15.8 (3.3)	15.6 (5.2)	14.7 (3.5)	0.33	0.01	0.16
Tension (0 to 24)	4.3 (3.1)	4.5 (4.0)	4.8 (5.1)	5.0 (4.0)	4.2 (4.8)	3.4 (4.5)	0.85	0.69	0.33
Anger (0 to 28)	4.3 (3.1)	5.1 (6.1)	5.4 (7.0)	5.2 (6.1)	3.9 (3.7)	2.5 (4.7)	0.57	0.74	0.24
Fatigue (0 to 20)	6.9 (3.8)	6.2 (5.6)	5.7 (5.4)	5.5 (3.6)	4.5 (5.2)	4.8 (4.5)	0.49	0.27	0.77
Total mood disturbance (-24 to 124)	5.8 (11.5)	9.1 (21.8)	10.8 (26.2)	4.9 (16.6)	0.9 (23.5)	−0.9 (19.8)	0.39	0.98	0.27

Note: Pre, week 0 of intervention; Post 1, week 4 of intervention; Post 2, week 13 of intervention.
[a]Significant difference between the intervention group and the control group at post 1 ($p = 0.0002$).
[b]Significant difference in the group at pre and post 1 ($p = 0.005$).
[c]Significant difference between the intervention group and the control group at post 2 ($p = 0.003$).
[d]Significant difference in the group at pre and post 2 ($p = 0.03$).
[e]Significant difference in the group at pre and post 1 ($p = 0.03$).
[f]Significant difference in the group at pre and post 2 ($p = 0.02$).
[g]Significant difference in the group at pre and post 2 ($p = 0.04$).

Changes in dietary intakes and diet quality

Although there was no group × time interaction, there was a significant main effect of time for total energy intake ($p = 0.04$), percent of energy intake from protein ($p = 0.04$), grams and percent of energy intake from alcohol ($p = 0.01$ and $p = 0.0006$, respectively), grams of water ($p = 0.01$), grams of total sugar ($p = 0.01$), and grams of fiber ($p = 0.01$) (Table 4). There were no significant differences in the C-HEI scores between the intervention and control groups over time ($p = 0.63$) (Table 4). Overall, only few players consumed between 1.6 and 1.8 g of protein per kilogram of body weight per day (control: 10% pre vs. 11% post 1 vs. 33% post 2 and intervention: 31% pre vs. 15% post 1 vs. 8% post 2, respectively) just as they did not meet the recommendations specific to carbohydrate (i.e., 6 to 8 g/kg of body weight/day) (control: 0% pre vs. 0% post 1 vs. 0% post 2 and intervention: 8% pre vs. 8% post 1 vs. 0% post 2, respectively).

Table 4. A comparison of a nutrition intervention to a control group on dietary intakes and diet quality in male university football players.

	Control, mean (SD), $n = 10$			Intervention, mean (SD), $n = 13$			p		
Dietary variables (score range)	Pre	Post 1[a]	Post 2[b]	Pre	Post 1[c]	Post 2[c]	Group	Time	Interaction
Energy, kcal	3215 (826)	3473 (821)	3035 (629)	3500 (1093)	3114 (887)	2796 (745)	0.80	0.04	0.21
Carbohydrate, g/kg	3.3 (0.6)	3.6 (0.9)	3.3 (1.1)	3.6 (1.4)	3.2 (1.5)	2.8 (1.2)	0.59	0.09	0.11
Carbohydrate, % energy	42.5 (5.7)	43.7 (9.1)	42.2 (5.3)	40.4 (6.3)	39.2 (6.0)	36.8 (4.6)	0.02	0.49	0.63
Fat, % energy	37.0 (5.1)	35.2 (6.1)	37.9 (4.1)	38.9 (5.8)	37.5 (4.8)	39.7 (5.2)	0.16	0.30	0.99
Protein, g/kg	1.7 (0.5)	1.6 (0.8)	1.5 (0.3)	1.9 (0.8)	1.6 (0.7)	1.6 (0.5)	0.61	0.21	0.45
Protein, % energy	20.7 (4.0)	18.7 (4.9)	20.2 (2.3)	21.3 (3.2)	19.7 (3.3)	22.9 (3.2)	0.20	0.04	0.44
Alcohol, g	2.7 (6.6)	14.7 (19.9)	0 (0)	0.9 (3.2)	18.2 (25.8)	2.2 (3.6)	0.72	0.01	0.81
Alcohol, % energy	0.4 (1.0)	3.0 (4.0)	0 (0)	0.2 (0.8)	4.2 (5.5)	0.7 (1.2)	0.48	0.0006	0.72
Water, g	2937 (1174)	2701 (1133)	2036 (760)	3004 (1387)	2694 (1465)	2262 (1099)	0.78	0.01	0.93
Cholesterol, mg	557.7(228.9)	574.9 (278.9)	520.2 (283.9)	741.0 (323.8)	600.9 (246.5)	724.0 (326.9)	0.14	0.62	0.50
Trans fat, g	1.9 (1.2)	2.3 (1.1)	1.7 (1.2)	2.2 (1.2)	2.1 (1.1)	2.0 (1.1)	0.64	0.60	0.67
Total sugar, g	124.7 (52.9)	132.8 (60.7)	97.9 (47.5)	114.2 (49.5)	104.1 (43.8)	79.2 (44.6)	0.28	0.01	0.74
Fiber, g	27.5 (11.0)	26.5 (12.9)	24.9 (11.5)	34.5 (18.9)	24.9 (13.2)	22.3 (11.6)	0.82	0.01	0.09
C-HEI score (0-100)	56.0 (10.4)	50.7 (14.7)	58.5 (10.4)	65.0 (16.7)	59.6 (13.5)	62.1 (12.9)	0.11	0.19	0.63

Note: Pre, week 0 of intervention; Post 1, week 4 of intervention; Post 2, week 13 of intervention; C-HEI: Canadian Healthy Eating Index.
[a]7missing dietary recalls.
[b]4 missing dietary recalls.
[c]1 missing dietary recalls.

Changes in psychosocial determinants of performance

There were no significant differences in sleep quality, whereas sleep duration was significantly higher in the intervention compared to the control group following the intervention (group × time effect, $p = 0.05$) (Table 3). However, post hoc tests revealed no differences at post 1 and post 2 in the intervention compared to control group ($p = 0.61$ and $p = 0.98$, respectively). No significant differences in stress levels and total mood disturbances were observed between groups over time ($p = 0.16$ and $p = 0.27$, respectively) (Table 3).

Discussion

The results of the current study demonstrate that a nutrition intervention combining nutrition education and cooking workshops positively influences nutrition knowledge in football players, but had no short-term impact on dietary intakes, diet quality, and other psychosocial determinants.

The nutrition knowledge of players in the nutrition intervention increased by more than 10% and was significantly higher in the intervention compared to the control group immediately after the study and two months after the intervention. This improvement in nutrition knowledge is similar to that observed in previous studies with nutrition education intervention without cooking workshops (Abood et al. 2004; Heikkilä et al. 2019). A study using three educational sessions dispersed over four weeks conducted with college-level endurance athletes revealed a significant increase in nutrition knowledge of approximately 6% on a 79-item questionnaire (Heikkilä et al. 2019). A similar study in female soccer players and swimmers also found a significant increase in nutrition knowledge of

approximately 6% on a 42-item questionnaire (Abood et al. 2004). Thus, the incorporation of cooking workshops into an intervention that includes an educational component results in similar improvements in nutrition knowledge than nutrition education alone.

The combination of nutrition education and cooking workshops in the current intervention had the potential to increase intention (Savoie et al. 2015) and perceived behavioral control to prepare healthy meals (Bisogni et al. 2005); however, changes in these determinants were not observed. Contrary to what has been previously observed in other studies, the intention (Burke et al. 1991) and perceived behavioral control (Gacek 2015) of football players towards healthy eating habits were initially high in the current study suggesting possible recruitment bias. Since intention and perceived behavioral control are two predictors of a behavior (Azjen 1991), the lack of change following the intervention may explain the lack of change in the dietary intakes of football players. Although the use of a behavior change theory is recommended to foster changes in intention and eating habit changes in the normal population (Murimi et al. 2017) and athletes (Bentley et al. 2020), some studies have shown that changes in intention are not always associated with changes in behavior (McDermott et al. 2016). Moreover, even though changes in perceived behavioral control and intention with respect to preparation of healthy meals were not observed, it is possible that athletes increased their frequency of preparation of healthy meals. However, it was not possible to objectively document this effect in the present study since this behavior was not assessed in participants. In addition, the questions that measured intention and perceived behavioral control were aimed at general behaviors such as meal and snack preparation. More specific questions (e.g., cooking meals rich in protein) may have allowed observation of the behaviors of players directly related to the knowledge transmitted.

Combining nutritional education and cooking workshops in our study did not translate into changes in dietary intakes nor changes in the overall diet quality of football players. Even if the average protein intakes of the players in the control and intervention groups seemed compatible with recommendations provided in the workshops (i.e., 1.6–1.8 g/kg of body weight/day), very few participants meet the recommendations. As for carbohydrate consumption, even fewer participants met the recommendations. That said, these are the recommendations included in the cooking workshops that have been presented as suggestions and not as absolute guidelines. If the protein and carbohydrate consumption of the football players in the study are compared with recent recommendations (i.e., 1.4–2.0 g of protein per kilogram of body weight per day (Jäger et al. 2017) and 6–10 g of carbohydrate per kilogram of body weight per day (Thomas et al. 2016)), more players met those related to protein consumption (control: 40% pre vs. 22% post 1 vs. 56% post 2 and intervention: 46% pre vs. 23% post 1 vs. 46% post 2, respectively). However, there is no change for that related to carbohydrate consumption (control: 0% pre vs. 0% post 1 vs. 0% post 2 and intervention: 11% pre vs. 11% post 1 vs. 0% post 2, respectively). The consumption of proteins and carbohydrates remains problematic for most athletes. Considering that an increase in nutrition knowledge was observed, these results were surprising as general and sport-specific nutrition knowledge influences food choice and dietary intake of athletes (Birkenhead and Slater 2015). In addition to nutrition knowledge, intention, and perceived behavioral control, other individual determinants such as beliefs and attitudes as well as environmental determinants can influence food choices (Birkenhead and Slater 2015). Unfortunately, this study did not measure these other determinants. It is difficult to compare the current intervention with others since very few nutrition interventions for athletes have included a combination of nutrition education and cooking workshops. Curtis et al. (2012) compared the efficacy of three dietary intervention strategies differing in the amount of education and cooking skill provision and the use of a personalized goal setting framework with families. This study demonstrated the success of a nutrition intervention combining nutrition education and cooking workshops on short-term dietary intakes, but also highlights the importance of setting individual and personalized objectives during learning. Moreover, these results are consistent with Trakman et al. (2019) who reported that a group of athletes, comprised

of primarily football players, prefer to learn with individual advice rather than cooking workshops. Although our nutrition education intervention was designed specifically for football players, there were no individual or personalized objectives. Given the results of the studies cited above, the absence of individual and personalized objectives in the present study could have influenced changes in eating habits. In addition to the personalization of interventions, Murimi et al. (2017) stated that the duration of the intervention and the frequency of exposure are other important factors for the success of a nutrition education intervention. While Rossi et al. (2017) observed beneficial effects of the intervention on dietary intakes using nonconsecutive sessions, we believe that dispersing the intervention may perhaps allow more time for the participant to attempt the recipes and become more familiar with the content previously observed. Thus, it is possible that the temporal proximity of the cooking workshops in the current interventions has influenced its effectiveness. The time of the year chosen for the intervention may also be another important factor explaining the lack of differences. For example, the intervention of Rossi et al. (2017) was in an off-season period without training while the football players in the present study were in the off-season with important training. As a result, athletes had more time to plan and prepare meals. Therefore, setting individual and personalized objectives and planning the timing, duration, and frequency of exposure of the intervention may be important factors to consider in further studies.

The intervention had no significant effect on the psychosocial determinants of performance measured in this study. The analyses showed a significant interaction for sleep duration, but the multiple comparison tests did not reveal any significant intra or intergroup differences. A question regarding the athletes' schedules was not included; however, the student-athlete lifestyle often requires managing work, school, and sport, which may have affected the number of hours of sleep. Furthermore, the nutrition intervention did not have any significant effects on stress and overall well-being.

One of the main strengths of this study is the combined nutrition education and cooking workshops to help football athletes to prepare healthy meals for themselves. In addition, the intervention touched on themes specifically aimed at football student-athletes. However, this study also has some limitations. First, the nutrition knowledge questionnaire was developed by the research team to assess knowledge related to the content of the football-specific cooking workshops. Thus, the questionnaire was not validated; however, the internal consistency (Cronbach's alpha) of the nutrition knowledge questions demonstrate that it measures the same concept. It is also difficult to obtain direct measures of cooking skills and thus, we used indirect assessments using intention and perceived behavioral control. Unfortunately, this study did not assess the frequency of meal preparation in athletes. This prevents determination of whether intention, perceived behavioral control, and cooking skills are linked among the university football players who participated in the study. Self-reported questionnaires were used in the present study increasing the risk of social desirability bias. To decrease this bias, each athlete was informed, during each test period, that the questionnaires were not a test and that no response was considered better than another. Finally, it is important to note that the lack of effect of the intervention on dietary intakes and psychosocial determinants of performance in this study may be due to the small sample size and should be considered in future studies.

In conclusion, a nutrition intervention consisting of a combination of nutrition education and cooking workshops improves nutrition knowledge, but did not impact short-term dietary intakes, diet quality, or psychosocial determinants of performance in male university football athletes. Future studies are needed to examine the longer-term effects of such an intervention on meal preparation and cooking skills to determine if an improvement in nutrition knowledge eventually translates into improved and sustainable eating habits.

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Author contributions

DL and VD conceived and designed the study. DL performed the experiments/collected the data. DL, SP, RJ, and VD analyzed and interpreted the data. DL, SP, RJ, and VD drafted or revised the manuscript.

Competing interests

The authors report no conflicts of interest.

Data availability statement

All relevant data are within the paper.

References

Abbey EL, Wright CJ, and Kirkpatrick CM. 2017. Nutrition practices and knowledge among NCAA Division III football players. Journal of the International Society of Sports Nutrition, 14: 13. DOI: 10.1186/s12970-017-0170-2

Abood DA, Black DR, and Birnbaum RD. 2004. Nutrition education intervention for college athletes. Journal of Nutrition Education and Behavior, 36(3): 135–137. PMID: 15202989 DOI: 10.1016/S1499-4046(06)60150-4

American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada. 2000. Joint Position Statement: Nutrition and athletic performance. American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada. Medicine and Science in Sports and Exercise, 32(12): 2130–2145. DOI: 10.1097/00005768-200012000-00025

Azjen I. 1991. The theory of planned behaviour. Organizational Behavior and Human Decision Processes, 50(2): 179–211. DOI: 10.1016/0749-5978(91)90020-T

Battaglia C, D'Artibale E, Fiorilli G, Piazza M, Tsopani D, Giombini A, et al. 2014. Use of video observation and motor imagery on jumping performance in national rhythmic gymnastics athletes. Human Movement Science, 38: 225–234. DOI: 10.1016/j.humov.2014.10.001

Bentley MRN, Mitchell N, and Backhouse SH. 2020. Sports nutrition interventions: A systematic review of behavioural strategies used to promote dietary behaviour change in athletes. Appetite, 150: 104645. PMID: 32112958 DOI: 10.1016/j.appet.2020.104645

Bernardoa GL, Jomoria MM, Fernandesa AC, Colussib CF, Condraskyc MD, and Proençaa RPDC. 2018. Positive impact of a cooking skills intervention among Brazilian university students: Six months follow-up of a randomized controlled trial. Appetite, 130: 247–255. DOI: 10.1016/j.appet.2018.08.014

Birkenhead KL, and Slater G. 2015. A review of factors influencing athletes' food choices. Sports Medicine, 45(11): 1511–1522. PMID: 26243016 DOI: 10.1007/s40279-015-0372-1

Bisogni CA, Jastran M, Shen L, and Devine CM. 2005. A biographical study of food choice capacity: Standards, circumstances, and food management skills. Journal of Nutrition Education and Behavior, 37(6): 284–291. PMID: 16242059 DOI: 10.1016/S1499-4046(06)60158-9

Burke LM, Gollan RA, and Read RSD. 1991. Dietary intakes and food use of groups of elite australian male athletes. International Journal of Sport Nutrition, 1(4): 378–394. DOI: 10.1123/ijsn.1.4.378

Buysse DJ, Ill CFR, Monk TH, Berman SR, and Kupfer DJ. 1989. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. Psychiatry Research, 28(2): 193–213. PMID: 2748771 DOI: 10.1016/0165-1781(89)90047-4

Conner TS, Brookie KL, Richardson AC, and Polak MA. 2015. On carrots and curiosity: eating fruit and vegetables is associated with greater flourishing in daily life. British Journal of Health Psychology, 20(2): 413–427. PMID: 25080035 DOI: 10.1111/bjhp.12113

Curtis PJ, Adamson AJ, and Mathers JC. 2012. Effects on nutrient intake of a family-based intervention to promote increased consumption of low-fat starchy foods through education, cooking skills and personalised goal setting: the Family Food and Health Project. British Journal of Nutrition, 107(12): 1833–1844. DOI: 10.1017/S0007114511005101

Devlin BL, Leveritt MD, Kingsley M, and Belski R. 2017. Dietary intake, body composition, and nutrition knowledge of australian football and soccer players: Implications for sports nutrition professionals in practice. International Journal of Sport Nutrition and Exercise Metabolism, 27(2): 130–138. PMID: 27710165 DOI: 10.1123/ijsnem.2016-0191

Doherty RNN, Madigan S, Warrington G, and Ellis J. 2019. Sleep and Nutrition Interactions: Implications for Athletes. Nutrients, 11(4): 822. DOI: 10.3390/nu11040822

Eating Well with Canada's Food Guide; Health Canada: Ottawa, ON, Canada. 2007.

Fillion L, and Gagnon P. 1999. French adaptation of the shortened version of the profile of mood states. Psychological Reports, 84(1): 188–190. PMID: 10203949 DOI: 10.2466/pr0.1999.84.1.188

Fishbein M, and Ajzen I. 2010. Predicting and changing behavior : the reasoned action approach. New York, NY: Psychology Press.

Fullagar HHK, McCunn R, and Murray A. 2017. Updated review of the applied physiology of american college football: Physical demands, strength and conditioning, nutrition, and injury characteristics of america's favorite game. Journal of Sports Physiology and Performance, 12(10): 1396–1403. [online]: Available from ncbi.nlm.nih.gov/pubmed/28338375. DOI: 10.1123/ijspp.2016-0783

Gacek M. 2015. Association between self-efficacy and dietary behaviours of American football players in the Polish clubs in the light of dietary recommandations for athletes. Roczniki Panstwowego Zakladu Higieny, 66(4): 361–366. PMID: 26656418

Garriguet D. 2009. Diet quality in Canada. Health Reports, 20(3): 41–52. PMID: 19813438

Godin G. 2012. Les comportements dans le domaine de la santé. Comprendre pour mieux agir. Montréal, QC: Les Presses de l'Université de Montréal.

Heaney S, O'Connor H, Naughton G, and Gifford J. 2008. Towards an understanding of the barriers to good nutrition for elite athletes. International Journal of Sports Science and Coaching, 3(3): 391–401. DOI: 10.1260/174795408786238542

Heikkilä M, Lehtovirta M, Autio O, Fogelholm M, and Valve R. 2019. The impact of nutrition education intervention with and without a mobile phone application on nutrition knowledge among young endurance athletes. Nutrients, 11(9): 2249. DOI: 10.3390/nu11092249

Jacob R, Lamarche B, Provencher V, Laramee C, Valois P, Goulet C, and Drapeau V. 2016. Evaluation of a theory-based intervention aimed at improving coaches' recommendations on sports nutrition to their athletes. Journal of the Academy of Nutrition and Dietetics, 116(8): 1308–1315. DOI: 10.1016/j.jand.2016.04.005 PMID: 27234619

Jäger R, Kerksick CM, Campbell BI, Cribb PJ, Wells SD, Skwiat TM, et al. 2017. International Society of Sports Nutrition Position Stand: Protein and exercise. Journal of the International Society of Sports Nutrition, 14: 20. DOI: 10.1186/s12970-017-0177-8

Jonnalagadda SS, Rosenbloom CA, and Skinner R. 2001. Dietary practices, attitudes, and physiological status of collegiate freshman football players. Journal of Strength and Conditioning Research, 15(4): 507–513. PMID: 11726265

Khan S, and Khan RA. 2016. Healthy diet a tool to reduce anxiety and depression. Journal of Depression and Anxiety, 5: 220, 3 p. DOI: 10.4200/2167-1044.1000220

Lafrenière J, Lamarche B, Laramée C, Robitaille J, and Lemieux S. 2017. Validation of a newly automated web-based 24-hour dietary recall using fully controlled feeding studies. BMC Nutrition, 3(34): 10 p. DOI: 10.1186/s40795-017-0153-3

Lafreniere J, Laramee C, Robitaille J, Lamarche B, and Lemieux S. 2019. Relative validity of a web-based, self-administered, 24-h dietary recall to evaluate adherence to Canadian dietary guidelines. Nutrition, 57: 252–256. PMID: 30195246 DOI: 10.1016/j.nut.2018.04.016

Lemyre L, and Tessier R. 2003. La mesure de stress psychologique en recherche de première ligne. Le Médecin de famille canadien, 49: 1166–1169.

Levy J, and Auld G. 2004. Cooking classes outperform cooking demonstrations for college sophomores. Journal of Nutrition Education and Behavior, 36(4): 197–203. PMID: 15544728 DOI: 10.1016/S1499-4046(06)60234-0

Lohman R, Carr A, and Condo D. 2019. Nutritional intake in australian football players: Sports nutrition knowledge and macronutrient and micronutrient intake. International Journal of Sport Nutrition and Exercise Metabolism, 29(3): 289–296. PMID: 30028228 DOI: 10.1123/ijsnem.2018-0031

McDermott MAIS, Oliver M, Iverson D, and Sharma R. 2016. Effective techniques for changing physical activity and healthy eating intentions and behaviour: A systematic review and meta-analysis. British Journal of Health Psychology, 21(4): 827–841. PMID: 27193530 DOI: 10.1111/bjhp.12199

Murimi MW, Kanyi M, Mupfudze T, Amin R, Mbogori T, and Aldubayan K. 2017. Factors influencing efficacy of nutrition education interventions: A systematic review. Journal of Nutrition Education and Behavior, 49(2): 142–165. DOI: 10.1016/j.jneb.2016.09.003

Rossi FCE, Landreth A, Beam S, Jones T, Norton L, and Cholewa JM. 2017. The effects of a sports nutrition education intervention on nutritional status, sport nutrition knowledge, body composition, and performance during off season training in NCAA division I baseball players. Journal of Sports Science and Medicine, 16: 60–68. PMID: 28344452

Sánchez-Díaz S, Yanci J, Castillo D, Scanlan AT, and Raya-González J. 2020. Effects of Nutrition education interventions in team sport players. A systematic review. Nutrients, 12(12): 3664. DOI: 10.3390/nu12123664

Savoie MR, Mispireta M, Rankin LL, Neill K, LeBlanc H, and Christofferson D. 2015. Intention to change nutrition-related behaviors in adult participants of a supplemental nutrition assistance program-education. Journal of Nutrition Education and Behavior, 47(1): 81–85. PMID: 25270972 DOI: 10.1016/j.jneb.2014.08.009

Schuster J, Howells D, Robineau J, Couderc A, Natera A, Lumley N, et al. 2018. Physical-preparation recommendations for elite rugby sevens performance. The International Journal of Sports Physiology and Performance, 13(3): 255–267. PMID: 28771098 DOI: 10.1123/ijspp.2016-0728

Tam R, Beck KL, Manore MM, Gifford J, Flood VM, and O'Connor H. 2019. Effectiveness of education interventions designed to improve nutrition knowledge in athletes: A systematic review. Sports Medicine, 49(11): 1769–1786. PMID: 31372860 DOI: 10.1007/s40279-019-01157-y

Tarnopolsky MA, Atkinson SA, MacDougall JD, Chesley A, Phillips S, and Schwarcz HP. 1992. Evaluation of protein requirements for trained strength athletes. Journal of Applied Physiology, 73(5): 1986–1995. PMID: 1474076 DOI: 10.1152/jappl.1992.73.5.1986

Thomas TD, Erdman KA, and Burke LM. 2016. Position of the academy of nutrition and dietetics, dietitians of Canada, and the American college of sports medicine: nutrition and athletic performance. Journal of the Academy of Nutrition and Dietetics, 116(3): 501–528. PMID: 26920240 DOI: 10.1016/j.jand.2015.12.006

Trakman GL, Forsyth A, Hoye R, and Belski R. 2019. Australian team sports athletes prefer dietitians, the internet and nutritionists for sports nutrition information. Nutrition & Dietetics, 76(4): 428–437. DOI: 10.1111/1747-0080.12569