Enhancing sports nutrition knowledge among undergraduate student-athletes through educational interventions

Mejorando el conocimiento en nutrición deportiva entre estudiantes-atletas universitarios mediante intervenciones educativas

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Abstract

Introduction: Sports nutrition plays a critical role in enhancing athletic performance and maintaining athlete health. Despite its importance, many university student-athletes demonstrate limited knowledge in this area. Recent advances in educational technology offer innovative methods to deliver nutrition education effectively.Objective: This study aimed to evaluate the effectiveness of educational interventions specifically mobile applications on improving sports nutrition knowledge among university student-athletes.
Methodology:
A quasi-experimental study was conducted involving 100 university student-athletes divided into two groups: an experimental group that used the MyFitnessPal mobile application and a control group that received traditional lecture-based instruction. Pre- and post-intervention questionnaires were used to assess knowledge gains. Statistical analyses were performed to compare changes between groups.
Results: The experimental group demonstrated significantly greater improvements in sports nutrition knowledge compared to the control group ($P < 0.05$). The findings indicate that mobile-based learning tools were more effective than conventional teaching methods.
Discussion: These results support the integration of digital tools such as MyFitnessPal into sports nutrition education for student-athletes. The interactivity and accessibility of mobile applications likely contributed to better engagement and retention of information.
Conclusions: Educational mobile applications can serve as effective tools for enhancing sports nutrition knowledge among university athletes. Integrating such technologies into athlete development programs may positively influence performance and long-term health outcomes.

Keywords

Smartphone applications, sports nutrition knowledge, eating habits, undergraduate student, educational interventions.

Resumen

Introducción: La nutrición deportiva es esencial para mejorar el rendimiento y la salud de los atletas, pero muchos estudiantes-atletas universitarios carecen de conocimientos suficientes. Las tecnologías educativas modernas ofrecen métodos innovadores y eficaces para la enseñanza de la nutrición. Objetivo: Este estudio tuvo como objetivo evaluar la efectividad de las intervenciones educativas, específicamente mediante aplicaciones móviles, en la mejora del conocimiento sobre nutrición deportiva entre estudiantes-atletas universitarios.
Metodología: Se realizó un estudio cuasi-experimental con la participación de 100 estudiantes-atletas universitarios, divididos en dos grupos: un grupo experimental que utilizó la aplicación móvil MyFitnessPal y un grupo de control que recibió instrucción tradicional mediante clases magistrales. Se utilizaron cuestionarios antes y después de la intervención para evaluar el aumento del conocimiento. Se realizaron análisis estadísticos para comparar los cambios entre los grupos. Resultados: El grupo experimental mostró mejoras significativamente mayores en los conocimientos sobre nutrición deportiva en comparación con el grupo de control ($P < 0.05$). Los resultados indican que las herramientas de aprendizaje móviles fueron más eficaces que los métodos de enseñanza convencionales.
Discusión: Estos hallazgos respaldan la integración de herramientas digitales como MyFitnessPal en la educación nutricional para estudiantes-atletas. La interactividad y accesibilidad de las aplicaciones móviles probablemente contribuyeron a una mejor participación y retención de la información.
Conclusiones: Las aplicaciones móviles educativas pueden ser herramientas eficaces para mejorar el conocimiento en nutrición deportiva entre los atletas universitarios. Integrar estas tecnologías en los programas de desarrollo de atletas podría influir positivamente en su rendimiento y salud a largo plazo.

Palabras clave

Aplicaciones móviles, conocimiento sobre nutrición deportiva, hábitos alimentarios, estudiante de pregrado, intervenciones educativas.

Introduction

Athletes' energy and nutritional requirements increase due to the physical demands associated with training and competition(Burke et al., 2019) . Although nutrition is not the sole factor influencing athletic performance, improving dietary practices contributes to better nutritional status, enhanced performance, faster recovery, and improved overall health (Burke et al., 2019). However, evidence indicates a widespread deficiency in energy, carbohydrate, protein, and micronutrient intake among athletes (Abbey et al., 2017; Steffl et al., 2019), in addition to exceeding recommended saturated fat intake(Hinton et al., 2004) and the prevalence of inadequate hydration practices (McCrink et al., 2021).Dietary behaviors are influenced by several factors, including the physiological demands of exercise, post-exercise appetite suppression, the food environment, individual preferences, time constraints, and the cost and availability of food (Birkenhead & Slater, 2015a). Nutritional knowledge is considered a modifiable factor that can positively impact dietary behavior (Fahrenholtz et al., 2023; Patton-Lopez et al., 2018). This knowledge varies depending on the athlete's educational background, prior nutrition education, access to nutritional support, and sources of dietary information (Trakman et al., 2018).Poor nutrition knowledge is a significant barrier that can negatively impact athletes' performance (A. Amawi et al., 2023; A. T. Amawi et al., 2023).Therefore, sports organizations worldwide emphasize the importance of continuous nutrition education for young athletes, coaches, and parents (Athlete, 2018; Meyer et al., 2007). Proper nutrition is essential for maximizing athletic potential and enhancing performance (Alkasasbeh & Amawi, 2023).. However, several factors hinder athletes from consistently applying optimal nutrition practices, including limited time, inadequate meal preparation facilities, financial constraints, poor meal planning skills, and travel demands (MALINAUSKAS et al., 2007).

Nutrition education plays a critical role in promoting healthier eating behaviors by equipping individuals with the necessary knowledge and skills to make informed food choices. According to several studies, educational interventions have led to measurable improvements in dietary practices and nutrition awareness across diverse populations(W. AlKasasbeh et al., 2024; W. AlKasasbeh & Akroush, 2024; Alkasasbeh, Alawamleh, & Alrahahleh, 2024; Alkasasbeh, Shlool, et al., 2024; Provenza Paschoal & Silverio Amancio, 2004; Jamous et al., 2024) . Moreover, nutrition education enhances confidence in making sound nutritional decisions, leading to meaningful changes in attitudes and behaviors (Jagim et al., 2021) Despite this, many athletes underestimate their nutritional needs and do not strictly follow basic nutrition practices that support optimal performance (Condo et al., 2019; Posthumus et al., 2021; Orhan, 2021).There is a broad consensus on the positive relationship between nutrition knowledge (NK) and healthier dietary choices, such as increased fruit and vegetable intake (Orhan et al., 2024 ;A. Amawi et al., n.d.;Alaunyte et al., 2015a; DicksonSpillmann & Siegrist, 2011) and reduced fat consumption (Wardle et al., 2000). NK among athletes has been assessed through questionnaires measuring general nutrition knowledge (Alaunyte et al., 2015a; Spendlove et al., 2012) and athlete-specific nutrition knowledge (Jessri et al., 2010a; Zinn et al., 2005). However, studies comparing athletes with non-athletes often show mixed results, with some finding athletes' NK scores lower or similar to those of non-athletes (Devlin et al., 2017; Spendlove et al., 2012). These inconsistencies may stem from differences in measurement tools (Heaney et al., 2011).

Attendance at nutrition courses has been positively associated with improved NK (Dunn et al., 2007; Jessri et al., 2010b) Nevertheless, athletes often have limited knowledge of specific topics such as micronutrients and supplementation (Trakman et al., 2016). Higher NK scores correlate with increased carbohydrate intake (Devlin et al., 2017; Burke et al., 2001) and greater muscle mass in elite athletes (Devlin et al., 2017). A systematic review found no significant differences in NK based on gender or sport type (Burke et al., 2001).

Many factors influence food choices and dietary behavior, including cultural background, appetite, attitudes toward nutrition, and nutrition knowledge level (Devine, 2005; Furst et al., 1996) ; Birkenhead & Slater, 2015) . Additionally, body composition and aesthetic considerations can affect athletes' eating behaviors (Byrne & McLean, 2002; Sundgot-Borgen & Torstveit, 2004) . However, the impact of dietary behavior on athletic performance is under-researched due to challenges in accurately measuring food intake and the need for validated questionnaires in large samples (Heaney et al., 2011; Trakman et al., 2016). Beyond formal education, athletes frequently rely on sources such as media, parents, friends, teammates, coaches, and professional staff for nutritional information (Shoaf et al., 1986; Torres-

McGehee et al., 2012)). These sources may sometimes provide inaccurate guidance, posing risks to athletes' dietary behaviors (Rockwell et al., 2001; Zinn et al., 2006) (Cockburn et al., 2014) .

Electronic tools are increasingly preferred for dietary assessment over traditional methods (Rollo et al., 2011). Approximately one-third of sports dietitians use diet apps with clients and consider them effective for self-monitoring (Jospe et al., 2015a) . Image-based diet apps are favored because they reduce the burden of food recording and improve accuracy compared to traditional logs (Gemming, Utter, & Ni Mhurchu, 2015; Wang et al., 2002). Although automated image analysis for dietary logs is under development, current systems still require manual input (Martin et al., 2008; Thompson & Subar, 2017).Previous interventions aimed at improving athletes' NK have varied in length and delivery, including group sessions, lectures, and individual counseling (Abood et al., 2004; Beggs et al., 2016) . These interventions have been effective in increasing nutrition knowledge, enhancing self-confidence, and promoting positive dietary changes (Abood et al., 2004; Beggs et al., 2016). Despite the time and resource demands of traditional education, mobile applications offer a convenient and time-efficient alternative for nutrition education and dietary assessment (Gemming, Utter, & Mhurchu, 2015; Jospe et al., 2015b). However, the use of mobile apps in athlete nutrition education is still in its early stages and requires further investigation (Nour et al., 2017).

While previous studies have highlighted the potential benefits of nutrition education and even explored mobile applications as tools for dietary assessment and self-monitoring, there remains a clear gap in the literature regarding the effectiveness of mobile-based educational interventions specifically designed to enhance nutrition knowledge among university student-athletes. Most existing applications focus on diet tracking or general health promotion, with limited emphasis on structured educational content tailored to athletic populations. Moreover, few studies have assessed whether such mobile tools can lead to measurable improvements in nutritional knowledge or behavioral change in a university sports context. This study addresses this gap by evaluating the impact of a mobile application-based nutrition education program on student-athletes' nutrition knowledge and awareness.

This study aims to evaluate the effectiveness of educational interventions in enhancing sports nutrition knowledge among university student-athletes. Given the essential role of nutrition in optimizing athletic performance, improving nutritional knowledge can significantly enhance athletes' health and competitive outcomes. Additionally, the study seeks to identify the most effective educational methods for increasing university athletes' awareness of healthy eating habits, thereby supporting their overall well-being and athletic success.We hypothesize that nutrition education interventions will improve sports nutrition knowledge and awareness among college student-athletes, leading to better nutritional behaviors, enhanced athletic performance, and improved health outcomes.

Method

Participants

A total of 100 university student-athletes (aged 18–25 years) from various sports disciplines at a private university in Jordan participated in the study. Participants were randomly assigned to one of two groups: the experimental group (n = 50), which received a mobile application-based sports nutrition education using MyFitnessPal, and the control group (n = 50), which received conventional lecture-based instruction covering the same content.Selection was based on participants' active involvement in organized sports and their expressed willingness to take part in the study. To ensure baseline comparability between the two groups, demographic and athletic variables such as gender, training experience, and body mass index (BMI) were recorded and evaluated prior to the intervention.

Inclusion Criteria

Participants were eligible to enroll in the study if they met the following conditions:
Aged between 18 and 25 years.

Enrolled as student-athletes at the university.

Regularly engaged in organized sports training (at least three sessions per week).

Able to use mobile applications effectively.

Willing to commit to the intervention protocol for the full three-month study duration.

Exclusion Criteria

Participants were excluded from the study if they:

- Had received prior formal education in sports nutrition.
- Had medical conditions or dietary restrictions (e.g., eating disorders or chronic diseases) that could interfere with nutrition-related outcomes.
- Were undergoing concurrent nutrition education or dietary counseling.
- Failed to complete either the pre-intervention or post-intervention assessments.
- Demonstrated non-adherence to the assigned intervention (e.g., irregular use of the mobile application or absence from lectures).
- Withdrew from the study at any point.

As shown in Table 1 below, the demographic variables of participants were distributed among the two study groups (control and experimental). Numbers and percentages for each demographic information (i.e., gender, training experience, and BMI category) are provided.

The results in the table indicate no significant imbalance in distribution between the two groups in terms of gender, training experience, and BMI categorical variables, confirming that the demographic characteristics of the two groups were comparable prior to any experimental intervention.

Table 1. Demographic variables about students presented as numbers and percentages of participants in a group

Demographic Variables	Control Group (N% = 50)	Experimental Group (N% = 50)
Sex		
Male	28 (56.0)	30 (60.0)
Female	22 (44.0)	20 (40.0)
Training Experience (years)		
Less than 1 year	12 (24.0)	10 (20.0)
1–2 years	18 (36.0)	20 (40.0)
More than 2 years	20 (40.0)	20 (40.0)
BMI Category		
Underweight (BMI < 18.5)	5 (10.0)	4 (8.0)
Normal weight (BMI 18.5–24.9)	25 (50.0)	26 (52.0)
Overweight (BMI 25–29.9)	15 (30.0)	16 (32.0)
Obese (BMI ≥ 30)	5 (10.0)	4 (8.0)

Procedure

A sample of university student-athletes from various sports disciplines at a private university was selected using stratified random sampling to ensure balanced representation across gender and training experience. Participants were randomly assigned into two groups: an experimental group (n = 50) and a control group (n = 50), minimizing potential selection bias.

Prior to the intervention, all participants completed the "NK for Athletes" questionnaire to assess their baseline sports nutrition knowledge.

For the experimental group, the intervention involved the use of the MyFitnessPal mobile application, which offered structured educational content over a period of 12 weeks. The content was delivered through:

Weekly educational videos (one per week) on sports nutrition topics such as energy needs, macronutrients, hydration, and pre/post-training meals.

Twice-weekly articles (total of 24) focusing on micronutrient roles, meal timing, and dietary planning for performance.

Interactive tracking features, including daily food logs and progress tracking with personalized feedback from in-app algorithms.

Participants were instructed to use the application at least 5 days per week, spending approximately 20–30 minutes per session. Compliance was monitored through weekly app usage reports.

For the control group, traditional educational interventions were provided. These included weekly in-person lectures (one session per week, each lasting 60 minutes) for 12 weeks. The lecture content mirrored the app-based educational material, covering:Principles of sports nutrition,Macronutrients and energy systems,Hydration strategies,Vitamins and minerals, Nutritional planning and dietary supplements.

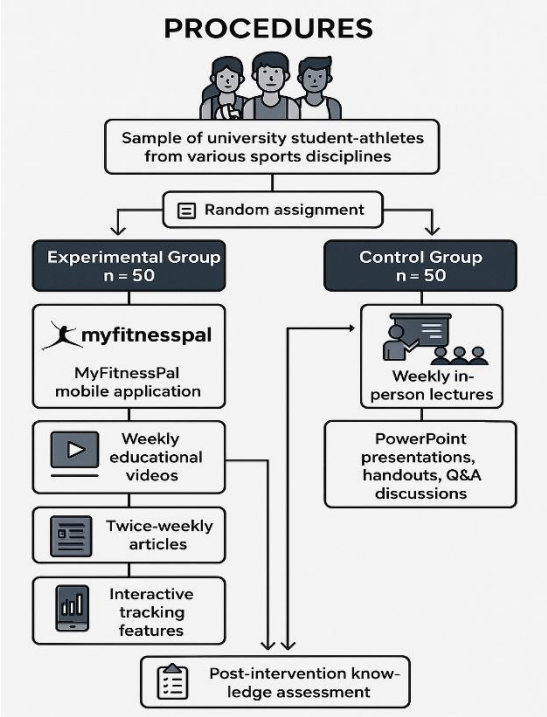
Lecture materials included PowerPoint presentations, handouts, and Q&A discussions to ensure consistency in content delivery between groups.

After the 12-week period, the same questionnaire was re-administered to assess post-intervention knowledge. Changes in sports nutrition knowledge were compared between the two groups to evaluate the effectiveness of each educational approach.

To reduce the risk of contamination between groups, participants were instructed not to share educational materials or discuss the intervention content with peers in the opposite group. Additionally, lecture sessions and application access were organized separately to maintain group integrity.

A power analysis was conducted using G*Power software (version 3.1), assuming a moderate effect size (d = 0.5), a significance level of 0.05, and power of 0.80. The analysis indicated that a minimum of 88 participants would be required. Thus, 100 participants were recruited to account for potential attrition, see figure 1.

Figure 1 .Procedure of study



Ethical Considerations

This study was conducted in accordance with the ethical standards of research involving human participants. Ethical approval was obtained from the Scientific Research Committee at the Faculty of Educational Sciences, Al-Ahliyya Amman University, prior to the commencement of the study (Approval No. AAU-ESC-2024-3). All participants were informed about the study objectives, procedures, potential risks, and benefits, and they voluntarily provided written informed consent before participating. Participation was entirely voluntary, and participants were assured of the confidentiality and anonymity of their responses. They also had the right to withdraw from the study at any time without any consequences.

Instrument

Sports nutrition knowledge

The "NK for Athletes" questionnaire, developed and validated by (Vázquez-Espino et al., 2020) , was used to measure knowledge of sports nutrition (SNK) among athletes. This instrument is characterized by its ease of use, low time burden, and up-to-date content. It consists of 59 items covering key domains of sports nutrition, including macronutrients (proteins, carbohydrates, fats), micronutrients (vitamins and minerals), hydration, and eating frequency. Participants received +1 point for each correct answer, -1 point for each incorrect answer, and 0 points for unanswered items, with a maximum possible score of 59 points indicating a higher level of knowledge.

The original validation process involved expert evaluation to ensure content validity, and exploratory factor analysis confirmed its construct validity. The initial internal consistency reliability was moderate, with a Cronbach's alpha of 0.731. The questionnaire has since been used in several peer-reviewed studies across different athletic populations, further confirming its reliability and applicability in sports nutrition research. In the current study, internal consistency was reassessed, yielding a Cronbach's alpha of 0.925, indicating excellent reliability within the sample.

Validity of the Questionnaire

To ensure content and contextual validity for the target population, the questionnaire was reviewed by a panel of experts in sports nutrition. Based on their feedback, minor linguistic and cultural adaptations were made to enhance relevance and comprehension among Jordanian university student-athletes. A pilot study was conducted on a small sample (n = 15) to evaluate the clarity, suitability, and acceptability of the adapted instrument. Feedback from the pilot confirmed that the questionnaire was appropriate for use in this specific context.

Data analysis

A range of statistical methods was employed to analyze the study data, based on the nature and distribution of the variables. Descriptive statistics, including frequencies and percentages, were used to summarize the demographic characteristics of the participants.To assess the internal consistency of the Sports Nutrition Knowledge (SNK) questionnaire, Cronbach's alpha coefficient was calculated, indicating a high level of reliability.Data normality was examined using the Kolmogorov–Smirnov test. Variables that followed a normal distribution were summarized using means and 95% confidence intervals, while non-normally distributed variables were reported as medians and interquartile ranges (IQR).Due to the non-normal distribution of some variables (particularly in the experimental group), non-parametric tests were employed. The Mann–Whitney U test was used to compare SNK scores between the experimental and control groups after the intervention. For within-group comparisons between pre- and post-intervention scores, the Wilcoxon Signed-Rank Test was applied.

Effect sizes were calculated to estimate the practical significance of the observed differences. A significance level of $P < 0.05$ was adopted for all statistical analyses.

Results

The values of Cronbach's Alpha coefficient are presented in Table 2 to assess the internal consistency of the study scales. Cronbach's Alpha is a statistical measure of reliability, with higher values indicating greater consistency within the scale. In this study, Cronbach's Alpha scores exceeded 0.90, demonstrating strong reliability in measuring the intended parameters. These results confirm a high level of internal consistency, indicating that the scales used in the study were highly reliable.

The original version of the questionnaire demonstrated a moderate internal consistency (Cronbach's alpha = 0.731). In the current study, internal consistency was assessed again, and a Cronbach's alpha of 0.925 was obtained, indicating excellent reliability within the sample.

Table 2. Internal consistency assessment of scales

Scale	Cronbach's Alpha	Number of Items
Sports Nutrition Knowledge (SNK)	0.925	59

A total of 100 participants completed the study and were included in the final analysis (50 in the experimental group and 50 in the control group). The Kolmogorov–Smirnov test indicated that the data for the control group were normally distributed ($p = 0.20$), while the data for the experimental group significantly deviated from normality ($p < 0.001$).

In response to this deviation, we evaluated data transformation methods such as logarithmic and square root transformations. However, these attempts did not yield a satisfactory normal distribution. Consequently, non-parametric tests were employed to preserve the integrity and interpretability of the results.

Therefore, the Mann–Whitney U test was used to compare Sports Nutrition Knowledge (SNK) scores between groups.

After the three-month intervention, the experimental group, which used the MyFitnessPal application, achieved significantly higher SNK scores compared to the control group. The median score for the experimental group was 45.0 (IQR = 40–49), while the control group had a median score of 32.0 (IQR = 28–36). The Mann–Whitney U test showed a statistically significant difference between the groups ($U = 488.0$, $p < 0.001$), with a large effect size ($r = 0.65$). The 95% confidence interval for the median difference between the two groups was [10.5, 15.0].

According to Cohen's classification, this effect size ($r = 0.65$) represents a large practical impact, indicating that the use of the MyFitnessPal application had a substantial and meaningful effect on improving sports nutrition knowledge among university athletes.

These results suggest that mobile app–based nutrition education using MyFitnessPal significantly improved student-athletes' knowledge of sports nutrition compared to traditional lecture-based methods.

Table 3. Comparison of Sports Nutrition Knowledge Scores Between Experimental and Control Groups After Intervention

Group	Median (IQR)	Mann–Whitney U	p-value	Effect Size (r)	95% CI for Median Difference
Experimental (n = 50)	45.0 (40.0–49.0)	488.0	< 0.001	0.65 (large)	[10.5, 15.0]
Control (n = 50)	32.0 (28.0–36.0)				

*P < 0.05 indicates statistical significance

Table 4 presents the mean scores of sports nutrition knowledge (Sports NK), along with 95% confidence intervals for both the control and experimental groups, as well as the standard deviation, F value, and P-value.The mean sports nutrition knowledge score in the control group was 65.62, with a confidence interval of (63.10–68.14) and a standard deviation of 13.59. In contrast, the experimental group had a higher mean score of 74.34, with a confidence interval of (71.00–77.68) and a standard deviation of 23.62. Statistical analyses revealed a significant difference between the two groups, with an F of 12.760 and a P-value <.001, indicating statistical significance ($P < 0.05$).These results highlight the impact of the educational intervention using the MyFitnessPal application, as the experimental group showed a notable improvement in sports nutrition knowledge compared to the control group. This confirms the effectiveness of mobile educational applications in enhancing nutritional awareness among university athletes.

Table 4. Demographic Characteristics of the Study Participants

Group	Time Point	Median (IQR)	p-value (within group)
Experimental (n = 50)	Pre-test	31.0 (28.0–35.0)	—
	Post-test	45.0 (40.0–49.0)	< 0.001
Control (n = 50)	Pre-test	30.5 (27.0–34.0)	—
	Post-test	32.0 (28.0–36.0)	0.068

*P < 0.05 indicates statistical significance

Discussion

The findings of this study provide support for the hypothesis that mobile application-based nutrition education can significantly enhance sports nutrition knowledge and awareness among university student-athletes. The intervention using the MyFitnessPal app led to statistically significant improvements in post-intervention nutrition knowledge scores in the experimental group compared to the control

group, which received traditional lecture-based instruction. This aligns with previous studies suggesting that technology-assisted education can be a powerful tool for behavior change and knowledge acquisition in athletic populations (Gemming, Utter, & Ni Mhurchu, 2015; Jospe et al., 2015a).

These results are consistent with research indicating that improving nutrition knowledge positively influences dietary behavior and athletic performance (Burke et al., 2019 Abbey et al., 2017; Steffl et al., 2019). . Nutrition knowledge is a modifiable factor that can lead to healthier dietary choices, and educational interventions have been shown to improve nutrition awareness and confidence (Fahrenholtz et al., 2023; Patton-Lopez et al., 2018) ,This supports the importance of continuous nutrition education for athletes, coaches, and related personnel to address common gaps in dietary intake and hydration practices (Meyer et al., 2007;McCrink et al., 2021).One key explanation for the greater improvement in the experimental group may lie in the interactive, user-driven nature of the MyFitnessPal app. Unlike traditional lectures, the app allowed participants to engage with content at their own pace, reinforced learning through practical food logging and feedback, and provided frequent exposure to tailored nutritional content. These features likely contributed to more sustained engagement and retention of nutritional concepts (Nour et al., 2017).

Moreover, the app's real-time feedback and daily tracking functions may have enhanced self-awareness and accountability regarding dietary choices, contributing not only to knowledge gains but potentially to better nutritional behavior. While this study focused on knowledge and awareness rather than behavior outcomes, prior research suggests that improved nutritional knowledge is often accompanied by healthier food choices (Alaunyte et al., 2015b; Wardle et al., 2000) .Thus, it is plausible that the knowledge improvements observed here could translate into improved dietary practices in the long term.

The control group, although exposed to the same educational content, did not exhibit the same level of improvement, highlighting the limitations of passive, lecture-based methods. Traditional instruction often suffers from limited retention and lower engagement, especially when not reinforced by practical application or visual stimuli (Abood et al., 2004). . This emphasizes the need to adopt more modern, learner-centered approaches in nutrition education, particularly for digitally literate populations such as university students.

Additionally, no significant differences were observed in nutrition knowledge improvements based on gender, BMI category, or years of training experience, indicating that the mobile-based intervention was equally effective across diverse demographic subgroups. This finding is consistent with previous systematic reviews that reported no significant impact of gender or sport type on nutritional knowledge outcomes (Burke, 2001), suggesting that mobile applications can be broadly applicable and equitable tools for nutrition education.

However, it is important to acknowledge that while the study showed a clear improvement in knowledge, it did not directly assess whether these gains led to measurable improvements in dietary intake, performance outcomes, or body composition. These factors are crucial for determining the ultimate effectiveness of nutrition interventions in athletic contexts. Future research should explore these behavioral and physiological outcomes to build on the current findings.According to the Social Cognitive Theory (Bandura, 1986), behavior change is influenced by factors such as self-efficacy, outcome expectations, and observational learning. The MyFitnessPal app likely enhanced self-efficacy through immediate feedback and daily tracking, empowering users to believe in their ability to adopt healthier nutrition habits. This theoretical framework supports the idea that digital interventions, when designed to foster engagement and self-regulation, can effectively facilitate knowledge acquisition and potentially lead to behavior change. However, further research is needed to empirically test these mechanisms within athletic populations.

Finally, participant feedback indicated high satisfaction with the app-based learning method, with many expressing appreciation for its flexibility and usability. This suggests good acceptability of mobile applications as educational tools among student-athletes and supports broader integration of such technologies in sports science curricula.

In conclusion, the results of this study confirm the effectiveness of mobile application-based nutrition education in improving sports nutrition knowledge among university athletes. These findings highlight

the potential of digital tools to complement or even replace traditional methods in sports nutrition education, offering an accessible, interactive, and impactful approach to fostering better-informed, healthier athletes.

Recommendations

It is recommended that sports institutions adopt an integrative approach when implementing digital interventions in athletic settings to enhance their effectiveness in improving health-related knowledge(Alawamleh & AlKasasbeh, 2024), behaviors, and athletic performance. This includes incorporating specialized digital applications in areas such as nutrition(W. J. AlKasasbeh & Amawi, 2023), recovery, and general health into athletes' training and educational programs, while providing initial training and ongoing technical support to ensure optimal use. Applications should be scientifically grounded and offer diverse, personalized educational content that meets individual user needs, with features for tracking and periodically evaluating progress. Interactive strategies, such as gamification and performance-based challenges, are encouraged to boost user engagement, along with blending digital interventions with face-to-face training sessions to reinforce understanding and interaction(Alkasasbeh, Alawamleh, Aloran, et al., 2024; W. J. AlKasasbeh & Amawi, 2024). Involving coaches in the implementation process is essential to support the sustainability of the targeted behaviors. Systematic scientific evaluations using reliable tools should be conducted before and after the interventions to assess their effectiveness. Finally, the selected applications should be user-friendly, compatible across devices, and compliant with data protection and privacy regulations in accordance with applicable legal standards.

Study limitations

While the findings are promising, several limitations should be acknowledged. First, the study relied on a relatively small sample size from a single university, which may limit the generalizability of the results to broader athletic populations. Additionally, the short duration of the intervention means that long-term retention and behavioral changes were not assessed. Potential biases such as self-reporting inaccuracies in app usage and motivation differences between participants could have influenced the outcomes. It is also possible that other unmeasured factors, such as prior nutrition knowledge or external dietary influences, contributed to the observed improvements.

Regarding the statistical analysis, the experimental group showed a non-normal distribution of post-intervention scores, whereas the control group's scores were normally distributed. This discrepancy could be attributed to individual variability in how participants engaged with the app-based intervention, with some users benefiting more than others, leading to a skewed distribution. Such variability highlights the need for further research to explore user engagement patterns and their impact on learning outcomes. Future studies should consider larger samples and more rigorous designs to address these factors comprehensively.

Conclusions

This study assessed the effectiveness of educational interventions in enhancing athletes' knowledge of sports nutrition. The results demonstrated that participants who used the MyFitnessPal mobile application showed statistically greater improvements in nutritional knowledge compared to those who received traditional, lecture-based education. These findings suggest that digital interventions, when appropriately designed and implemented, can enhance learning outcomes in the context of sports nutrition. However, the conclusions drawn from this study should be interpreted within the scope of its limitations, including a relatively small sample size, short intervention duration, and reliance on self-reported data. While the results are promising, they are not generalizable to all athletic populations or digital tools. Future research should involve larger and more diverse samples, extended follow-up periods to assess long-term impact, and the inclusion of objective performance or physiological outcomes. Additionally, further investigation is needed to identify which features of digital applications most effectively support behavior change in athletes. Despite these limitations, this study contributes to the growing

evidence supporting the integration of digital tools into sports nutrition education in a targeted and evidence-based manner.

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