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Educational intervention using a mobile app to enhance sports nutrition knowledge and dietary habits in student-athletes: a randomized controlled trial

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Introduction: The increasing use of digital tools in education offers innovative ways to improve health behaviors. This study aims to evaluate the effectiveness of a mobile application intervention in enhancing sports nutrition knowledge and improving dietary habits among university student-athletes.

Methods: A total of 100 university student-athletes were randomly assigned to either an experimental group (n = 50), which utilized the "MyFitnessPal" mobile application for nutrition education, or a control group (n = 50), which received traditional lecture-based instruction. Both groups completed validated pre- and post-intervention questionnaires over a three-month period to assess changes in sports nutrition knowledge and dietary habits.

Results: The experimental group showed significantly greater improvements in both sports nutrition knowledge and dietary habits compared to the control group ($p < 0.05$).

Discussion: These findings suggest that mobile applications like "MyFitnessPal" are more effective than traditional educational methods in enhancing nutritional awareness and promoting healthier dietary behaviors among student-athletes. Mobile application-based interventions can play a key role in improving athletic performance and overall health. Future research should explore the long-term impact and generalizability of such interventions across diverse athletic populations.

KEYWORDS

mobile application, sports nutrition knowledge, eating habits, undergraduate student, educational interventions, dietary habits

Introduction

Poor knowledge of nutrition is a potential barrier that negatively affects athletes' performance (Amawi et al., 2023a, Amawi et al., 2023b, Amawi et al., 2023c). Thus, across all sports organizations around the globe, it is emphasized that young athletes, coaches, and parents should receive constant nutritional education (Meyer et al., 2007; Athlete, 2018;

Alkasasbeh et al., 2024). Proper nutrition is known to be central to maximizing athleticism and can help improve athletic performance (Alkasasbeh et al., 2024; AlKasasbeh and Akroush, 2024; Alkasasbeh and Amawi, 2023; Orhan, 2024). Nevertheless, there are a number of barriers that can prevent athletes from putting optimal nutrition practices into action (AlKasasbeh et al., 2024; Malinauskas et al., 2007). These factors include limited time, insufficient meal preparation facilities, financial constraints, poor meal planning skills, inadequate preparation skills, and time-shift travel demands. Research on nutrition education has demonstrated its impact on increasing individuals' knowledge about food, improving dietary habits, and enhancing nutrition awareness (Provenza Paschoal and Silverio Amancio, 2004). Such studies have also shown that nutritional education increases knowledge about nutrition and improves individuals' confidence in making prudent nutritional decisions, which consequently enables real change in their perceptions (Jagim et al., 2021). Many athletes simply underestimate their nutritional needs and are often too lax in adhering to basic nutrition practices that promote optimal performance (Condo et al., 2019; Posthumus et al., 2021).

There is broad agreement on the positive impact of nutrition knowledge (NK) level on increasing fruit and vegetable consumption (DicksonSpillmann and Siegrist, 2011; Alaunyte et al., 2015) and reducing fat consumption (Wardle et al., 2000). NK scores in athletes have been analyzed using questionnaires designed to measure general knowledge of nutrition (Alaunyte et al., 2015; Spendlove et al., 2012) or specialized knowledge of athlete nutrition (Jessri et al., 2010; Zinn et al., 2005).

Most studies comparing athletes of all levels of sport involvement with non-athletes have shown that athletes' NK scores were either lower than or not different from non-athletes' scores (Spendlove et al., 2012; Devlin et al., 2017). Unfortunately, definitive conclusions cannot be reached due to differences in measurement tools between studies (Abu Jamous et al., 2024; Heaney et al., 2011). Studies have shown a positive association between nutritional knowledge (NK) scores and attendance at nutrition courses (Dunn et al., 2007; Jessri et al., 2010). Athletes have also been shown to have poor knowledge of topics such as micronutrients and supplementation (Trakman et al., 2016). An association has been found between NK and increased carbohydrate intake (Devlin et al., 2017; Burke et al., 2001) and increased muscle mass in elite athletes (Devlin et al., 2017). A systematic review showed no significant differences based on gender or type of sport (Burke et al., 2001).

There are many factors that influence food choice and dietary behavior (Furst et al., 1996; Devine, 2005; Orhan et al., 2024). Factors influencing athletes' dietary behavior include cultural background, appetite, attitudes toward nutrition, and level of nutritional knowledge. These factors apply to both normal individuals and athletes (Birkenhead and Slater, 2015). Changes in body composition and aesthetics can also influence athletes' dietary behaviors (Byrne and McLean, 2002; Sundgot-Borgen and Torstveit, 2004). However, the impact of dietary behavior on athletic performance has not been adequately studied due to the difficulty of accurately measuring food intake and the need to use validated questionnaires in large samples (Heaney et al., 2011; Trakman et al., 2016). In addition to mandatory education, athletes rely on other sources such as the media, parents, friends, teammates, coaches, and professional staff (Shoaf et al., 1986; Torres-McGehee et al., 2012). These sources may influence their dietary behaviors and may sometimes provide inaccurate information (Zinn et al., 2006; Rockwell et al., 2001). Research suggests that a lack of knowledge and inaccurate nutritional guidance pose risks to athletes (Cockburn et al., 2014).

Participants prefer electronic methods to assess diet over traditional methods (Al-Nawaiseh, 2025). A survey also showed that approximately one-third of sports dietitians (32.4%, $n = 180$) use diet apps with their clients (Alawamleh and AlKasasbeh, 2024; Jospe et al., 2015). Many dietitians rated these apps as effective tools to improve client self-monitoring (Jospe et al., 2015). However, there is little research on the use of image-based diet apps or social media features to support athlete care. Users prefer image-based apps because they reduce the burden of recording and provide more accurate data compared to traditional logs (AlKasasbeh and Amawi, 2024; Alkasasbeh et al., 2024; AlKasasbeh and Amawi, 2023; Wang et al., 2002; Gemming et al., 2015). Dietary logs that use automated image analysis techniques to estimate intake are still under development (Martin et al., 2008; Thompson and Subar, 2017). Unfortunately, these logs currently require manual analysis (Martin et al., 2008; Thompson and Subar, 2017).

Previous interventions to improve athletes' NK have varied in duration and content (Abood et al., 2004; Beggs et al., 2016). Education was delivered via group sessions, lectures (Abood et al., 2004; Rossi et al., 2017), or individual sessions (Beggs et al., 2016). Studies have shown increased athletes' nutrition knowledge (Abood et al., 2004; Beggs et al., 2016), along with improved self-confidence and positive dietary changes (Abood et al., 2004; Beggs et al., 2016). Although educational interventions (EI) are time- and resource-intensive (Rossi et al., 2017), mobile applications may provide a convenient and time-efficient alternative (Jospe et al., 2015; Gemming et al., 2015). In addition to assessing dietary intake, applications may contribute to increased nutrition knowledge (Nour et al., 2017). However, mobile applications in this area are still in their infancy (Nour et al., 2017).

This study aims to investigate the effectiveness of a mobile application intervention in enhancing Sports nutrition knowledge and improving dietary habits among university student-athletes. This study is of great importance due to the role of nutrition in improving sports performance, as proper knowledge of nutrition can improve athletes' health and performance in competitions. In addition, the study contributes to identifying the best educational methods that can be used to enhance university athletes' awareness of healthy eating habits, which helps in developing effective strategies to support athletes' health and achieve better result. In this study, we hypothesized that (EI) aimed at improving sports nutrition knowledge would improve eating habits and increase nutritional awareness in college student-athletes, contributing to improved athletic performance and overall health.

Materials and methods

Participants

The study included student-athletes from different sports disciplines at a private university. A total of 100 participants were recruited for the study, with 50 athletes in the control group and 50 athletes in the experimental group. The control group received traditional lecture-based EI, while the experimental group used the "MyFitnessPal" mobile application for sports nutrition education. Participants were selected based on their participation in sports and their willingness to participate in the study. Demographic variables

such as gender, training experience, and body mass index (BMI) were considered to ensure comparable groups before and after the intervention. Inclusion criteria included that participants be student-athletes at a university, active in sports in a specific sports discipline, between the ages of 18 and 25, able to use mobile applications effectively, and willing to participate in the study and adhere to the EI during the study period (3 months). In contrast, students with medical conditions that affected their ability to participate in sports or diet, or who were currently receiving nutritional counseling or nutrition-related (EI) from other professionals, as well as students with eating disorders or health conditions that required special follow-up that might affect the study results, were excluded from the experimental group. Students who did not adhere to the use of the MyFitnessPal app regularly in the experimental group or did not participate in traditional lectures in the control group, as well as students who did not agree to voluntarily participate in the study or withdrew from it mid-term, were also excluded. The study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Scientific Research Ethics Committee at Al-Ahliyya Amman University.

Procedures

A sample of university student-athletes from various sports disciplines at a private university was selected and randomly divided into two groups: an experimental group that used the "MyFitnessPal" mobile application for the educational intervention, and a control group that received traditional lecture-based education.

At the beginning of the study, all participants completed baseline questionnaires assessing their knowledge of sports nutrition and their eating habits, with a focus on awareness of proper nutrition and its role in enhancing sports performance.

Experimental group

Participants in the experimental group were provided access to the "MyFitnessPal" application, which included educational modules designed to improve sports nutrition knowledge and promote healthier eating habits. The modules comprised videos, articles, and interactive exercises covering topics such as macronutrients and micronutrients, hydration strategies, timing of meals around training, and the impact of nutrition on athletic performance. Additionally, the app featured tools to help participants track their daily food intake and receive personalized feedback. Participants were instructed and encouraged to use the application regularly over the three-month intervention period. Throughout this period, the research team provided weekly reminders and monitored app usage remotely to ensure adherence. Participants could also reach out via email or messaging for support or questions related to the app content.

Control group

The control group attended a series of traditional lecture sessions delivered in person by a certified sports nutritionist affiliated with the university. The lectures covered the same educational content provided in the "MyFitnessPal" application, including nutrition fundamentals, meal planning, hydration, and performance nutrition strategies. A total of six lecture sessions were conducted over the three months, each lasting approximately 60 min. Attendance was recorded to monitor adherence.

Three months after the intervention, all participants completed the same questionnaires as at baseline to assess changes in their sports nutrition knowledge and eating habits. The study focused on measuring improvements in understanding the effect of nutrition on sports performance and any positive changes in dietary behaviors (see Figure 1).

Instruments

Sports nutrition knowledge (SNK)

The "NK for Athletes" questionnaire (Vázquez-Espino et al., 2020) was used to measure knowledge of sports nutrition (SNK) among athletes and is characterized by its ease of use, low time burden, and up-to-date content. The questionnaire consists of 59 items covering multiple domains of sports nutrition, such as macronutrients (proteins, carbohydrates, fats), micronutrients (vitamins and minerals), hydration, and eating frequency. Participants were asked to answer these items, and +1 point was awarded for each correct answer, −1 point for each incorrect answer, and 0 points were awarded for items that were not answered. The maximum score that could be achieved on the questionnaire was 59 points, indicating a higher level of knowledge if scores closer to the maximum were obtained. The scale showed a moderate level of internal consistency, with a Cronbach's alpha of 0.731, indicating that the measured items consistently assess the intended constructs, which enhances the reliability of the results and provides a solid basis for future analyses. To facilitate interpretability and comparison of scores, raw scores were normalized to a 0–100 scale using the following formula: Normalized Score = (Raw Score ÷ 59) × 100. This allowed for easier comparison across groups and clearer presentation of results in.

Dietary habits (DH)

The questionnaire consists of 13 questions focusing on different aspects of dietary habits (Turconi et al., 2008), such as breakfast composition, daily meal frequency, regular fruit and vegetable intake, and soft drink consumption. Some questions have multiple response options, such as "always," "often," "sometimes," and "never," while others have four response options. Scores from 0 to 3 are given for each response, with the highest score representing the healthiest option. The maximum score that can be obtained in this section is set at 39 points. The scale showed good reliability, with a Cronbach's alpha of 0.724, indicating that the questionnaire consistently measures the intended (DH) of athletes.

Data analysis

Several statistical methods were used in analyzing the results of the study. First, the Cronbach's alpha test was used to assess the reliability of the tools used in the study. The Kolmogorov–Smirnov test was also applied to test the conformity of the distribution to the normal distribution of the data. Due to the deviation of some data from the normal distribution, non-parametric tests were used in the statistical analysis. In addition, analysis of variance (ANOVA) was used to compare the differences between the experimental and control groups.

Results

As shown in Table 1 below, the demographic variables of participants were distributed among the two study groups (control

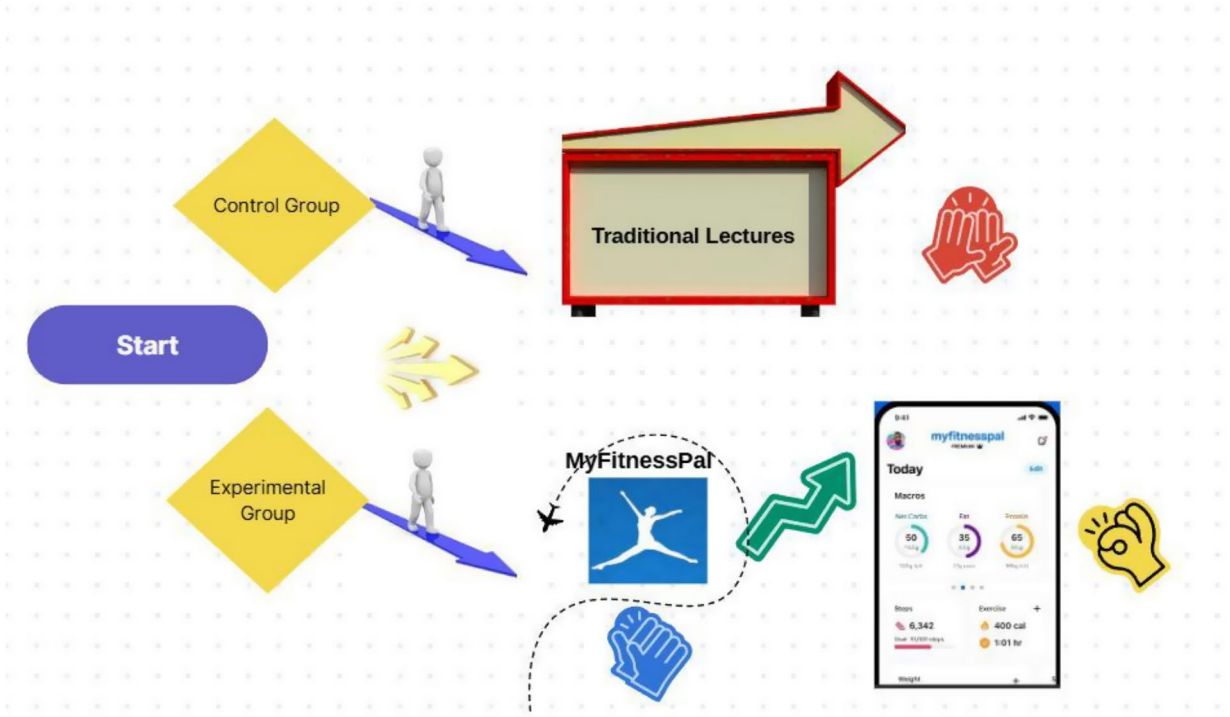

FIGURE 1
Study procedures evaluating the impact of MyFitnessPal versus traditional education on (Sports NK) and (DH).

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.

The values of Cronbach's Alpha coefficient are presented in Table 2 below to assess the degree of internal consistency of study scales. Cronbach's Alpha coefficient is a statistical measurement of the internal consistency of the scale; high values indicate great reliability and internal consistency. Cronbach's Alpha scores were greater than 0.90, indicating good reliability in measuring the desired parameters in the study, and consequently, the results indicate a high internal consistency as both the scales yielded a good range of Cronbach's Alpha scores.

Table 3 presents the results of the Kolmogorov–Smirnov (K–S) test used to assess the normality of the distribution of Sports Nutrition Knowledge (Sports NK) and Dietary Habits (DH) scores for both the control and experimental groups. The K–S test showed that the Sports NK scores in the experimental group significantly deviated from a normal distribution ($p < 0.001$), whereas the control group's scores followed a normal distribution ($p = 0.20$). For Dietary Habits (DH), both groups showed statistically significant deviations from normality: the experimental group exhibited a strong deviation ($p < 0.001$), and the control group showed a moderate but statistically significant deviation ($p = 0.01$). Based on these findings, since not all variables met the assumption of normality, we employed non-parametric statistical tests (e.g., Mann–Whitney U test) for

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)

TABLE 2 Internal consistency assessment of scales.

Scale	Cronbach's Alpha**	Number of Items
Dietary Habits (DH)	0.912	13
Sports Nutrition Knowledge (SNK)	0.925	59

**Cronbach's Alpha values indicate internal consistency reliability of the scales.

TABLE 3 Kolmogorov–Smirnov test for Sports NK scores and DH as (95% confidence intervals in parenthesis).

Variable	Control group (N = 50): statistic (95% CI)	*p-value	Experimental group (N = 50): statistic (95% CI)	*p-value
(Sports NK)	0.059 (0.045–0.073)	0.20	**0.350 (0.310–0.390)**	**<0.001**
Dietary Habits (DH)	0.134 (0.120–0.148)	0.01	**0.450 (0.400–0.500)**	**<0.001**

*Denotes the p-value. A p-value less than 0.05 indicates a statistically significant result, meaning there is a significant deviation from normal distribution according to the Kolmogorov–Smirnov test. **Kolmogorov–Smirnov test used to assess normality. $p < 0.05$ indicates a significant deviation from normal distribution. Bold values indicate statistically significant results ($p < 0.05$), showing a significant deviation from normal distribution according to the Kolmogorov–Smirnov test.

subsequent analyses, in accordance with the significance threshold ($p < 0.05$).

The mean scores ± standard deviation (SD) and 95% confidence interval (CI) for Dietary Habits (DH) and Sports Nutrition Knowledge (Sports NK) in both the control and experimental groups are presented in Table 4. The normalized Sports NK score in the experimental group was 74.34 ± 23.62 (95% CI: 71.00–77.68), which was significantly higher than that of the control group (65.62 ± 13.59, 95% CI: 63.10–68.14). The original maximum raw score for the Sports NK questionnaire was 59; therefore, all NK scores were scaled to a 0–100 range using the formula: (raw score ÷ 59) × 100. The difference between groups was statistically significant ($F = 12.760$, $p < 0.001$). Likewise, the experimental group had a mean DH score of 54.00 ± 10.57 (95% CI: 52.00–56.00), compared to 48.08 ± 10.76 (95% CI: 46.50–49.66) in the control group. This difference was also statistically significant ($F = 10.456$, $p < 0.001$). These findings suggest a significant positive effect of the mobile application-based intervention on both Sports NK and DH scores, as indicated by p-values < 0.05 in both variables (Figure 2).

Discussion

This study aimed to investigate the effectiveness of a mobile application-based educational intervention (EI) in enhancing sports nutrition knowledge (SNK) and improving dietary habits (DH) among university student-athletes. The findings demonstrated that the experimental group, which used the MyFitnessPal app, exhibited significantly greater improvements in both SNK and DH compared to the control group that received traditional lecture-based instruction. The MyFitnessPal app served not only as a dietary tracking tool but also included structured educational modules designed specifically for this intervention. These modules encompassed interactive lessons on macronutrients, micronutrients, hydration strategies, nutrient timing, and the role of nutrition in athletic performance. This modular design allowed learners to access content at their own pace, revisit challenging topics, and actively engage with learning materials through daily logging, reminders, and personalized feedback based on their dietary inputs. This differs significantly from traditional lectures, which typically follow a linear, one-way communication model with limited personalization or real-time feedback. One of the key advantages of mobile app interventions is their flexibility and adaptability. Students can engage with the app anytime and anywhere, which fits well into the dynamic schedules of athletes. Unlike lecture-based instruction that occurs at fixed times and places, mobile apps accommodate athletes' time constraints and travel demands, reducing the logistical barriers that often hinder consistent participation in educational sessions. Moreover, the self-monitoring features of apps encourage active involvement and accountability, which may contribute to sustained behavior change.

These results are consistent with many previous studies that emphasized the role of nutritional education in increasing individuals' knowledge of nutrition and improving their eating behaviors (Provenza Paschoal and Silverio Amancio, 2004). Some studies have also shown that nutritional education interventions contribute to increasing confidence in making correct nutritional decisions, which leads to real changes in individuals' perceptions of healthy nutrition (Jagim et al., 2021). In addition, many studies prefer electronic methods for delivering nutritional education to athletes, as they have shown that these methods are more effective compared to traditional methods (Rollo et al., 2011). On the other hand, nutrition knowledge is a pivotal element in improving athletic performance, and studies have shown that there is a positive relationship between increasing athletes' levels of nutrition knowledge and increasing fruit and vegetable consumption while reducing fat consumption (DicksonSpillmann and Siegrist, 2011; Alaunyte et al., 2015). The results of this study show that the experimental group that used the "MyFitnessPal" application demonstrated a significant improvement in their level of nutrition knowledge, which is consistent with research showing that digital interventions can be effective in enhancing nutritional knowledge and changing eating behaviors (Jospe et al., 2015).

Furthermore, several studies have shown that various factors can influence athletes' nutrition behaviors, including cultural factors, personal preferences, and time pressure (Furst et al., 1996; Devine, 2005). In many cases, athletes struggle to implement optimal nutritional practices due to time constraints and a lack of tools to prepare meals (Malinauskas et al., 2007). However, this study provides evidence that mobile apps such as MyFitnessPal can be an effective way to overcome these challenges, providing users with easy ways to track their diet and adhere to healthy habits without needing to devote extensive preparation time.

This study also points to the importance of ongoing nutritional education in improving overall health and athletic performance. The level of nutritional knowledge is positively associated with improved eating decisions among athletes, which ultimately impacts athletic performance and overall health (Provenza Paschoal and Silverio Amancio, 2004). Enhancing nutrition knowledge through e-learning interventions is an important step toward improving nutritional awareness among athletes, especially in a university environment with busy athletic activities and demanding schedules.

Mobile applications like MyFitnessPal provide real-time feedback, data visualization, and personalized goal-setting—all of which are difficult to implement in traditional classroom settings. These features allow users to see the immediate consequences of their food choices, which may help bridge the gap between knowledge acquisition and practical application. Despite the advantages, mobile app interventions

TABLE 4 Mean Sports NK scores and DH as (95% confidence intervals in parenthesis) in between different group of the questionnaire.

Variable	Mean (95% CI)**	Control group (N = 50): s.d	Mean (95% CI) **	Experimental group (N = 50): s.d	F	*p-value
Sports NK	65.62 (63.10–68.14)	13.59	**74.34 (71.00–77.68)**	23.62	12.760	0.000
Dietary Habits	48.08 (46.50–49.66)	10.76	**54.00 (52.00–56.00)**	10.57	10.456	0.001

*p < 0.05 indicates statistical significance.
**95% CI represents the confidence interval for the mean scores.
Bold values indicate statistically significant differences between groups (p < 0.05). 95% CI represents the 95% confidence interval for the mean scores.

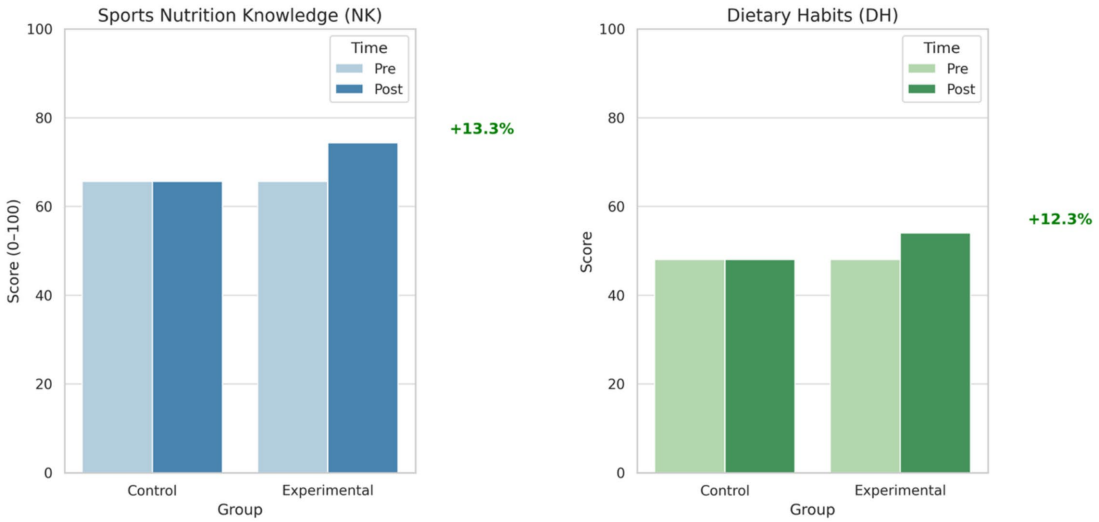

FIGURE 2
Comparison of pre- and post-intervention mean scores for (Sports NK) and (DH) between the control and experimental groups.

should not be viewed as a complete replacement for traditional methods. Instead, they could serve as complementary tools that enhance existing educational programs, particularly for populations like university athletes who require flexible and engaging learning solutions. Future research could explore hybrid models that combine in-person sessions with app-based learning to maximize the benefits of both modalities.

In conclusion, the current findings affirm that mobile application-based education—especially when grounded in evidence-based content and interactive design—can be a powerful tool for improving nutrition knowledge and dietary practices in athletes. The modular design of the MyFitnessPal app and its flexible access were likely key factors contributing to the success of this intervention. With increasing technological literacy and the demand for personalized learning, digital interventions offer a scalable and effective alternative to traditional lecture-based education. Future studies should examine long-term adherence and explore how to further enhance engagement within app-based modules to ensure lasting behavioral change.

Conclusion

This study aimed to evaluate the effectiveness of EI in enhancing athletes' knowledge of sports nutrition and improving their eating habits. The results showed that the use of the MyFitnessPal mobile application was more effective in improving sports nutrition awareness and eating habits in the experimental group compared to the control group that received traditional education through lectures. Although traditional education was effective in improving nutritional awareness, digital interventions provided more significant results. The study recommends the development of blended educational strategies that combine digital and traditional education, with a focus on the use of specialized sports nutrition mobile applications to enhance nutritional knowledge. Athletes should also be encouraged to continue using these applications to monitor their eating habits in the long term. Training strategies that include digital means provide opportunities for interaction and regular monitoring, which enhances athletes' understanding of the importance of nutrition in sports performance. The study also recommends future research to examine the long-term impact of digital interventions on athletes' nutrition and performance in sports competitions.

Limitations

This study had several limitations that should be acknowledged. First, the intervention period was limited to 3 months, which may not be sufficient to observe long-term behavioral changes in dietary habits or sustained improvements in nutrition knowledge. Second, the study relied on self-reported questionnaires, which may

introduce response bias or inaccuracies in assessing actual dietary behaviors. Third, the sample was limited to student-athletes from a single private university, which may restrict the generalizability of the findings to other populations or competitive levels. Additionally, the study did not assess actual performance outcomes, such as athletic performance or physical health indicators, which could provide a more comprehensive understanding of the intervention's impact. Finally, although the "MyFitnessPal" application was used as the primary digital tool, the study did not examine the differential impact of specific features within the app (e.g., tracking, educational modules, or interactive feedback), which could inform future improvements in app design and intervention strategies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Al-Ahliyya Amman University-College of Educational Sciences - Scientific Research Council. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

WA: Resources, Writing – original draft, Data curation, Software, Methodology, Investigation, Visualization, Writing – review & editing, Funding acquisition, Validation, Project administration, Conceptualization, Formal analysis, Supervision. AA: Writing – original draft, Writing – review & editing. SA-N: Writing – original draft. DA: Writing – original draft. KA: Writing – original draft. TA: Writing – original draft. BO: Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

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