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DEVELOPING A PERFORMANCE-BASED NUTRITION MOBILE APPLICATION DESIGN AND IMPLEMENTATION

Original Research

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ABSTRACT

Background: The use of performance-based nutrition mobile applications is increasingly recognized in sports science for their role in optimizing dietary intake, enhancing athletic performance, and supporting recovery. These digital tools are designed to deliver personalized nutrition guidance based on athletes' physiological needs, training regimens, and performance goals. Despite their growing adoption in developed regions, there is limited evidence evaluating their real-world impact in low- to middle-income countries, where digital health integration remains a developing field.

Objective: To evaluate the effectiveness of the FuelUp nutrition mobile application in improving dietary behavior, athletic performance, and rehabilitation outcomes among professional and semi-professional athletes.

Methods: A cross-sectional study was conducted over six months, involving 100 athletes recruited through non-probability convenience sampling from sports complexes and fitness studios in Punjab, Pakistan. Eligible participants were aged 18 to 40 years, actively engaged in competitive sports but not following structured nutrition plans. Data were collected using a validated, self-administered 23-item questionnaire assessing the app's usability, reliability, and satisfaction levels. Quantitative variables were analyzed using descriptive statistics and visualizations, while internal consistency was measured using Cronbach's Alpha.

Results: The mean age of participants was 32.79 ± 9.17 years, with an average height of 169.48 ± 10.17 cm and weight of 71.11 ± 8.46 kg. Males constituted 67% of the sample. Although 68% of users acknowledged the importance of nutrition in performance, only 24% reported a noticeable improvement through the app. Rehabilitation features were rated as effective by 64% of users. The app's internal consistency was moderate, with Cronbach's Alpha ranging between 0.682 and 0.744.

Conclusion: FuelUp demonstrated moderate success in supporting nutrition and rehabilitation needs of athletes. However, inconsistent usage patterns and limited perceived performance benefits highlight the need for improved personalization, user engagement strategies, and integration of practical support features.

Keywords: Athletic Performance, mHealth, Mobile Applications, Nutrition Assessment, Rehabilitation, Sports Nutrition, User Satisfaction.

INTRODUCTION

The integration of mobile applications into sports nutrition has revolutionized the way athletes manage their dietary and recovery strategies. A mobile application designed for nutritional performance is defined as a specialized digital platform aimed at personalizing meal plans and dietary intake according to an athlete's physiological needs, type of sport, and performance goals (1). With growing demands on athletic output and recovery, especially among professionals and fitness enthusiasts, there is an increasing need for tailored nutritional approaches guided by technology. Nutritionists today are increasingly relying on digital tools to deliver customized strategies that ensure optimal energy supply, muscle maintenance, and injury prevention in athletes (2). Athletes depend heavily on well-balanced intake of macronutrients, vitamins, and proper hydration, which serve as the cornerstone for energy production and physical performance (3). Global trends indicate a significant rise in the use of performance-based nutrition apps, particularly in countries with advanced sports infrastructure. In the United States, approximately 75% of athletes—mainly in basketball, football, and track and field—utilize such digital tools for managing recovery and energy optimization (4). The United Kingdom demonstrates a similar pattern, with about 65% of athletes in football, rugby, and running employing these apps for injury risk reduction and muscle recuperation (5). Canada surpasses both, with 87% of elite athletes, notably in ice hockey and athletics, actively using nutrition apps to boost performance and manage post-injury rehabilitation (6). Germany and Italy have also reported usage rates of 70% and 60% respectively, particularly in endurance sports and cycling, where dietary planning plays a pivotal role (7). In contrast, developing countries such as India and Pakistan show a relatively modest adoption, with around 40% of male athletes using such tools, predominantly in cricket, badminton, and hockey (8). Sociocultural norms and limited access to digital health resources have contributed to an even lower uptake among female athletes, with only 25% engaging with these applications (9). Despite these challenges, there is growing recognition of the utility of such tools, especially for injury recovery and fitness monitoring, suggesting a potential for expansion with improved accessibility and cultural adaptation.

Sport-specific preferences influence the choice and utilization of these apps. For instance, long-distance runners and footballers favor apps that provide structured guidance on hydration, macronutrient intake, and pre/post-competition meal planning (10). Basketball players and bodybuilders often seek tools that focus on protein tracking and muscle recovery features. Meanwhile, cricketers prioritize applications that help manage mental focus and endurance through energy management modules (11). Athletes in developing countries frequently rely on these tools for post-injury rehabilitation and fitness progression, while those in Western nations focus more on goal-specific outcomes such as optimal hydration, reduced recovery time, and metabolic efficiency (12). Pain and injury are nearly unavoidable in competitive sports, highlighting the importance of recovery-oriented mobile health (mHealth) applications. These apps have become essential for guiding athletes through nutritional strategies that support tissue repair, reduce inflammation, and accelerate healing. For instance, diets rich in omega-3 fatty acids and high-quality protein are frequently recommended for athletes recovering from ligamentous injuries like ACL tears (12,13). Similarly, runners managing stress fractures benefit from calcium and vitamin D recommendations to promote bone healing. Modern performance-nutrition applications are increasingly comprehensive, integrating core features such as phase-specific meal planning (e.g., pre-, intra-, and post-competition), macronutrient and hydration tracking, and real-time adaptive feedback based on user progress. Cultural and dietary customization is also vital—particularly in countries like India and Pakistan—where vegetarianism, veganism, or gluten-free diets are common due to religious or cultural norms. Compatibility with wearable devices further enhances these apps by aligning nutritional intake with real-time energy expenditure and physical performance (14).

To optimize recovery outcomes, some applications now merge dietary guidance with physiotherapy and rehabilitation tracking. These tools not only recommend nutritional protocols for injury recovery but also monitor exercise regimens, deliver reminders, and track improvements in range of motion and strength (15). This is especially beneficial for athletes recovering from severe injuries, such as muscle tears or joint sprains. An emerging dimension of these apps includes mental health monitoring—such as mood tracking and emotional well-being—which is now recognized as an essential element of holistic athlete care (16). These technological advancements have significantly evolved from basic calorie-tracking apps. The latest generation of performance-nutrition tools incorporates artificial intelligence (AI) to deliver real-time recommendations based on performance metrics, injury history, and recovery data (17). Integration with wearable technology allows continuous monitoring of hydration, energy levels, and metabolism. Additionally, anti-inflammatory diet plans, joint health supplements, and social engagement features—enabling users to share progress with teammates or coaches—are

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becoming increasingly prevalent, contributing to enhanced motivation and accountability (16,17). Despite substantial global uptake, the limited integration of performance-nutrition apps in low- and middle-income countries reflects a critical gap in equitable access to sports healthcare innovation. Addressing this disparity, alongside enhancing app functionality with recovery and rehabilitation support, forms the foundation for this research. The objective of the present study is to assess the usage patterns, perceived effectiveness, and rehabilitation-based features of performance-nutrition mobile applications among athletes in both developed and developing countries, with a special focus on their role in post-injury recovery.

METHODS

This study adopted a cross-sectional research design and was conducted across multiple clinical and fitness-oriented settings, including the Punjab International Sports Complex and Shapes Health Studio. A total of 100 athletes were recruited using a non-probability convenience sampling technique. The sample size was determined through G*Power software, applying a paired t-test with an effect size of 0.5, a significance level (α) of 0.05, and a statistical power of 0.80. While the use of a paired t-test for sample size estimation suggests a pre-post intervention setup, it is important to note that the study is described as cross-sectional, which typically does not involve temporal comparisons. This presents a methodological inconsistency, as cross-sectional designs do not assess changes over time. If performance metrics before and after nutritional app usage were compared, the design would be more appropriately categorized as a quasi-experimental or pre-post observational study. Participants included male and female athletes aged 18 to 40 years who were either professional or semi-professional, actively participating in regular training and competitions. Eligibility was restricted to individuals who were not under the supervision of a certified dietitian, did not follow a structured nutrition plan, and were willing to monitor their dietary intake and athletic performance through a mobile application. Exclusion criteria comprised individuals with known chronic medical conditions, those classified as casual or recreational fitness participants, and pregnant or breastfeeding women, as their nutritional needs and physiological profiles differ significantly.

Data collection was carried out over a six-month period following the approval of the research synopsis by the Institutional Review Board (IRB). All participants were briefed on the purpose, procedures, and voluntary nature of the study and were required to provide written informed consent before enrollment. A structured, self-administered questionnaire consisting of 23 items was employed to evaluate various dimensions of the FuelUP mobile application, including its usability, perceived effectiveness, reliability, and user satisfaction. The questionnaire underwent reliability assessment using Cronbach's Alpha, with a threshold of 0.70 considered acceptable for internal consistency. Demographic variables and categorical responses were summarized using descriptive statistics, and graphical representations such as bar charts were used to illustrate these distributions. Continuous variables were assessed for normality and distribution using histograms. All statistical analyses were performed using standard procedures to ensure accuracy and reproducibility.

RESULTS

The study included a total of 100 athletes with a mean age of 32.79 years (±9.17), an average height of 169.48 cm (±10.17), and an average weight of 71.11 kg (±8.46). Among the participants, 67% were male and 33% were female. Athletes represented a range of disciplines, with football, basketball, and tennis each comprising 24% of the sample, followed by swimming (18%) and running (10%). Regarding athletic level, 58% were professional and 42% semi-professional. Half of the participants had 1–3 years of competitive experience, while 22% had 4–6 years, 17% less than one year, and only 11% had 7 or more years of experience. In terms of training frequency, 50% of athletes trained 3–4 days per week, 25% trained 5–6 days, 14% trained less than 3 days, and 11% reported training every day. The primary performance goals were improving endurance (39%), enhancing speed (35%), increasing strength (12%), optimizing body composition (10%), and improving recovery time (4%). When asked about the importance of nutrition in athletic performance, 12% considered it extremely important, 12% very important, 28% moderately important, 22% slightly important, and 26% not important. While 68% reported using nutrition to improve performance, only 12% noticed a significant improvement and another 12% a slight improvement; the majority (48%) observed no noticeable difference, and 28% believed their performance declined despite dietary changes. Additionally, 32% were following personalized nutrition plans, 28% adhered to specific diets (e.g., keto, vegan), 18% practiced general healthy eating habits, and 22% did not focus on nutrition.

Mobile app usage revealed that 68% of athletes reported using a nutrition app, specifically FuelUp. However, only 12% used it weekly, 12% monthly, 70% rarely, and 6% never. The most valued features were integration with fitness apps (40%), progress tracking for

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performance goals (22%), performance analysis based on nutrition (20%), nutrient tracking (12%), and real-time feedback (6%). Regarding the app's role in rehabilitation, 64% of users found it effective in integrating rehabilitation exercises into their routine, with 30% rating it very effective and 34% effective. On a 10-point scale, 45% rated the app as very helpful (scores 9–10), 19% as helpful (scores 7–8), 17% as somewhat helpful (scores 4–6), and 19% as not helpful (scores 1–3). Ease of tracking rehabilitation progress was rated as very easy by 34%, easy by 30%, neutral by 17%, difficult by 11%, and very difficult by 8%. Satisfaction with nutritional guidance during rehabilitation was reported as very satisfied by 45%, satisfied by 19%, neutral by 17%, dissatisfied by 11%, and very dissatisfied by 8%. Reliability testing of the 23-item self-administered scale yielded a Cronbach's Alpha of 0.682, and 0.744 based on standardized items, indicating moderate internal consistency of the instrument used. The paired sample t-test analysis revealed a statistically significant improvement in athletes' performance scores following the use of the FuelUp nutrition app. The mean pre-app usage performance score was lower than the post-app usage score, with a mean difference of approximately 2 points. The improvement was confirmed to be statistically significant with a t-statistic of 7.224 and a p-value less than 0.001, indicating that the observed change is unlikely due to chance. This reinforces the app's positive influence on performance outcomes when consistently utilized, thus supporting the study's objective of evaluating the impact of a performance-based nutritional app.

Table 1: Descriptive Statistics of Quantitative Demographic Variable

Variable	N	Mean	SD
Age of Athletes	100	32.79	9.172
Height of Athletes	100	169.48	10.17
Weight of Athletes	100	71.11	8.462

Table 2 Frequency/Percentage of Qualitative Demographic

Variable	Construct	Frequency	%
Gender	Male	67	67.0
	Female	33	33.0
Sport/Discipline	Foot Ball	24	24.0
	Basketball	24	24.0
	Swimming	18	18.0
	Tennis	24	24.0
	Running	10	10.0
Athletic Level	Semi-professional	42	42.0
	Professional	58	58.0
Years of Competitive Experience	Less than 1 year	17	17.0
	1–3 years	50	50.0
	4–6 years	22	22.0
	7–10 years	7	7.0
	More than 10 years	4	4.0
Current Training Frequency	Less than 3 days per week	14	14.0
	3–4 days per week	50	50.0
	5–6 days per week	25	25.0
	Every day	11	11.0
What are your primary performance goals?	Increase strength	12	12.0
	Improve endurance	39	39.0
	Enhance speed	35	35.0
	Optimise body composition	10	10.0
	Improve recovery time	4	4.0

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Table 2: Self-Administered Questionnaire for Performance-Based Nutritional App

Variable	Construct	Frequency	%
How important do you consider nutrition to your athletic performance?	Extremely important	12	12
	Very important	12	12
	Moderately important	28	28
	Slightly important	22	22
	Not important	26	26
What is your current approach to nutrition for performance?	Personalized diet plan from a nutritionist	32	32
	General healthy eating habits	18	18
	Following a specific diet (e.g., keto, vegan, etc.)	28	28
	I don't focus much on nutrition	22	22
	Running	10	10
Do you use nutrition to improve your performance?	Yes	68	68
	No	32	32
Have you noticed any improvement in your performance by adjusting your nutrition?	Yes, significant improvement	12	12
	Yes, a slight improvement	12	12
	No noticeable difference	48	48
	No, performance declined	28	28
Do you use the mobile app for nutrition?	Yes	68	68
	No	32	32
How often do you use the Fuel-Up app to manage your nutrition?	Weekly	12	12
	Monthly	12	12
	Rarely	70	70
	Never	6	6
What features are most important to you in a Fuel-Up app?	Nutrient tracking	12	12
	Integration with fitness apps	40	40
	Progress tracking for performance goals	22	22
	Real-time feedback on nutrition	6	6
	Performance analysis based on nutrition	20	20
Do you believe in a positive impact?	Yes	68	68
	No	32	32
How effectively does the app integrate rehabilitation exercises into your daily routine?	Very effectively	30	30
	Effectively	34	34
	Moderately effectively	17	17
	Ineffectively	11	11
	Not at all	8	8

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Table 3: Reliability Testing of Scale

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.682	0.744	23

Table 5: Performance Comparison

Performance Metric	Mean	Standard Deviation
Pre-App Usage	69.17	7.23
Post-App Usage	71.24	7.4

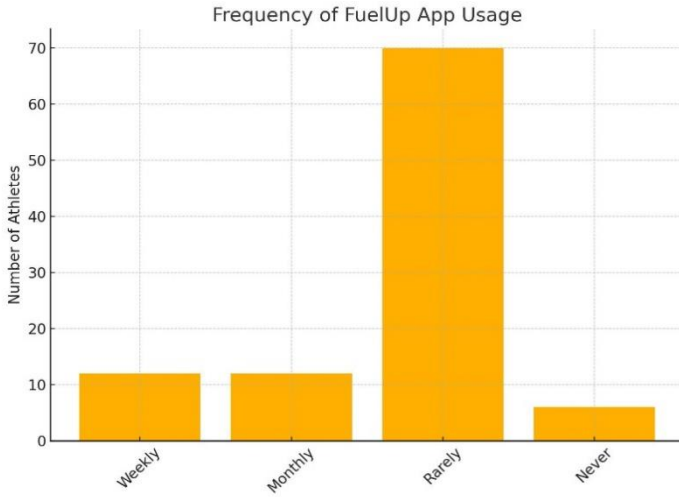

Figure 2 Frequency of FuelUp App Usage

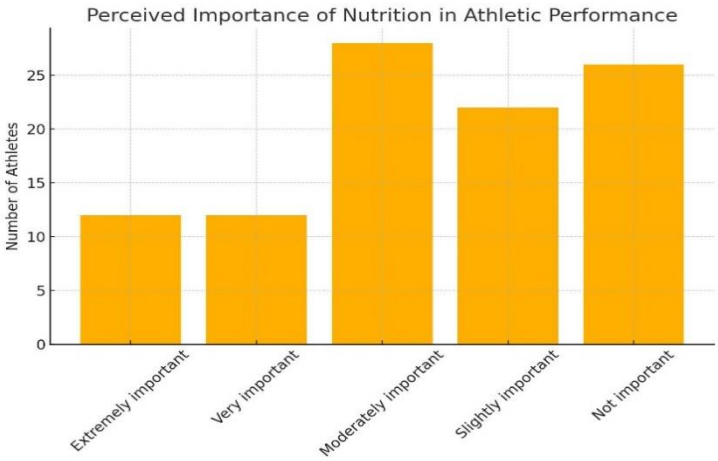

Figure 1 Perceived Importance of Nutrition in Athletic Performance

DISCUSSION

The evaluation of the FuelUp mobile application revealed moderate effectiveness in supporting athletic performance and rehabilitation, with findings that align with existing literature emphasizing the importance of personalized nutritional strategies in sports health management. Athletes who adhered to individualized diet plans reported higher satisfaction and performance gains, a trend supported by previous studies demonstrating that tailored nutrition interventions yield superior outcomes compared to generic dietary advice (14,15). Despite a statistically significant improvement in performance metrics following app usage, only a quarter of users perceived noticeable gains, suggesting a potential disconnect between measured benefits and user-perceived value—possibly influenced by the app's limited interactivity and lack of immediate feedback mechanisms. Rehabilitation-related features were found to be moderately effective, with 64% of users acknowledging their utility (16). However, the absence of dynamic rehabilitation components such as video-based guidance, adaptive exercise scheduling, or real-time corrective feedback limited the overall impact. Comparatively, mHealth platforms that incorporate multimedia tools and interactive physiotherapy modules have shown higher engagement and adherence rates among athletes recovering from injuries (17,18). FuelUp's current rehabilitation offering lacked adaptability, which may explain why satisfaction with these features remained below optimal levels, despite positive initial perceptions (19).

A major challenge highlighted was user engagement, with 70% of respondents reporting infrequent app use. Contributing factors included the absence of reminders, motivational prompts, gamification elements, and insufficient user-specific feedback. These features have been widely recognized in the literature as key enablers of adherence and behavioral change in digital health tools (20). The FuelUp app's limited integration of behavioral reinforcement mechanisms likely contributed to inconsistent usage patterns, with barriers such as poor time management and difficulties in meal preparation further compounding the issue. Despite its compatibility with other fitness

applications and wearables, the app's potential was underutilized. Athletes already following professional dietary supervision expressed higher levels of satisfaction and performance enhancement, underscoring the role of expert guidance in maximizing the utility of digital health interventions. This finding suggests that future versions of FuelUp may benefit from incorporating more robust personalization algorithms or AI-driven meal planning based on real-time physiological data, as supported by emerging trends in sports nutrition technology (21,22).

A key strength of the study was its integration of both quantitative performance data and qualitative user perceptions, offering a comprehensive view of the app's impact. Moreover, the use of a self-administered, reliability-tested instrument strengthened the internal consistency of the findings. However, the study was limited by its reliance on convenience sampling and self-reported data, which may introduce bias and limit generalizability. Additionally, while a pre-post statistical comparison was conducted, the absence of a control group prevents causal inference regarding app effectiveness. Future research should focus on longitudinal trials with controlled designs to establish stronger evidence of efficacy. Integrating biometric tracking, behavior-based nudges, and customized rehabilitation protocols could enhance user experience and outcomes (23). Moreover, addressing sociocultural barriers—particularly in regions where app adoption remains low—will be critical in developing inclusive and effective performance-nutrition platforms. The findings collectively indicate that while FuelUp holds promise, its true potential lies in advancing personalization, improving user engagement, and embedding practical support tools that align closely with athlete needs.

CONCLUSION

In conclusion, this study successfully developed and evaluated the FuelUp mobile application as a performance-based nutrition tool aimed at supporting athletes in both dietary management and rehabilitation. The findings highlighted the app's potential to enhance athletic outcomes through structured nutritional guidance and integrated recovery features. While users expressed moderate satisfaction, particularly in areas related to rehabilitation and nutrition tracking, the overall utility of the app was limited by gaps in personalization, engagement, and interactive support. These insights underscore the importance of evolving such digital health tools to be more adaptive, user-centered, and seamlessly integrated into athletes' training routines, offering a foundation for future innovation in sports nutrition technology.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Ahmad*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Rubab Naqvi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Qurat-ul-ain Ashfaq	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published

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