RESEARCH ARTICLE

Survey-Based Insights on the Role of Dietary Probiotics and Prebiotics in Optimizing Digestive Health and Physical Performance for Athletes

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Abstract: ***Background:*** The relationship between diet, digestive health, and physical performance is increasingly recognized, particularly among athletes. Probiotics and prebiotics have gained attention for their potential to enhance gut health and improve performance outcomes. However, limited research focuses on athletes' perceptions and experiences with these dietary components.

Aims: This study aims to explore athletes' perceptions of probiotics and prebiotics concerning their digestive health and physical performance, addressing the existing gap in the literature regarding their specific impact on athletic populations.

Methods: A cross-sectional survey was conducted with 425 athletes from various sports disciplines in Saudi Arabia. Participants completed a structured questionnaire assessing their consumption habits, awareness levels, beliefs about the effects of probiotics and prebiotics, and experiences with digestive health.

Results: The findings revealed a mean frequency of consumption of probiotics at 3.93 (SD = 1.62) and prebiotics at 4.22 (SD = 0.95), with awareness levels of 2.89 (SD = 2.23) for probiotics and 2.88 (SD = 2.12) for prebiotics. Males reported significantly higher beliefs in the impact of probiotics (mean: 4.14, $p = .0103$) and prebiotics (mean: 4.23, $p < .0001$) on physical performance compared to females. Significant differences in awareness were noted based on competitive level, with professionals exhibiting the highest awareness scores (probiotics: 4.07, prebiotics: 4.44, $p < .0001$).

Conclusion: The study underscores the importance of personalized nutrition strategies for athletes, highlighting the need for tailored probiotic and prebiotic interventions to optimize digestive health and enhance performance.

Keywords: Sports, probiotics, prebiotics, digestive health, physical performance, athletes.

1. INTRODUCTION

The relationship between diet, digestive health, and physical performance has garnered increasing attention in both scientific and athletic communities [1-3]. Among the many dietary strategies adopted to enhance well-being and athletic performance, the use of probiotics and prebiotics has emerged as a promising area of interest. Probiotics and prebiotics are often discussed together, as they work in synergy to maintain and improve gut health [4]. Their role in promoting digestive health, boosting immunity, and enhancing overall physical performance is increasingly being recognized, particularly among athletes seeking to optimize their health and maximize their physical capabilities [5, 6].

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Probiotics are live microorganisms, primarily bacteria and yeasts, which, when consumed in adequate amounts, confer health benefits to the host. These beneficial microorganisms help balance the gut microbiota, a complex community of microorganisms residing in the digestive tract [7]. The human gut contains trillions of microbes, including beneficial and harmful bacteria, and maintaining this balance is crucial for overall health. Probiotics are known to improve gut barrier function, prevent the colonization of harmful pathogens, and enhance the body's immune response. These microorganisms are commonly found in fermented foods, such as yogurt, kefir, and sauerkraut, as well as in dietary supplements [8].

Prebiotics, on the other hand, are non-digestible food components, typically fibers, that promote the growth and activity of beneficial bacteria in the gut. By serving as food for probiotics and other beneficial bacteria, prebiotics help

support a healthy gut microbiome [9]. They are found in various plant-based foods, such as bananas, onions, garlic, and whole grains. Prebiotics play a critical role in enhancing gut microbiota diversity, which is essential for efficient digestion, nutrient absorption, and maintaining a healthy immune system. Together, probiotics and prebiotics form a powerful duo in promoting gut health and, by extension, overall well-being [10].

The gut microbiota has far-reaching effects beyond digestion. Recent research [11, 12] has highlighted the connection between gut health and physical performance, particularly in athletes. A well-balanced gut microbiome not only supports efficient digestion and nutrient absorption but also plays a role in regulating inflammation and oxidative stress, factors that can significantly affect athletic performance and recovery. Athletes often face unique physiological demands, such as intense physical exertion and psychological stress, which can disrupt gut health, leading to gastrointestinal discomfort, impaired nutrient absorption, and weakened immune function. The inclusion of probiotics and prebiotics in athletes' diets has been shown to enhance immune function, improve gut integrity, and potentially improve performance by reducing exercise-induced inflammation and promoting quicker recovery [13].

Despite the promising evidence, a significant gap remains in the literature regarding the direct impact of dietary probiotics and prebiotics on digestive health and physical performance in athletes [14, 15]. While many studies have explored their benefits in the general population [16-18], few have specifically focused on athletes, who may experience different gut health dynamics due to their intensive training regimens and dietary habits. Furthermore, the type, dosage, and combination of probiotics and prebiotics that can yield optimal results for athletes remain unclear.

Several studies have highlighted the potential of probiotics in enhancing digestive health. Shing *et al*. [19] found that probiotics, particularly strains such as *Lactobacillus* and *Bifidobacterium*, improved gut barrier function and reduced gastrointestinal distress in endurance athletes. This aligns with the understanding that intense physical activity can disrupt gut integrity, leading to conditions such as leaky gut syndrome. By improving gut permeability and reducing inflammation, probiotics may alleviate common gastrointestinal issues faced by athletes, such as bloating, cramps, and diarrhea during or after exercise.

However, not all studies report consistent results. Costa *et al*. [20] conducted a placebo-controlled trial on endurance athletes and found no significant difference in gastrointestinal symptoms between the probiotic and placebo groups, suggesting that the efficacy of probiotics may vary depending on individual factors, such as baseline gut health and the intensity of exercise. Moreover, the strain-specific nature of probiotics complicates the development of generalized recommendations. West *et al*. [21] emphasized that while some probiotic strains effectively reduced exercise-induced gastrointestinal issues, others had no notable impact, suggesting the need for personalized approaches to probiotic supplementation.

1.1. Prebiotics and Digestive Health

Prebiotics, often combined with probiotics in synbiotic supplements, are gaining recognition for their role in supporting gut microbiota diversity and overall gut health. Slavin [22] demonstrated that prebiotics, such as inulin and Fructooligosaccharides (FOS), stimulate the growth of beneficial gut bacteria, which enhances digestion and improves nutrient absorption. This is particularly important for athletes, whose high energy demands require efficient digestion and nutrient uptake. Hoffman *et al*. [23] noted that prebiotics can also enhance the gut's immune response, providing additional protection against pathogens, which is crucial for athletes who are more susceptible to infections due to rigorous training regimens.

Despite these benefits, some studies raise concerns about gastrointestinal tolerance to prebiotics. Axelrod *et al*. [24] noted that high doses of prebiotics, particularly in fiber-rich diets, can lead to adverse effects such as bloating and gas, potentially offsetting the digestive benefits. This raises the question of optimal dosage for athletes, who may already have high-fiber diets. More research is needed to determine the precise quantities of prebiotics that confer digestive health benefits without causing discomfort.

1.2. Probiotics, Prebiotics, and Physical Performance

The impact of probiotics and prebiotics on physical performance is an emerging area of research, with mixed results. Jäger *et al*. [25] reported that probiotic supplementation improved endurance and recovery in athletes by reducing inflammation and oxidative stress, two critical factors that influence performance. Their study showed that athletes taking probiotics had reduced muscle soreness and faster recovery times, which they attributed to the anti-inflammatory properties of probiotics. This is supported by Huang *et al*. [26], who found that probiotics reduced markers of muscle damage post-exercise and improved time-to-exhaustion in endurance athletes. Contrarily, Pugh *et al*. [27] found minimal effects of probiotics on actual performance metrics, such as VO2 max, sprint times, or power output, although improvements were observed in subjective measures like fatigue and recovery perception. These findings suggest that while probiotics may not directly enhance physical performance in terms of measurable outputs, they contribute to the overall well-being of athletes, potentially improving their ability to train and recover efficiently.

For prebiotics, the evidence regarding their direct impact on physical performance is less established. Gleeson *et al*. [28] suggested that prebiotics could indirectly support performance by improving gut health and enhancing nutrient absorption; however, there is limited direct evidence linking prebiotics to enhanced athletic performance. Most studies focus on the immune-modulating and gut health benefits, which can indirectly influence performance by reducing illness and gastrointestinal distress.

1.3. Combined Use: Synbiotics

The combination of probiotics and prebiotics, known as synbiotics, is proposed as a potentially more effective approach to enhancing both digestive health and physical performance. Studies [13, 29, 30] have demonstrated that synbiotic supplementation in athletes results in improved gut microbiota diversity, reduced gastrointestinal discomfort, and enhanced overall well-being. The synergistic effect of probiotics and prebiotics appears to offer broader benefits, including improved nutrient absorption and enhanced immune system function. However, Di Dio *et al*. [31] emphasized the need for more rigorous, long-term studies to verify these results and identify the best combinations of strains and prebiotic types.

While a growing body of evidence supports the beneficial effects of probiotics and prebiotics on digestive health and performance [32-34], significant gaps remain. One major limitation across many studies is the small sample sizes and short duration of interventions, which may not capture the long-term effects of supplementation [13]. Moreover, many studies [3,5,7] fail to account for individual differences in gut microbiota composition, diet, and exercise intensity, all of which can significantly influence the outcomes of probiotic and prebiotic interventions. Sanders *et al*. [5] also highlighted the lack of standardization in the strains and dosages used across studies, making it difficult to draw generalized conclusions.

Given the increasing interest in dietary strategies to enhance athletic performance, the lack of concrete data on the role of probiotics and prebiotics in optimizing digestive health and physical performance in athletes presents a research gap. This study aims to address this gap by conducting a survey-based investigation to gain insights into how athletes perceive and utilize probiotics and prebiotics in their diets, as well as how these dietary components may influence their digestive health and physical performance. Through this research, the study seeks to provide a clearer understanding of the potential benefits of probiotics and prebiotics in the athletic population and inform future dietary recommendations.

2. METHODS

A cross-sectional survey design was adopted in this study. The selection of different approaches and the procedures adopted are explained in the following sections.

2.1. Study Settings and Participants

The survey will be conducted online to ensure broad participation across different athletic disciplines and geographical regions. The target population for the study will consist of athletes from different sports clubs across Saudi Arabia, who engage in regular training, both amateur and professional, across a range of sports disciplines, such as endurance sports (*e.g*., running, cycling, swimming), strength-based sports (*e.g*., weightlifting, bodybuilding), and team sports (*e.g*., football, basketball, rugby). This diverse approach will enable a comprehensive understanding of how probiotics and prebiotics impact different types of athletic performance and digestive health outcomes.

The survey was distributed through multiple channels to ensure a diverse and representative sample of athletes across Saudi Arabia. Social media platforms such as Twitter (X), Instagram, and Snapchat were utilized, with targeted posts in fitness and sports-related groups, collaborations with local influencers, and direct outreach to relevant users. Athletic forums, including Saudi-based online communities, such as the Saudi Sports Federation Forum and local fitness discussion boards, were leveraged by engaging in discussion threads and working with moderators to promote participation. Additionally, direct outreach was conducted through sports clubs and organizations, such as Al Hilal FC, Al Nassr FC, the Saudi Olympic and Paralympic Committee, and regional fitness centers. Survey links were shared *via* email newsletters, WhatsApp and Telegram groups, and official club communication channels. This multi-faceted approach maximized participant reach and ensured engagement from athletes across various sports disciplines and competitive levels.

2.2. Participant Inclusion Criteria

Participants were required to meet the following criteria:

- **Age**: Athletes aged 18 years and above were eligible to participate. This age range ensures that participants have the ability to independently manage their dietary needs and provide informed consent.
- **Training Regimen**: Participants were required to engage in structured athletic training for a minimum of four hours per week. This criterion is designed to focus on individuals who have an active training regimen, which is more likely to place physical stress on their bodies and influence gut health.
- **Dietary Awareness**: Participants should have a basic understanding of their dietary habits, including whether or not they regularly consume foods or supplements containing probiotics and/or prebiotics.
- **Health Status**: Only athletes who report no diagnosed chronic gastrointestinal diseases (*e.g*., Crohn's disease, ulcerative colitis) were included, as these conditions could confound the relationship between diet, gut health, and performance outcomes.

2.3. Participant Exclusion Criteria

Participants were excluded from the study if they:

- Have taken antibiotics within the past three months, as antibiotics significantly alter the gut microbiota and could skew the results regarding probiotics and prebiotics' effects.
- Were currently on a medically prescribed diet for gastrointestinal or metabolic conditions (*e.g*., celiac disease, irritable bowel syndrome).
- Were pregnant or breastfeeding, as hormonal changes during these periods can affect both gut health and phys-

ical performance, potentially confounding the study results.

2.4. Sampling

A stratified random sampling method [35] is employed in this study to ensure a representative sample of the Saudi Arabian athletes across different regions and demographic groups. The sample is stratified based on key variables, including sports discipline, level of competition, age, gender, and education. This approach ensures that all significant subgroups within the population are adequately represented in the study. Within each stratum, participants are randomly selected to reduce selection bias and increase the generalizability of the findings. The target sample size is approximately 400 participants (based on an estimated sample of 383), distributed proportionally across the selected sports clubs. This sample size is designed to provide sufficient statistical power for analyzing variations in participants' perceptions.

The sample size for this study was determined using Cochran's formula [36], a widely used statistical method for calculating an appropriate sample size in survey research. Given the large and diverse population of athletes in Saudi Arabia, the sample was designed to ensure representativeness across different sports disciplines, competitive levels, and demographic characteristics. Based on an estimated population proportion of 50% (which provides the maximum variability), a 95% confidence level, and a 5% margin of error, the minimum required sample size was calculated to be 383 participants. To account for potential non-responses or incomplete data, the final target sample was increased to 425 athletes, ensuring sufficient statistical power to detect meaningful differences between groups.

To assess the adequacy of the sample size in achieving reliable and statistically significant results, post-hoc power analysis was performed using G*Power software. The results confirmed that the sample size provided a statistical power exceeding 0.80, which is generally considered acceptable for detecting medium to large effect sizes in comparative analyses. This validation supports the robustness of the findings and ensures that the study results are generalizable to the broader athletic population in Saudi Arabia.

2.5. Questionnaire Design

The survey questionnaire is designed to gather insights into athletes' use of probiotics and prebiotics as well as their effects on digestive health and physical performance. It begins with participant information, including a brief explanation of the survey's purpose, confidentiality assurances, and eligibility criteria, ensuring that only athletes aged 18 years or above who engaged in competitive training participate. The demographics section collects data on age, gender, sport discipline, level of competition, training frequency, and years of involvement in their sport. The core of the survey employs Likert-scale questions to assess the frequency of probiotics and prebiotics consumption [37], athletes' beliefs regarding their impact on digestive health and physical performance [38], and their effectiveness in managing gastrointestinal issues [39]. This structured approach allows for a comprehensive analysis of athletes' perceptions and experiences with these dietary components.

A certified translator [40] translated the questionnaire from English to Arabic. The accuracy of the translated version was subsequently validated by two professors from the eHealth department at King Faisal University. They proposed several grammatical adjustments, which were incorporated into the Arabic version of the questionnaire. To further refine the instrument, a pilot study was conducted with a sample of 14 athletes. The data collected from this exploratory study were analyzed, and the Cronbach's alpha coefficient was calculated for all items. The coefficient exceeded 0.7, indicating robust internal consistency and reliability of the questionnaire [41].

2.6. Data Collection

Data for this study were collected over a four-week period using a structured survey questionnaire, available in both English and Arabic. The questionnaire was distributed exclusively through online platforms to ensure broad accessibility and convenience for participants across various regions in Saudi Arabia, including urban, suburban, and rural areas. The online distribution leveraged social media, email networks, and community forums to reach a diverse population. This digital approach facilitated the collection of comprehensive data, ensuring participants could complete the survey at their convenience. At the end of four weeks, 487 responses were received, out of which 62 responses were incomplete. After removing incomplete responses, a final sample of 425 was considered for data analysis.

2.7. Data Analysis

To achieve the study's objectives, the data were analyzed using the Statistical Package for the Social Sciences (SPSS, IBM Version 24). Descriptive statistics, including means and standard deviations, were employed to present the demographic characteristics of the participants. Additionally, a two-sample t-test with unequal variances and a one-way ANOVA were conducted to further analyze the data.

2.8. Ethical Considerations

The study received approval from the research ethics committee at King Faisal University (KFU-REC-2024-OCT-ETHICS2705). Informed consent was obtained from all participants before their involvement. To ensure confidentiality and data security, responses were anonymized, and data were stored on secure servers. The study adhered to all relevant ethical standards, with no reported conflicts of interest or external funding sources, thereby upholding research integrity and minimizing bias.

3. RESULTS

The demographic data in Table **1** indicates a sample predominantly composed of males (58.1%), with females representing 41.9% of the participants. In terms of sports types,

Table 1. Participants demographics.

	Variables	N	Relative Frequency
Gender	Male	247	58.1%
	Female	178	41.9%
Type of Sports	Artistic Sports	12	2.8%
	Combat Sports	60	14.1%
	Endurance Sports	110	25.9%
	Motor Sports	32	7.5%
	Strength Sports	50	11.8%
	Team Sports	161	37.9%
Engagement with sports (in years)	1-3	127	29.9%
	4-6	167	39.3%
	7-10	68	16.0%
	> 10	63	14.8%
Competitive level	Amateur	169	39.8%
	Semi-Professional	183	17.2%
	Professional	73	43.1%

the majority of participants engage in team sports (37.9%), followed by endurance sports (25.9%) and combat sports (14.1%). Artistic, motor, and strength sports are less represented, with artistic sports having the lowest participation rate at 2.8%. Regarding engagement duration, the largest group has been involved in sports for 4-6 years (39.3%), while 29.9% have 1-3 years of experience. A smaller proportion has more extensive experience, with 16% participating for 7-10 years and 14.8% for over 10 years. Competitively, the majority of participants identify as amateurs (39.8%), followed closely by semi-professionals (17.2%), and professionals make up 43.1%, indicating a well-rounded representation of skill levels.

The data in Table **2** highlight participants' consumption habits, awareness, beliefs, and perceived effects of prebiotics and probiotics. Probiotics are consumed at a relatively high frequency (mean: 3.93), which is slightly lower than that of prebiotics (mean: 4.22). Awareness levels for both prebiotics and probiotics are moderate, with nearly identical mean values (2.89 for probiotics and 2.88 for prebiotics). Participants generally believe that probiotics have a more positive impact on digestive health (mean: 3.81) and physical performance (mean: 4.02) than prebiotics, with respective belief scores of 2.93 and 3.64.

Regarding effects, both prebiotics and probiotics are perceived to improve digestive health, with very similar scores (probiotics: 3.89, prebiotics: 3.83). However, prebiotics are seen as more effective in alleviating gastrointestinal issues (mean: 3.99) compared to probiotics (mean: 3.6). Interestingly, prebiotics have a slightly higher mean score (3.89) for improving physical performance compared to probiotics (3.79). Participants report occasionally experiencing gastrointestinal issues (mean: 2.82) but tend to manage these issues through dietary changes (mean: 3.73). Overall, the data suggests a stronger belief in the benefits of probiotics for physical performance, but prebiotics are more highly rated for managing gastrointestinal issues.

Fig. (**1**) indicates that prebiotics are consumed slightly more frequently than probiotics across all age groups. The highest consumption for both is observed in the 40-49 years group (4.06 for probiotics and 4.75 for prebiotics), while the lowest is in the ≥50 years group (3.5 for probiotics and 3.87 for prebiotics). Younger adults (18-29 years) also show relatively high consumption, whereas the 30-39 years group has slightly lower values. This suggests that middle-aged adults may be more health-conscious regarding gut health, while older adults consume these supplements less frequently.

Fig. (**2**) suggests that awareness of probiotics and prebiotics varies across age groups, with prebiotic awareness being slightly higher overall. The highest awareness is found in the 30-39 years group (3.03 for probiotics and 3.08 for prebiotics), while the lowest is found in the 18-29 years group for prebiotics (2.73) and in the ≥50 years group for probiotics (2.75). The 40-49 years group shows moderate awareness levels. This pattern indicates that middle-aged adults (30-39 years) are the most informed about probiotics and prebiotics, whereas younger and older adults have comparatively lower awareness.

Fig. (**3**) indicates that participants generally believe in the positive impact of probiotics on digestive health more than

Table 2. Frequency of consumption, awareness, beliefs, and effects of prebiotics and probiotics.

Factors		Probiotics (Mean Values)	Prebiotics (Mean Values)
Frequency of consumption (1: Never; 5: Regular)		3.93	4.22
Awareness (1: very low; 5: Very high)		2.89	2.88
Beliefs	Positive impact on digestive health (1: Strongly disagree; 5: Strongly agree)	3.81	2.93
	Positive impact on Physical performance (1: Strongly disagree; 5: Strongly agree)	4.02	3.64
Effects	Improved digestive health (1: Strongly disagree; 5: Strongly agree)	3.89	3.83
	Improved Physical performance (1: Strongly disagree; 5: Strongly agree)	3.79	3.89
	Alleviated gastrointestinal issues (1: Strongly disagree; 5: Strongly agree)	3.6	3.99
Frequently experience gastrointestinal issues (1: Strongly disagree; 5: Strongly agree)		2.82	
Manage gastrointestinal issues through dietary changes (1: Strongly disagree; 5: Strongly agree)		3.73	

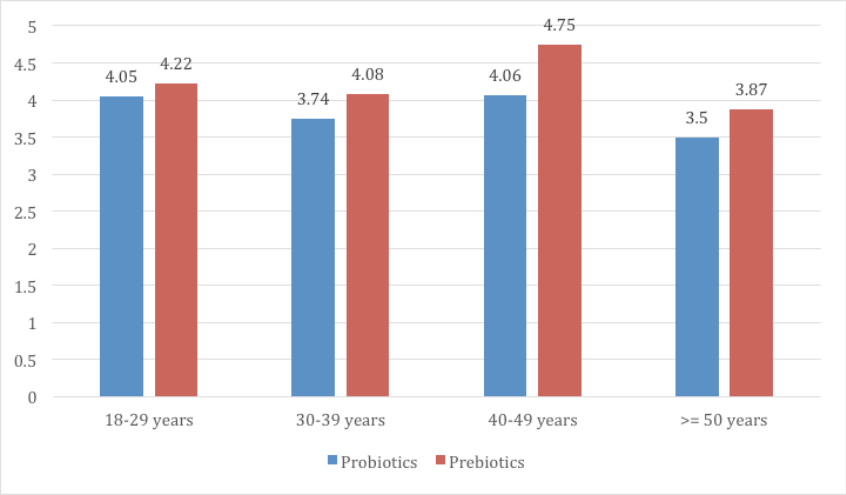

Fig. (1). Mean values related to the frequency of consuming probiotics and prebiotics rated on a scale (1: Never; 5: Regularly) across participants' age groups. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

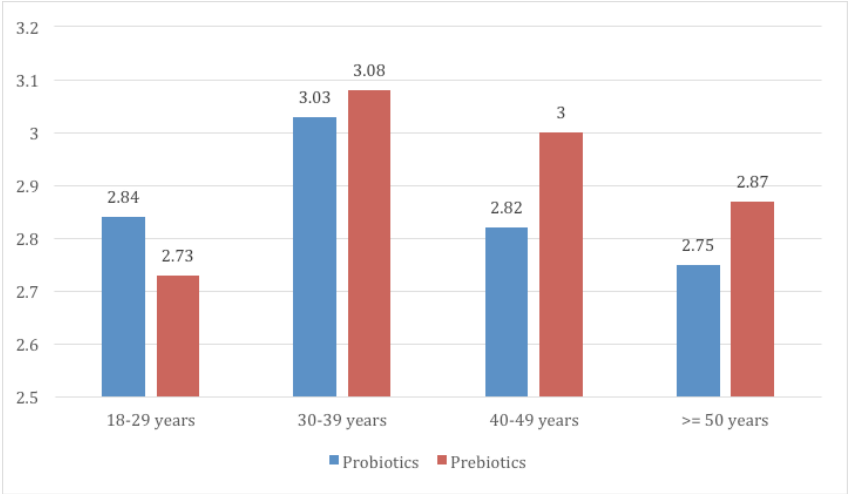

Fig. (2). Mean values related to awareness of probiotics and prebiotics rated on a scale (1: Never; 5: Regularly) across participants' age groups. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

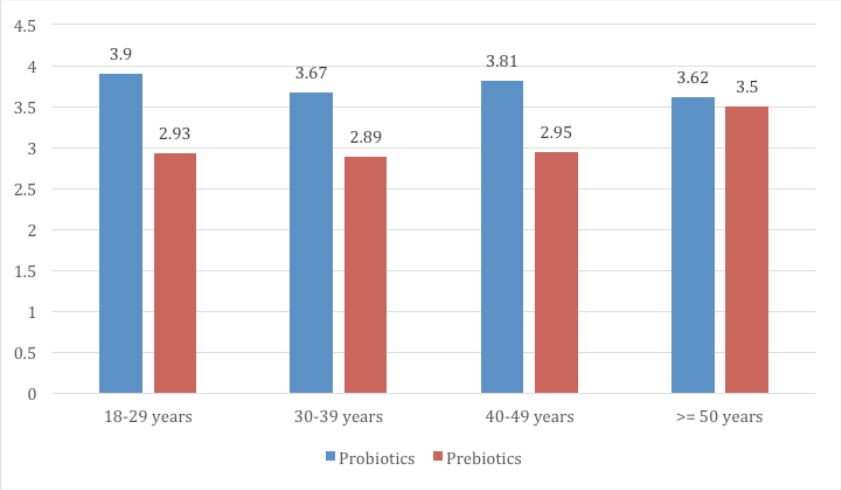

Fig. (3). Mean values related to the belief that probiotics and prebiotics have a positive impact on digestive health rated on a scale (1: Strongly Disagree; 5: Strongly Agree) across participants' age groups. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

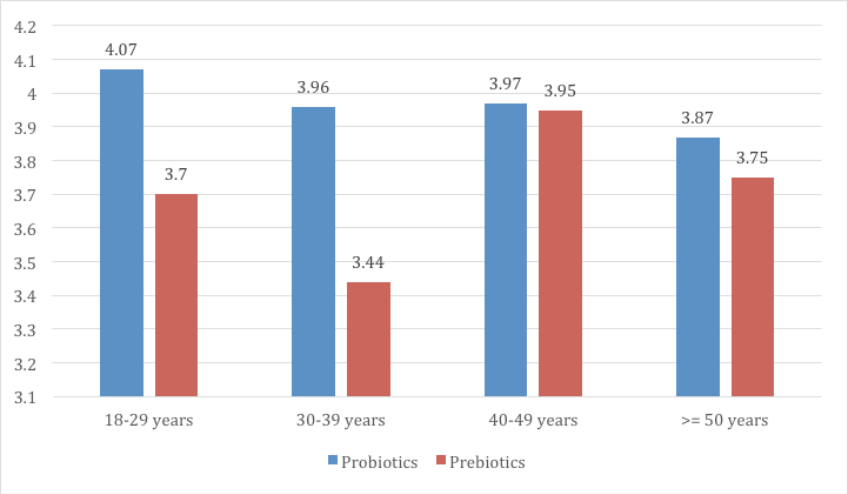

Fig. (4). Mean values related to the belief that probiotics and prebiotics have a positive impact on physical performance rated on a scale (1: Strongly Disagree; 5: Strongly Agree) across participants' age groups. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

prebiotics. Probiotic belief scores are relatively high across all age groups, with the highest in the 18-29 years group (3.9) and the lowest in the ≥50 years group (3.62). In contrast, belief in the benefits of prebiotics is lower overall, but it increases with age, reaching its highest value in the ≥50 years group (3.5). This suggests that while younger individuals have stronger faith in probiotics, older adults tend to recognize the benefits of prebiotics more than younger age groups.

Fig. (**4**) suggests that participants generally believe probiotics have a greater positive impact on physical performance than prebiotics. The highest belief in probiotics is among the 18-29 years group (4.07), while the lowest is in the ≥50 years group (3.87). For prebiotics, belief increases with age, peaking in the 40-49 years group (3.95). This trend suggests that younger individuals associate probiotics more with physical performance, whereas middle-aged adults (40-49 years) have a relatively higher belief in the benefits of prebiotics for performance.

The t-test results (Table **3**) show no significant gender differences in the frequency of consumption or awareness of probiotics and prebiotics. However, males tend to believe more strongly in the positive impact of probiotics and prebiotics on physical performance, with statistically significant differences (probiotics $p = .0103$; prebiotics $p < .0001$). Both genders perceive similar effects on digestive health and physical performance. While females rate prebiotics slightly higher for alleviating gastrointestinal issues, this difference is not significant. The main gender difference lies in beliefs about physical performance.

The ANOVA results in Table **4** reveal several significant differences in participants' perceptions based on the type of

Table 3. T-test results assessing the difference between participants' perceptions based on their gender.

Factors	Gender	N	Probiotics			Prebiotics		
			Mean	Variance	*p*-value	Mean	Variance	p-value
Frequency of Consumption	Male	247	3.98	1.62	.4795	4.30	1.02	.0654
	Female	178	3.89	1.58		4.11	1.13	
Awareness	Male	247	2.93	2.23	.6385	2.86	2.75	.7623
	Female	178	2.86	2.01		2.91	2.34	
Positive impact on digestive health (beliefs)	Male	247	3.85	1.16	.4355	2.91	1.45	.6203
	Female	178	3.76	1.51		2.97	1.54	
Positive impact on Physical performance (beliefs)	Male	247	4.14	0.86	.0103*	4.23	1.05	< .0001*
	Female	178	3.87	1.57		2.84	1.92	
Improved digestive health (effects)	Male	247	3.88	1.41	.8217	3.79	1.62	.3777
	Female	178	3.90	1.32		3.89	1.44	
Improved Physical performance (effects)	Male	247	3.76	1.70	.4654	3.87	1.39	.4941
	Female	178	3.85	1.49		3.94	1.23	
Alleviated gastrointestinal issues (effects)	Male	247	3.68	1.83	.1377	3.94	1.50	.2579
	Female	178	3.48	1.98		4.07	1.37	

* Statistically significant difference at a .05 confidence interval.

sport played. Awareness of probiotics differs significantly (p = .0131), with artistic sports participants showing the highest awareness (mean = 4.00), while motor sports participants have the lowest (mean = 2.53). For prebiotics, there is a significant difference in beliefs about their impact on physical performance (p = .0006), with motor sports participants reporting the highest belief (mean = 4.56) and endurance sports participants the lowest (mean = 3.40).

No significant differences were found in the frequency of consumption, beliefs about digestive health, or the effects of probiotics or prebiotics across different sport types. However, artistic sports participants report significantly higher perceptions that probiotics alleviate gastrointestinal issues (mean = 4.17; p = .0297) compared to other sports. Overall, awareness and specific beliefs about physical performance and gastrointestinal benefits show the most variation across sport types.

The ANOVA results in Table **5** highlight several significant differences in perceptions based on participants' years of experience in sports. For prebiotics, a significant difference is observed in the frequency of consumption (p < .0001), with participants who have 4-6 years and 7-10 years of experience consuming prebiotics more frequently (means = 4.45 and 4.44) than participants with over 10 years or 1-3 years of experience. However, for probiotics, no significant difference is observed in consumption frequency across experience levels (p = .1066). Awareness of probiotics shows a significant difference (p = .0001), with participants having 1-3 years of experience exhibiting the highest awareness (mean = 3.28), while those with 7-10 years of experience have the lowest (mean = 2.51). No significant difference is found for prebiotic awareness. A significant difference in beliefs about the impact of prebiotics on digestive health is observed (p = .0208), with participants who have 1-3 years of experience holding stronger beliefs in the positive effects (mean = 3.20). Meanwhile, no significant difference is seen for probiotics in this category. For the positive impact on physical performance, participants with over 10 years of experience have the highest belief in probiotics (mean = 4.32, p = .0007), while no significant differences are found for prebiotics. In terms of the actual effects on digestive health, physical performance, and alleviation of gastrointestinal issues, no significant differences are found across experience levels for either probiotics or prebiotics. The only borderline case is gastrointestinal issues alleviated by probiotics (p = .089), where more experienced participants (those with over 10 years of experience) rate the effect slightly higher. In summary, the most significant differences across experience levels are in the frequency of prebiotic consumption, awareness of probiotics, and beliefs about the positive impact of probiotics on physical performance.

The ANOVA results in Table **6** highlight several significant differences in participants' perceptions based on their competitive level. Awareness of both probiotics and prebiotics shows a highly significant difference (p < .0001) across groups, with professionals having the highest awareness (means = 4.07 for probiotics and 4.44 for prebiotics), while amateurs report the lowest (means = 2.17 and 1.54, respectively). For beliefs about the positive impact of probiotics on digestive health, amateurs report the highest

Table 4. ANOVA results assessing the difference between participants' perceptions based on the type of sport played.

Factors	Type of Sports	N	Probiotics			Prebiotics		
			Mean	Variance	*p*-value	Mean	Variance	*p*-value
Frequency of Consumption	Artistic Sports	12	3.58	1.72	.3051	4.50	0.45	.5029
	Combat Sports	60	3.83	1.77		4.03	1.35	
	Endurance Sports	110	4.03	1.49		4.23	1.06	
	Motor Sports	32	3.94	1.61		4.44	0.90	
	Strength Sports	50	4.26	1.14		4.26	1.09	
	Team Sports	161	3.84	1.73		4.21	1.04	
Awareness	Artistic Sports	12	4.00	1.27	.0131*	3.67	2.42	.4852
	Combat Sports	60	2.87	1.81		2.88	2.68	
	Endurance Sports	110	2.79	2.31		2.93	2.64	
	Motor Sports	32	2.53	1.93		2.81	2.35	
	Strength Sports	50	3.34	2.11		3.04	2.77	
	Team Sports	161	2.84	2.11		2.76	2.48	
Positive impact on digestive health (beliefs)	Artistic Sports	12	3.67	0.97	.8659	2.75	1.66	.7454
	Combat Sports	60	3.83	1.26		2.85	1.32	
	Endurance Sports	110	3.75	1.26		2.87	1.49	
	Motor Sports	32	4.03	1.26		3.19	1.90	
	Strength Sports	50	3.86	1.39		2.86	1.47	
	Team Sports	161	3.80	1.39		2.99	1.47	
Positive impact on Physical performance (beliefs)	Artistic Sports	12	4.08	0.81	.1478	4.25	1.11	.0006*
	Combat Sports	60	4.28	0.95		3.72	1.70	
	Endurance Sports	110	3.85	1.31		3.40	1.91	
	Motor Sports	32	3.88	1.08		4.56	0.64	
	Strength Sports	50	3.94	1.24		3.68	2.02	
	Team Sports	161	4.10	1.17		3.55	2.00	
Improved digestive health (effects)	Artistic Sports	12	3.17	1.79	.0796	3.50	1.91	.7502
	Combat Sports	60	3.87	1.37		3.90	1.35	
	Endurance Sports	110	3.90	1.27		3.95	1.66	
	Motor Sports	32	3.59	1.80		3.81	1.32	
	Strength Sports	50	4.18	1.38		3.78	1.48	
	Team Sports	161	3.91	1.28		3.76	1.59	
Improved Physical performance (effects)	Artistic Sports	12	3.17	1.79	.3141	3.50	1.55	.1841
	Combat Sports	60	3.87	1.47		3.90	1.21	
	Endurance Sports	110	3.85	1.36		3.97	1.13	
	Motor Sports	32	3.78	1.72		4.03	0.87	
	Strength Sports	50	4.04	1.63		4.18	1.25	
	Team Sports	161	3.71	1.78		3.76	1.57	
Alleviated gastrointestinal issues (effects)	Artistic Sports	12	4.17	1.24	.0297*	4.08	1.72	.851
	Combat Sports	60	3.43	2.22		3.82	1.47	
	Endurance Sports	110	3.51	1.96		4.02	1.43	
	Motor Sports	32	3.47	1.61		3.97	1.39	
	Strength Sports	50	4.16	1.24		4.12	1.29	
	Team Sports	161	3.53	1.95		4.01	1.51	

* Statistically significant difference at a .05 confidence interval.

Table 5. ANOVA results assessing the difference between participants' perceptions based on their experience of playing sports.

Factors	Experience (in Years)	N	Probiotics			Prebiotics		
			Mean	Variance	*p*-value	Mean	Variance	*p*-value
Frequency of Consumption	1-3	127	3.83	1.74	.1066	3.98	1.37	< .0001*
	4-6	167	4.01	1.37		4.45	0.73	
	7-10	68	4.18	1.16		4.44	0.70	
	> 10	63	3.70	2.31		3.87	1.37	
Awareness	1-3	127	3.28	2.05	.0001*	3.01	2.60	.5126
	4-6	167	2.87	2.13		2.77	2.59	
	7-10	68	2.51	1.93		3.01	2.37	
	> 10	63	2.62	2.11		2.79	2.71	
Positive impact on digestive health (beliefs)	1-3	127	3.64	0.99	.1662	3.20	1.14	.0208*
	4-6	167	3.93	1.21		2.80	1.50	
	7-10	68	3.76	1.73		2.74	1.84	
	> 10	63	3.89	1.68		2.95	1.59	
Positive impact on Physical performance (beliefs)	1-3	127	4.17	1.20	.0007*	3.51	1.66	.4308
	4-6	167	3.97	1.15		3.67	1.93	
	7-10	68	3.62	1.31		3.63	2.33	
	> 10	63	4.32	0.77		3.86	1.74	
Improved digestive health (effects)	1-3	127	3.82	1.36	.1969	3.87	1.64	.5203
	4-6	167	3.81	1.40		3.89	1.45	
	7-10	68	3.99	1.33		3.63	1.28	
	> 10	63	4.14	1.32		3.81	1.90	
Improved Physical performance (effects)	1-3	127	3.72	1.55	.1853	3.82	1.31	.1993
	4-6	167	3.72	1.67		3.84	1.30	
	7-10	68	3.81	1.65		3.93	1.44	
	> 10	63	4.11	1.49		4.17	1.24	
Alleviated gastrointestinal issues (effects)	1-3	127	3.62	1.90	.089	3.87	1.54	.2422
	4-6	167	3.68	2.01		4.10	1.32	
	7-10	68	3.22	1.85		4.10	1.29	
	> 10	63	3.75	1.52		3.84	1.72	

* Statistically significant difference at a .05 confidence interval.

Table 6. ANOVA results assessing the difference between participants' perceptions based on their experience of competitive level.

Factors	Competitive level	N	Probiotics			Prebiotics		
			Mean	Variance	*p*-value	Mean	Variance	*p*-value
Frequency of Consumption	Amateur	169	4.08	1.45	.1606	4.28	0.95	.3479
	Semi-Professional	183	3.82	1.70		4.23	1.12	
	Professional	73	3.92	1.66		4.07	1.20	
Awareness	Amateur	169	2.17	1.58	< .0001*	1.54	0.65	< .0001*
	Semi-Professional	183	3.11	2.05		3.50	2.10	
	Professional	73	4.07	0.93		4.44	0.64	

(Table 6) Contd….

Factors	Competitive level	N	Probiotics			Prebiotics		
			Mean	Variance	*p*-value	Mean	Variance	*p*-value
Positive impact on digestive health (beliefs)	Amateur	169	3.96	1.14	.0326*	2.92	1.39	.7939
	Semi-Professional	183	3.77	1.46		2.97	1.59	
	Professional	73	3.56	1.22		2.86	1.48	
Positive impact on Physical performance (beliefs)	Amateur	169	4.02	1.31	.9993	3.75	1.74	.4625
	Semi-Professional	183	4.02	1.10		3.57	2.04	
	Professional	73	4.03	1.08		3.60	1.85	
Improved digestive health (effects)	Amateur	169	3.91	1.46	.9441	3.95	1.50	.0663
	Semi-Professional	183	3.87	1.38		3.83	1.52	
	Professional	73	3.89	1.15		3.55	1.64	
Improved Physical performance (effects)	Amateur	169	3.85	1.70	.1017	3.98	1.29	.0011*
	Semi-Professional	183	3.86	1.54		4.01	1.20	
	Professional	73	3.51	1.53		3.45	1.50	
Alleviated gastrointestinal issues (effects)	Amateur	169	3.49	1.98	.3244	4.12	1.23	.1632
	Semi-Professional	183	3.71	1.79		3.94	1.57	
	Professional	73	3.58	1.97		3.84	1.58	

* Statistically significant difference at a .05 confidence interval.

belief (mean = 3.96, p = .0326), while professionals report the lowest (mean = 3.56). However, no significant differences are observed for beliefs about the impact of prebiotics on digestive health, as well as for the impact of either probiotics or prebiotics on physical performance.

When assessing the actual effects of probiotics and prebiotics, significant differences are found only in the improved physical performance from prebiotics (p = .0011), where amateurs rate the effects higher (mean = 3.98) than professionals (mean = 3.45). No significant differences are found for other effects, including improvements in digestive health or alleviation of gastrointestinal issues. In summary, the largest differences based on competitive level are in awareness and beliefs about the digestive benefits of probiotics, with professionals showing higher awareness but lower belief in digestive health benefits. Amateurs perceive stronger effects of prebiotics on physical perform.

4. DISCUSSION

This study aimed to explore athletes' perceptions and use of probiotics and prebiotics concerning digestive health and physical performance. The findings provide new insights into the consumption habits, awareness levels, beliefs, and perceived effects of these dietary components among athletes, with results that both support and challenge existing literature.

One of the most notable findings is the moderate to high frequency of probiotic and prebiotic consumption among athletes, with prebiotics consumed more regularly than probiotics. This aligns with research by Hoffman *et al*. [23], who noted the growing recognition of prebiotics as a means of supporting gut health and nutrient absorption, particularly in active populations. However, our results contrast with studies like Costa *et al*. [20], which found inconsistent results regarding the efficacy of probiotics in alleviating gastrointestinal symptoms in athletes. The variation in probiotic efficacy, as suggested by our data, could be attributed to the strain-specific nature of probiotics, as highlighted by West *et al*. [21], who emphasized the need for personalized probiotic interventions based on individual gut microbiota.

Interestingly, despite the moderate awareness levels of both probiotics and prebiotics, athletes perceived probiotics as having a stronger positive impact on physical performance than prebiotics. This perception is consistent with studies by Jäger *et al*. [25], who reported improvements in athletic recovery and a reduction in inflammation from probiotics. Our study supports the idea that probiotics can indirectly enhance physical performance by promoting quicker recovery and reducing muscle soreness. However, direct enhancements in measurable athletic performance metrics, such as VO2 max or power output, were not the focus of this study, and further research is needed in this area. The findings align with the results of Pugh *et al*. [27], who found minimal direct impact of probiotics on performance metrics.

Regarding digestive health, both probiotics and prebiotics were perceived to improve gut function, although prebiotics were rated slightly higher for alleviating gastrointestinal issues. This finding aligns with Slavin [22], who pointed out the key role of prebiotics in promoting gut microbiota diversity, which is essential for efficient digestion. However, some studies, such as those by Axelrod *et al*. [24], have raised concerns about the gastrointestinal tolerance of prebiotics, particularly when consumed in large amounts. Our data suggest that while athletes generally perceive prebiotics positively, there may be a threshold beyond which the bene-

fits of prebiotics could be outweighed by digestive discomfort.

The gender differences observed in our study, where males rated the impact of probiotics and prebiotics on physical performance more positively, are worth noting. This supports existing literature, such as the findings of Jäger *et al*. [25], who found that male athletes often report more significant improvements from probiotic supplementation. However, the lack of significant differences in digestive health perceptions between genders is a novel finding, suggesting that the gut health benefits of probiotics and prebiotics may be perceived similarly across genders.

When comparing perceptions based on the type of sport, athletes from motor and strength sports reported the highest belief in the impact of prebiotics on physical performance. This is an interesting deviation from endurance sports, where gut health is often prioritized due to the strain placed on the digestive system during prolonged activity. The higher rating by strength and motor athletes could reflect the growing awareness of gut health's role in recovery and nutrient absorption in power-based sports, a connection previously noted by Huang *et al*. [26].

Another significant finding is the variation in perceptions based on competitive level. Professionals demonstrated higher awareness of probiotics and prebiotics but reported lower beliefs in their digestive health benefits compared to amateurs. This could be due to the professionals' greater exposure to advanced nutrition strategies, making them more critical of generalized benefits. This contrasts with findings from Shing *et al*. [19], who observed that elite athletes benefited more from probiotic supplementation in terms of reduced gastrointestinal issues. However, the lower belief in digestive health benefits among professionals in our study could reflect the need for more targeted probiotic strains or dosages, as highlighted by Sanders *et al*. [5].

Although the current study examined athletes' perceptions of using dietary probiotics and prebiotics to improve gastrointestinal health and physical performance, insights from clinical populations provide contextual relevance. For example, Alhajri 2025 surveyed the physical activity and nutritional status of pediatric leukemia patients and reported a significant association between low physical activity and poor nutrient intake, particularly among females and older children [42]. These findings highlight the broader implications of diet and physical activity for overall health and functional capacity. Given that athletes and clinical populations may experience gastrointestinal disturbances or nutrient malabsorption in response to various stressors, combining probiotics and prebiotics may represent an integrated nutritional approach to improve gut health and performance outcomes.

5. IMPLICATIONS

The findings of this study have both theoretical and practical implications. Theoretically, this research expands on existing literature by providing nuanced insights into how athletes perceive the impact of probiotics and prebiotics on digestive health and physical performance, highlighting the significance of personalized supplementation approaches. The study's results challenge the uniform application of probiotics and prebiotics across athletic populations, reinforcing the need for more targeted, strain-based studies that consider factors like gender, type of sport, and competitive level. Practically, these insights can inform athletes, coaches, and sports nutritionists about the potential benefits and limitations of incorporating probiotics and prebiotics into athletes' diets. Tailoring supplementation strategies to individual needs, sport type, and level of competition could enhance both digestive health and recovery, thereby optimizing overall performance. Future dietary recommendations for athletes should emphasize personalized nutrition plans that account for the varying effects of these dietary supplements across different athlete populations.

6. LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional survey design may restrict the ability to establish causal relationships between the consumption of probiotics and prebiotics and their perceived effects on digestive health and physical performance. Additionally, the reliance on self-reported data could introduce bias, as participants might overestimate or underestimate their consumption habits and beliefs regarding probiotics and prebiotics. Furthermore, the study did not account for variations in dietary patterns, individual gut microbiota compositions, or specific probiotic strains, all of which could influence outcomes. Lastly, the sample size, while sufficient for statistical analysis, may not adequately represent the broader athletic population, particularly across different sports and competitive levels. Future research should address these limitations by employing longitudinal designs, larger and more diverse samples, and detailed dietary assessments to better understand the impact of probiotics and prebiotics on athletes.

CONCLUSION

This study highlights the growing recognition of probiotics and prebiotics among athletes as crucial dietary components for optimizing digestive health and enhancing physical performance. The findings indicate that athletes generally perceive probiotics as more beneficial for physical performance, while prebiotics are viewed as effective for managing gastrointestinal issues. Despite moderate awareness levels, significant differences were observed based on factors such as gender, type of sport, and competitive level, emphasizing the need for personalized supplementation approaches. Male athletes demonstrated stronger beliefs in the performance-enhancing effects of these dietary components, as compared to females. Whereas, professionals exhibited higher awareness but lower belief in their digestive health benefits compared to amateur athletes.

Furthermore, the results highlight the importance of understanding the specific effects of probiotics and prebiotics on various athletic populations, considering their unique dietary habits, physiological demands, and levels of training intensity. The study also highlights variations across differ-

ent sports disciplines, with endurance athletes prioritizing digestive health benefits, while athletes in strength and motor sports showed a greater belief in the performance-enhancing properties of prebiotics. These insights suggest that nutritional interventions should be tailored to the needs of specific athletic groups, integrating probiotic and prebiotic strategies that align with their dietary patterns, training regimens, and recovery requirements.

Given the limitations identified, including the reliance on self-reported data, potential response biases, and the need for a more diverse sample representing a broader range of athletic disciplines and competition levels, future research should focus on longitudinal studies with objective performance measures. Additionally, studies should explore the effects of specific probiotic strains and prebiotic types to determine the optimal dosages and combinations for different categories of athletes. Detailed dietary assessments and microbiome analyses could further clarify the relationship between these dietary components and athletic outcomes, leading to more precise recommendations.

In summary, as athletes continue to seek effective strategies to enhance their performance, recovery, and overall well-being, this study contributes valuable insights into the role of probiotics and prebiotics in sports nutrition. By addressing gaps in awareness, perceptions, and usage patterns, this research lays the groundwork for more tailored nutritional recommendations, encouraging evidence-based dietary interventions that support digestive health and athletic performance. Future studies should build upon these findings to develop comprehensive guidelines that integrate probiotics and prebiotics into personalized sports nutrition plans, ultimately benefiting athletes across various disciplines and levels of competition.

AUTHORS' CONTRIBUTIONS

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study received approval from the research ethics committee at King Faisal University (KFU-REC-2024-OCT-ETHICS2705).

HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants prior to their involvement.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

STANDARDS OF REPORTING

Strobe guidelines were followed.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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