

Investigating Nutrition Literacy Levels among Adolescent Swimmers

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Abstract This research delves into the nutrition knowledge (NK) of adolescent swimmers (AS) during the critical phase of adolescence, a period that plays a pivotal role in establishing enduring health patterns. The background underscores the paramount importance of comprehending NK among AS, given its lasting impact on their overall well-being. During adolescence, nutritional habits can significantly influence growth, development, and long-term health outcomes. The primary objective of this study is to comprehensively assess NK among AS and explore potential variations influenced by demographic factors. The study specifically focuses on a cohort of 60 adolescent swimmers enrolled at the University of Jordan. Data collection was conducted through a thorough NK questionnaire, covering various aspects. Statistical analyses were performed using One-Way ANOVA tests and Independent Samples t-Tests to examine the connections between NK and variables such as Body Mass Index (BMI), training experiences, and genders. These analyses aimed to uncover any correlations or disparities in NK based on these factors. The findings of the study revealed a moderate overall knowledge level among AS, with participants scoring an average of 59.5 out of 110 on the NK questionnaire. Notably, no statistically significant differences were observed in knowledge levels across BMI groups, training experiences, or genders. This suggests a relatively consistent level of NK within the studied population. In practical terms, the study highlights the significance of integrating NK into the training regimen of adolescent swimmers to optimize their overall health. It

suggests that targeted interventions, including workshops or educational programs, could enhance the NK of AS.

Keywords Nutritional Knowledge, Adolescent Swimmers, Nutrition Recommendations, Nutrient Sources, Food Choices

1. Introduction

Nutrition stands as a pivotal element influencing athletes' performance and their coaches alike, underscoring the significance of sound dietary practices in enhancing athletic prowess and overall physical well-being [1]. Adolescence, typically ranging from ages 10 to 19, constitutes a pivotal stage in an individual's life during which they solidify enduring patterns of adult health, encompassing their dietary choices and attitude towards food [2]. During adolescence, certain young athletes, such as swimmers, often experience a substantial increase in their training commitments, which can serve as a pathway to elite sports participation. Adolescent athletes face unique nutritional challenges, as proper dietary practices are essential for supporting growth, athletic performance, and potential careers in sports [3], [4].

Swimmers, in particular, often engage in intense training regimes from a young age to develop their technical skills, physiological capacity, and competitive abilities [5]. The demanding training regimen, combined with the essential

nutritional requirements for growth and development, places significant energy demands on adolescent swimmers (AS). They require increased amounts of macronutrients and micronutrients, including carbohydrates, proteins, Thiamine and zinc [6], [7], [8].

Yet, research has demonstrated that dietary habits for AS are often suboptimal. Individuals engaged in swimming often fail to consume adequate energy, carbohydrates, and essential nutrients like calcium, iron, magnesium, and iodine [9]. These nutritional deficiencies can lead to enduring adverse effects on the health and performance of swimmers over the long term.

For example, inadequate energy intake can lead to issues like ovarian suppression in female swimmers, resulting in decreased performance [10]. Additionally, insufficient carbohydrate intake can lead to muscle fatigue during intense training periods [6].

Enhancing the nutritional practices of adolescent athletes can be effectively achieved by improving their nutrition knowledge (NK) [11]. NK plays a pivotal role in athletes' food choices, with higher NK being associated with healthier dietary habits among athletic populations [12]. Unfortunately, adolescent athletes, especially swimmers, often have poor NK [13], [14]. This may be attributed to the NS information they rely on, such as parents, coaches, and magazines, with a minimal percentage consulting registered dietitians [15].

Furthermore, previous research has demonstrated that nutrition education interventions can significantly improve NK in athletes from various sports [16], [17], [18]. Yet, there is limited understanding regarding the effects of nutrition education on the NK of AS. Therefore, there is an imperative to conduct a thorough investigation into the NK of AS to rectify the existing voids in their understanding of nutrition. This research aims to shed light on the specific needs and challenges faced by AS, offering insights that can inform targeted nutrition education strategies and contribute to the overall advancement of NK.

The study explores two key research questions regarding AS and their NK. Firstly, it examines the extent of NK demonstrated by AS. Secondly, it investigates whether there is a statistically significant variation in NK among AS and to what extent this difference is influenced by demographic factors.

2. Materials and Methods

Instruments

In the phase of data collection, researchers utilized a succinct NK questionnaire, particularly the version developed by Parmenter and Wardle [19]. This comprehensive questionnaire is divided into four sections, offering a thorough assessment of participants' comprehension and knowledge of nutrition. These sections encompass various aspects, such as present DR, NS, EFC,

and the connections between DD.

These elements encapsulate crucial factors connecting Understanding influencing dietary behavior, involving awareness of the latest expert DR, familiarity with nutrient-dense foods, the capability to make health-conscious food choices, and an understanding of one's health implications of specific foods. The survey consists of a total of 45 questions. Of these, 34 questions consist of multiple-choice questions, and the remaining 11 are true-false, and the test scores range from 0 to 110.

The researchers employed the NK questionnaire developed by Parmenter and Wardle for several reasons. Firstly, this questionnaire has been widely used and validated in previous research, indicating its reliability and validity in assessing participants' understanding and knowledge of nutrition-related topics. Its comprehensive nature, divided into four sections covering various aspects of nutrition knowledge, makes it suitable for capturing a broad range of information. Secondly, the questionnaire's structure aligns well with the objectives of the study. By encompassing sections on dietary recommendations, nutrient sources, everyday food choices, and connections between diet and disease, it allows researchers to assess multiple dimensions of NK relevant to the study's focus on understanding the factors influencing dietary behavior.

The internal consistency of the NK questionnaire has been substantial, as evidenced by a substantial Cronbach's alpha coefficient of 0.95. Particularly what is noteworthy are the essential components of the questionnaire, including dietary recommendations (DR), nutrient sources (NS), everyday food choices (EFC), and connections between diet and disease (DD), which displayed robust Cronbach's alpha coefficients of 0.82, 0.93, 0.61, and 0.88, respectively. These findings notably enhance the credibility of the NK questionnaire as a dependable and valid instrument for assessing NK.

To gather data, participants were provided with a link to the online survey through a mobile instant messaging application, such as WhatsApp or Teams.

Table 1 offers a thorough evaluation of the validity and reliability of variables within the knowledge section, providing crucial insights into the quality of the measurement tools employed in the study. The column labeled "Self-Consistency Coefficient" indicates the extent of consistency in participants' responses for each variable, with higher values (e.g., 0.904 for DR) suggesting a higher level of self-consistency. The α values (Cronbach's alpha) assess internal consistency, reflecting the reliability of the items within each variable. For instance, DR demonstrates good internal consistency with an α value of 0.81. Furthermore, the table furnishes information regarding the number of items and specifies the variables under consideration, such as the "choice of daily foods."

The classification of levels for NK and its domains has been adopted based on the tripartite statistical classification shown in Table 1.

Table 1. The evaluation of the validity and reliability of the variables

variables	Quantity of items	α	self-validation coefficient value
Knowledge section	-	-	-
DR*	4	0.81	0.904
NS**	21	0.92	0.963
EFC***	10	0.60	0.780
DD****	10	0.87	0.937
Total NK	45	0.94	0.973

*Dietary Recommendations

**Nutrient Sources

***Everyday Food Choices

****Connections Between Diet and Disease

Table 2. Classification of Levels for Domains

Level	NK	DD	EFC	NS	DR
Low	0 - 36.5	0 - 7	0 - 3	0 - 23	0 - 3
Moderate	37 - 73.5	7.5 - 13	4 - 7	24 - 46	4 - 7
High	74 - 110	13.5 - 20	8 - 10	47 - 69	8 - 11

Table 2 outlines a comprehensive classification system for levels of NK across distinct domains related to diet and health. The three overarching levels—Low, Moderate, and High—are defined based on specific numerical ranges within five key domains (NK, DD, EFC, NS, DR). Each domain is characterized by distinct numerical ranges for each level, facilitating a nuanced assessment of NK in diverse facets of diet and health.

Procedures

The research design employed in this study was descriptive, and data were collected using a cross-sectional approach. Prior to conducting the study, it received approval from the Ethics Committee at Al-Ahliyya Amman University, and all participating individuals willingly provided informed consent to be part of the research.

A cross-sectional research design was implemented to assess the knowledge of nutrition among AS at the Arena pool at Al-Ahliyya Amman University. The recruitment of participants commenced in September 2023 when researchers visited the university's swimming pool. AS received a concise overview of the research study's objectives and were extended invitations to voluntarily participate. Prospective research participants were assured

of the confidential treatment of their results and information, with no incentives provided for participation.

The data collection phase coincided with the training sessions, occurring between September 16, 2023, and December 1, 2023. While coaches refrained from active participation in the study, both coaches and researchers were present to assist participants in addressing any queries during the completion of the questionnaire. The typical duration for completing the survey averaged around 30 minutes.

The decision to employ online questionnaires, facilitated by the presence of researchers and coaches, was made to ensure efficient data collection without imposing additional burdens on the participants' time. This method also allowed for standardized data collection procedures and minimized potential biases that could arise from direct interviews.

Participants provided self-reports of their height and weight, permitting the computation, indicated as kilograms per square meter (kg/m^2), for body mass index (BMI). Studies have shown a strong correlation between self-reported and measured BMIs [20]. Subsequently, the height and weight data underwent comparison with the Centers for Disease Control (CDC) growth charts to identify any instances of self-reported values that deviated excessively from the norm [21]. In cases where self-reported data deviated excessively from CDC norms, participants were contacted for verification, and if necessary, further measurements were obtained to ensure accuracy.

Participants

Out of the 80 AS, ranging in age from 12 to 18 years and categorized according to the International Swimming Federation classification, 59 of them (75%) volunteered to partake in the study. Table 3 presents demographic data related to AS, offering both numerical counts and corresponding percentages for participants within distinct groups based on specific variables. In terms of gender distribution, the table reveals that 54.2% of the participants are male, while 45.7% are female. The Body Mass Index (BMI) data showcases a diverse distribution across percentiles: 59.32% within the 25th percentile, 22.03% within the 50th percentile, and 18.6% within the 75th percentile. Furthermore, the table provides insights into the experience of training among participants, with 61.01% having 2-4 years of experience, 18.6% having 5-7 years, 15.2% having 8-10 years, and a smaller percentage, 0.05%, having more than 11 years of training experience (see table 3).

Table 3. Displays demographic variables related to AS, presenting both the numerical counts and corresponding percentages of participants within each group

Demographic variables	N(%)
Gender	
Male	32(54.2%)
Female	27(45.7%)
BMI	
25th Percentile	35(59.32%)
50th Percentile	13(22.03%)
75th Percentile	11(18.6%)
Experience of Training	
2-4 years	36(61.01%)
5-7 years	11(18.6%)
8-10 years	9(15.2%)
11 years >	3(0.05%)

The study's inclusion criteria comprised AS aged between 12 and 18 years, currently engaged in swimming training, and willing to participate voluntarily. Conversely, individuals outside the specified age range, those not actively involved in swimming training during the study period, those with medical conditions or physical limitations impacting swimming participation or

performance, and those unwilling or unable to provide informed consent were excluded from participation.

Statistical Analysis

The statistical analysis involved Utilizing One-Way ANOVA tests and Independent Samples t-Tests for examination. NK among AS. F-values and significance levels were used to assess the statistical significance of observed differences in various domains, including the influence of Body Mass Index (BMI), training experience, and gender.

3. Results

Table 4 provided a comprehensive overview of NK among 59 AS, detailing mean scores, standard deviations, relative importance percentages, and knowledge levels across various domains. The domains included DR, NS, EFC, and DD. The mean scores indicated a moderate level of knowledge in each domain, with an overall NK average of 59.5. Standard deviations revealed variability within each domain, suggesting differing levels of proficiency among AS. The relative importance percentages highlighted DD as particularly significant, with a 62.5% importance rating.

Table 4. Means and Standard Deviations for Domains of NK Among AS (n=59)

Number	Domain	Score	Mean	Standard Deviation	Relative Importance (%)	Level
1	DR*	11	6.0	1.916	54.5	Moderate
2	NS**	69	36.0	9.905	52.2	Moderate
3	EFC***	10	5.0	1.815	50	Moderate
4	DD****	20	12.5	4.155	62.5	Moderate
Total NK		110	59.5	14.571	53.6	Moderate

*Dietary Recommendations

**Nutrient Sources

***Everyday Food Choices

****Connections Between Diet and Disease

Relationship between NK and Demographics:

Table 5. One-Way ANOVA Analysis of NK among AS in Relation to Body Mass Index (BMI)

Domain	Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F Value	Significance Level
DR *(out of 11)	Between Groups	2.287	3	0.762	0.199	0.897
	Within Groups	210.696	55	3.831		
	Total	212.983	58			
NS** (out of 69)	Between Groups	291.198	3	97.066	0.989	0.405
	Within Groups	5398.802	55	98.160		
	Total	5690.000	58			
EFC *** (out of 10)	Between Groups	5.332	3	1.777	0.526	0.666
	Within Groups	185.652	55	3.375		
	Total	190.983	58			
DD**** (out of 20)	Between Groups	74.618	3	24.873	1.476	0.231
	Within Groups	926.865	55	16.852		
	Total	1001.483	58			
Overall NK (out of 110)	Between Groups	651.024	3	217.008	1.023	0.389
	Within Groups	11662.459	55	121.045		
	Total	12313.483	58			

*Dietary Recommendations

**Nutrient Sources

***Everyday Food Choices

****Connections Between Diet and Disease

Table 5 presented the outcomes of applying a One-Way Analysis of Variance (ANOVA) test to evaluate the NK level among AS in relation to their Body Mass Index (BMI). The table encompassed various domains of knowledge, including DR, NS, EFC, DD, and Overall NK. The analysis was divided into "Between Groups" and "Within Groups," examining the differences in knowledge levels among different BMI classifications and the variations within each BMI category, respectively.

The results included key statistical measures such as sum of squares, degrees of freedom, mean square, F-value, and the significance level (p-value). The F-value signified the ratio of variance between groups to variance within groups. The significance level indicated the probability that observed differences were not due to chance. In general, a significance level below 0.05 was commonly regarded as statistically significant.

Upon examining the table, it appeared that, in each domain, the p-values were above the conventional significance threshold of 0.05. Consequently, the observed differences in NK levels among AS, categorized by BMI,

were not statistically significant in the domains examined. These results provided insights into the lack of substantial variations in NK among different BMI groups, emphasizing the need for further investigation or targeted interventions to understand and address potential influencing factors.

In Table 6, depicting the results of a One-Way ANOVA test assessing the NK level among AS based on the training experience variable, the findings suggested the lack of statistically significant differences when considering a significance level (α) of 0.05 or lower among the means of NK across all domains related to the training experience variable. The computed F-value for Overall NK was 0.254, with a significance level of 0.854.

Table 7 illustrated the outcomes derived from employing an independent samples t-test to assess the NK level among AS based on the gender variable. The table revealed that no statistically significant differences were observed at the 0.05 significance level between male and female AS in NK across all domains. The t-value for Overall NK was 0.516 with a significance level of 0.608.

Table 6. One-Way ANOVA Analysis of NK among AS in Relation to Training Experience

Domain	Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F Value	Significance Level
DR* (out of 11)	Between Groups	6.690	3	2.230	0.595	0.621
	Within Groups	206.293	55	3.751		
	Total	212.983	58			
NS**(out of 69)	Between Groups	160.646	3	53.549	0.533	0.662
	Within Groups	5529.354	55	100.534		
	Total	5690.000	58			
EFC*** (out of 10)	Between Groups	6.539	3	2.180	0.650	0.586
	Within Groups	184.444	55	3.354		
	Total	190.983	58			
DD**** (out of 20)	Between Groups	3.775	3	1.258	0.069	0.976
	Within Groups	997.708	55	18.140		
	Total	1001.483	58			
Overall NK (out of 110)	Between Groups	171.669	3	57.223	0.254	0.854
	Within Groups	12141.814	55	220.760		
	Total	12313.483	58			

*Dietary Recommendations

**Nutrient Sources

***Everyday Food Choices

****Connections Between Diet and Disease

Table 7. Results of Independent Samples t-Test for NK among AS Based on Gender

Domain	Group	Count	Mean	Standard Deviation	Degrees of Freedom	t Value	Significance Level
DR*	Males	32	5.9	1.947	57	-0.616	0.540
	Females	27	6.2	1.902			
NS**	Males	32	36.8	7.413	57	0.656	0.514
	Females	27	35.1	12.136			
EFC***	Males	32	4.8	1.901	57	-1.075	0.287
	Females	27	5.3	1.701			
DD****	Males	32	13.0	2.761	57	1.004	0.320
	Females	27	11.9	5.363			
Overall NK	Males	32	60.4	9.626	57	0.516	0.608
	Females	27	58.4	18.998			

*Dietary Recommendations

**Nutrient Sources

***Everyday Food Choices

****Connections Between Diet and Disease

4. Discussion

This study aims to examine the NK among AS and understand potential variations influenced by demographic factors. The results indicate a moderate level of NK among the AS, with an average score of 59.5 out of 110. Despite analyzing demographic factors such as BMI, training experience, and gender, no statistically significant differences in NK were observed.

The results offer valuable insights into the NK of AS. These findings suggest that, overall, AS possess a moderate level of NK. However, specific areas require further attention and education. The study reveals that AS demonstrate a moderate knowledge of dietary recommendations, nutrient sources, everyday food choices and connections between diet and disease. This indicates a good understanding of what constitutes a healthy diet and the sources of various nutrients.

The study highlights a need for improvement in the understanding of everyday food choices, and this finding is significant because it suggests that AS may not fully grasp the impact of their dietary choices on their overall health and well-being. To optimize the performance and well-being of AS, addressing this knowledge gap in nutrition education is crucial [22].

By providing education and resources that specifically emphasize everyday food choices, coaches, parents, and educators [23] [24], [25], [26] can help AS make informed choices about their nutrition. This, in turn, can contribute to improvements in their athletic performance and overall health.

The finding that nutrient sources contribute significantly to participants' NK, constituting 52.2% of the total, underscores the vital role of understanding the origins of essential nutrients in maintaining a healthy diet. This knowledge is particularly crucial for AS, as it empowers them to make informed choices regarding their food intake, thereby supporting their athletic performance and overall well-being.

Regarding in Nutrient Sources ensuring athletes receive sufficient nutrients is crucial for maintaining their daily activities and enhancing performance during training and competition. Macronutrients, comprising carbohydrates, proteins, and fats, are pivotal components in athletic nutrition [27]. Professional sports organizations recommend suitable food and fluid choices to optimize health and exercise outcomes [28].

Several studies indicate that athletes often fall short of the recommended daily intake of macronutrients and micronutrients outlined in guidelines [29], [30]. Athletes are advised to consume 6 to 10 g/kg body mass of carbohydrates per day (6). Protein requirements slightly increase for highly active individuals, ranging from 1.2 to 1.4 g/kg body weight per day [31]. It is suggested to maintain moderate fat intake to support adequate carbohydrate consumption, with 20 to 25% of daily energy derived from fat. Athletes should strive for diets that meet

or exceed the Dietary Reference Intakes for all micronutrients [28] by incorporating a variety of foods in appropriate amounts. Priority should be given to meeting energy needs of all athletes [32]. As energy demands rise, athletes should first aim to meet the maximum recommended servings outlined in the food pyramid [28].

By being aware of nutrient sources, AS can strive to ensure a balanced diet that supplies the necessary vitamins, minerals, and macronutrients essential for their demanding physical activity. This informed approach to nutrition is fundamental for optimizing their athletic potential and safeguarding their long-term health.

Despite the positive attitude exhibited by AS toward nutrition education, there is a notable deficiency in their knowledge about nutrition, impacting their dietary choices [15], [33]. To address this gap, it is imperative to implement effective strategies tailored to this specific age group. Successful interventions within the general population of children often involve comprehensive nutritional programs with active parental involvement [34]. This underscores the importance of considering the familial context in fostering healthy eating habits among AS.

However, it is noteworthy that an increase in NK does not necessarily translate into the adoption of healthier eating habits [35]. Several factors contribute to this discrepancy, including taste preferences, convenience, shopping skills, label reading, food preparation, cultural influences, and family customs, all exerting varying degrees of impact on food intake [35], [36]. Understanding and addressing these factors are crucial for developing targeted interventions that go beyond mere knowledge dissemination.

The comprehension rate regarding the nutritional recommendations section stood at 54.5%. Aligned with findings from a study [37], this implies that nationwide health promotion initiatives, including the promotion of consuming 5 servings of fruits and vegetables daily, minimizing salt intake, and enhancing whole grain consumption, prove to be effective public education programs in boosting health awareness and advancing NK. Notably, every participant correctly responded to the query regarding the recommended daily servings of fruits and vegetables.

One study found that possessing nutritional knowledge is closely linked to making healthy food choices, irrespective of demographic variables [38]. In the context of this study, an analysis was conducted on the NK level among AS, with Body Mass Index (BMI) being considered as a demographic variable. Interestingly, despite variations in BMI, no statistically significant differences were observed in the NK levels, indicating a consistent awareness across different BMI categories. These results align with a previous study by Sedek & Yih [39], which reported a significant weak negative correlation between the BMI of subjects and NK.

When examining the impact of training experience

among AS, the results did not reveal statistically significant differences in NK. This suggests that variations in training experiences did not significantly influence the participants' nutritional knowledge. It underscores the importance of broader educational efforts to improve overall NK, emphasizing that training experiences alone may not be sufficient. This discovery aligns with findings from other related studies [40]. The anticipated outcome typically involves an augmentation of the athlete's knowledge and skills as their sporting experience expands, as indicated by the results of some studies [41].

The result reveals a moderate connection between diet and disease in the context of swimmers. Nutritional elements significantly contribute to shaping adolescents' capacity for achieving optimal growth and sustaining overall well-being [42]. In addition to its effect on growth, food intake is a critical determinant of athletic performance. In their pursuit of achieving sports goals, swimmers often prioritize their training and diet plans because a proper diet plays a crucial role in their overall performance and health. Swimmers require a well-balanced diet providing necessary nutrients to fuel their training, support muscle recovery, and optimize their performance in the water. There is a strong connection between diet and disease for swimmers, as improper nutrition can increase the risk of various diseases and negatively impact overall health. Specifically, inadequate energy intake can lead to decreased immune function, increasing susceptibility to illness and infection. Additionally, a diet lacking essential nutrients can compromise bone health, raising the risk of stress fractures and other musculoskeletal injuries. The outcomes of numerous clinical trials indicate that weight loss and improved biomarkers of metabolic diseases, such as obesity and type 2 diabetes, can result from low-carbohydrate, high-protein, high-fat diets, including the ketogenic diet [43]. Despite the favorable impacts on body composition associated with low-carbohydrate/high-fat diets, there is no observed enhancement in athlete performance [44], [45].

The study also explored the relationship between gender and NK among AS. The results indicated No statistically significant differences were found at the chosen significance level among means of NK across all domains related to the Gender variable. This aligns with previous research, emphasizing that gender does not significantly impact the NK of AS [33], [46].

Despite the absence of statistically significant differences based on variables like BMI, training experience, and gender, it's crucial to consider other potential influencers. Variables like education level and cultural background could potentially influence nutritional knowledge[33]. This highlights the need for a more nuanced understanding of the diverse factors influencing NK beyond the variables directly examined in this study.

In summary, while specific demographic variables showed no statistically significant disparities in nutritional knowledge among AS, a deeper understanding of

additional factors, including education and cultural background, is warranted. This comprehensive perspective is essential for developing effective nutritional education programs tailored to the unique needs of AS.

Overall, the findings suggested that AS possess a moderate level of NK, demonstrating an understanding of dietary recommendations, nutrient sources, everyday food choices, and connections between diet and disease. However, there is a need for improvement in understanding everyday food choices, emphasizing the impact of dietary decisions on overall health.

Recognizing the importance of understanding the origins of essential nutrients, particularly for AS, is crucial for making informed choices that support athletic performance and overall well-being. Effective strategies tailored to this specific age group, involving comprehensive nutritional programs with parental involvement, were suggested.

By incorporating nutrition education initiatives [47] into athletic training programs [48][49], coaches and educators can ensure that AS develop a comprehensive understanding of the role of nutrition in optimizing athletic performance and overall health. This knowledge will empower them to make informed choices regarding their diet, ultimately enhancing their performance in the pool [50]. The results of these studies suggest that nutrition education is crucial for AS to improve their overall NK and make informed dietary choices [51], [52]. Furthermore, nutrition education programs should not be limited to adolescents alone but should also involve parents and schools. Additionally, incorporating cooking classes into these programs can provide essential knowledge on cooking techniques and ingredients [53], equipping AS with practical skills to prepare healthy meals at home.

Improving NK among AS is crucial for optimizing their athletic performance and overall health. Incorporating nutrition education initiatives into athletic training programs is recommended to ensure AS develop a comprehensive understanding of nutrition's role in enhancing athletic performance and promoting well-being. Tailored nutrition education programs should involve not only adolescents but also parents and schools, including practical cooking classes to equip AS with essential skills for preparing healthy meals at home.

Multifaceted nutritional interventions with a focus on parental involvement are essential for addressing the diverse factors influencing dietary choices among AS. Efforts should be directed towards considering various influencers such as education level and cultural background to understand NK effectively. Despite no statistically significant differences based on BMI, training experience, and gender, it's vital to recognize the significance of these other potential influencers in understanding NK.

In summary, a comprehensive perspective is necessary for developing effective nutritional education programs tailored to the unique needs of AS. Integrating nutrition

education with athletic training programs emphasizes the direct link between nutrition and performance. Poor NK can lead to suboptimal performance, increased risk of injury and illness, long-term health implications, and negative impacts on mental well-being. Therefore, addressing these suggestions and understanding the consequences of poor nutrition is vital for promoting optimal health and performance among AS.

5. Strengths of the Study

1. The study thoroughly examined the NK among AS by considering various demographic factors such as BMI, training experience, and gender. This comprehensive approach provides a holistic understanding of the subject matter.
2. The study provided valuable insights into the NK of AS, shedding light on both areas of strength and areas for improvement. This information was instrumental in tailoring educational interventions aimed at enhancing the overall health and performance of AS.
3. Practical recommendations were offered for addressing the identified knowledge gaps, including the incorporation of NK initiatives into athletic training programs and the involvement of parents and schools. These recommendations had the potential to positively impact the dietary habits and health outcomes of AS.

6. Limitations of the Study

1. The study had a limited sample size, which could have affected the generalizability of the findings. A larger sample size would have enhanced the reliability and validity of the results.
2. The study used a cross-sectional design, which limited the ability to establish causality between demographic factors and NK among AS. Longitudinal studies could have provided a better understanding of how NK evolves over time.
3. The study did not account for potential external factors that may have influenced NK among AS, such as socioeconomic status or access to nutrition education resources. Considering these factors could have provided a more nuanced understanding of the subject matter.

7. Suggestions for Future Research

1. Future research could employ longitudinal study designs to track changes in NK among AS over time

and assess the long-term impact of educational interventions.

2. Conducting studies with a larger and more diverse sample size would enhance the generalizability of the findings and allow for subgroup analyses.
3. Utilizing objective measures, such as dietary assessments or biomarker analyses, could provide more accurate insights into the dietary habits and nutritional status of AS.
4. Including control groups of non-athlete adolescents would enable researchers to compare NK levels between AS and their non-athlete counterparts.
5. Future research could explore multifaceted approaches to improving NK among AS, considering the influence of various factors such as education level, cultural background, and access to resources.
6. Conducting intervention studies to evaluate the effectiveness of nutrition education programs in improving NK and promoting healthier dietary habits among AS would provide valuable evidence for future interventions.

By addressing these limitations and implementing the suggested recommendations, future research can contribute to a deeper understanding of NK among AS and inform more effective strategies for promoting optimal nutrition and health outcomes in this population.

8. Conclusions

In conclusion, this study sheds light on the NK among AS, aiming to understand potential variations influenced by demographic factors. The findings reveal a moderate level of NK among AS. Despite examining demographic factors such as BMI, training experience, and gender, no statistically significant differences in NK were observed. These results offer valuable insights into the nutrition literacy of AS, indicating a good understanding of dietary recommendations, nutrient sources, and connections between diet and disease. However, specific areas require further attention and education, suggesting the need for targeted interventions. Furthermore, the study underscores the uniformity in NK among AS, regardless of demographic variables, highlighting the necessity for tailored interventions [54] and educational approaches to address identified gaps and challenges. Overall, the outcomes of this study contribute to the broader field of nutrition by providing insights into the specific needs of AS. Moving forward, targeted interventions and educational programs can be designed to improve nutrition habits and support optimal athletic performance among this unique population, ultimately fostering healthier practices and enhancing overall well-being.

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