Jordan Journal of Nursing Research, Volume **5**, No. **2**, **2026**
DOI: https://doi.org/10.14525/JJNR.2026.11

Jordan Journal of Nursing Research

https://jjnr.just.edu.jo/jjnr

Alarming Biochemical Parameters among Athletes: The Role of Targeted Health Education in Dietary Supplement and Anabolic Hormone Consumers

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ARTICLE INFO

Article History:
Received: November 17, 2025
Accepted: January 8, 2026

ABSTRACT

Background: The rising misuse of dietary supplements and anabolic hormones among athletes is a growing global public health concern, with Egypt being no exception. ***Purpose*****:** This study evaluated the effectiveness of nursing health education intervention in enhancing knowledge, attitudes, and safe practices among Egyptian athletes who use dietary supplements and anabolic hormones. ***Methods*****:** The study applied a quasi-experimental design and selected 100 athletes conveniently from licensed fitness clubs in Beni-Suef governorate, Egypt. Data was collected through a structured questionnaire covering demographics, knowledge, attitudes, and supplement use, alongside biochemical analyses of liver and kidney functions. ***Results*****:** Biochemical findings indicated elevated health risks, with mean alkaline phosphatase at 139.4 ± 6.2 U/L, creatinine at 1.45 ± 0.15 mg/dL, and blood urea nitrogen at 23.5 ± 2.8 mg/dL. These values exceed reference ranges and were improved after the intervention. Additionally, knowledge scores significantly improved (11.4 ± 1.3 to 17.1 ± 0.9; $p < 0.0001$), attitudes shifted positively (14.2 ± 2.1 to 23.3 ± 2.6; $p < 0.001$), and safe use practices increased significantly ($p < 0.001$) at the end of the program. ***Conclusion*****:** Targeted health education proved effective in improving biochemical parameters, awareness, attitudes, and safer practices among athletes, while biochemical findings highlighted the urgent health risks associated with misuse. ***Implications for Nursing*****:** Expanding similar educational programs nationwide,

complemented by follow-up counseling and routine biochemical monitoring in collaboration with fitness centers and sport medicine clinics, can strengthen nurses' role in promoting safe supplement and hormone use among athletes.

Keywords: Biochemical parameters, Health promotion, Knowledge, Attitudes, Dietary supplements, Anabolic hormones, Athlete behavior.

What does this paper add?

1. It provides one of the first nursing-led intervention studies in Egypt, integrating biochemical assessment with behavioral outcomes among athletes using supplements and anabolic hormones.
2. It demonstrates that a targeted nursing educational program can significantly improve athletes' knowledge, attitudes, and safe-use practices while highlighting alarming biochemical abnormalities linked to misuse.
3. It offers an evidence-based framework for fitness clubs, sport federations, and healthcare providers to implement sustainable education and monitoring programs.
4. It highlights the critical role of nurses in early detection, counseling, and prevention of supplement- and hormone-related health risks.

Introduction

Athletes consume dietary supplements and anabolic hormones to enhance their performance, which is a popular strategy. It is estimated that nearly 60%-80% of athletes regularly consume these supplements, depending on the specific sport and level of competition. Dietary supplements include a wide range of commercially available products, such as proteins, amino-acids, vitamins, and herbal formulations. This is often perceived as safe despite the risk of contamination, improper dosing, or undisclosed active ingredients (Jagim et al., 2023). Many athletes use anabolic hormones, particularly anabolic-androgenic steroids (AASs), which are synthetic derivatives of testosterone used to promote muscle hypertrophy and rapid strength gains. However, the way how they are used differs from one athlete to another: some take them occasionally to meet specific training goals, while others make them a regular part of their daily fitness routine (Maughan, 2018).

Both the medical community and the sport community are very concerned about how dietary and anabolic supplements affect liver and kidney functions. Many supplements are generally regarded as safe when taken as prescribed, but over time, some products, especially those that contain high protein or anabolic steroids, may put stress on the kidneys and the liver (Mantri et al., 2023).

Liver dysfunction is known to occur, especially with anabolic steroids. Similar to this, consuming too much protein from supplements can put more strain on the kidneys, which may result in impairment or damage, particularly in people who already have renal diseases. Hormonal imbalances, cardiovascular diseases, and liver damage can also result from this condition. Anabolic steroids raise the risk of heart attack and stroke by raising blood pressure and cholesterol levels. They can also cause men to develop breast tissues (AlShareef et al., 2024).

It is crucial for athletes, coaches, and medical professionals to be aware of the potential risks associated with the use of dietary supplements and anabolic hormones, as these products may pose significant health hazards despite their perceived benefits for performance enhancement and muscle recovery. Many over-the-counter and online sport supplements have been found to contain undeclared substances, including anabolic steroids and stimulants, which are often not listed on product labels (Jovanov et al., 2019).

Exposure to these substances can disrupt normal hormonal regulation through suppression of the hypothalamic-pituitary-gonadal axis, leading to androgen deficiency, reduced libido, erectile dysfunction, infertility, and gynecomastia. In addition, excessive consumption of protein and creatine supplements may increase blood urea and serum creatinine levels, placing stress on liver and kidney functions even in otherwise healthy individuals. The use of energy drinks and stimulant-containing supplements has also been linked to cardiovascular effects, such as elevated blood pressure, palpitations, nervousness, and sleep disturbances. Moreover, anabolic steroid exposure from contaminated supplements may increase the risk of liver injury, adverse cardiovascular outcomes, psychological disturbances, and long-term

musculoskeletal complications, including reduced bone density. Therefore, athletes should exercise caution when using supplements and remain informed about possible short- and long-term consequences, particularly regarding hepatic and renal health. Healthcare providers play a critical role in monitoring athletes' health and providing guidance on safe supplement use, including routine liver and kidney function testing to facilitate early detection of abnormalities (Martin et al., 2018).

The effectiveness of public health education on dietary supplementation and anabolic hormone use among athletes hinges on various factors, including the accessibility of information, the credibility of sources, and cultural attitudes toward supplementation and performance enhancement. Thus, a multifaceted approach that incorporates culturally sensitive messaging, evidence-based guidance, and collaborative efforts between sport organizations, healthcare professionals, and governmental agencies is essential for fostering a culture of safety (Almohammadi et al., 2021).

According to Schwartz (2014), who estimated the use of anabolic-androgenic steroids (AASs) and good and bad practices related to dietary supplements among resistance-trained individuals, the percentage of AAS use was greater among younger individuals than among older individuals. Furthermore, the participants did not have sufficient knowledge regarding the negative effects of the excessive use of these drugs.

As a result, it is crucial to inform the community's resistance-trained members, particularly the younger trainers, about the negative consequences of abusing AASs. Furthermore, public health education on dietary supplementation and anabolic hormone use among athletes extends beyond mere awareness-raising to encompass skill-building, behavior change, and ongoing support (Montuori et al., 2021).

Although awareness of dietary supplement and anabolic hormone use has increased, research on this topic remains scarce in Egypt, particularly within the nursing field. Nursing professionals are uniquely positioned to promote health awareness among athletes due to their role in health education and community engagement. To address this research gap, the present study aimed to evaluate the effectiveness of a nursing-led educational intervention in improving athletes' knowledge, attitudes, and safe practices regarding dietary supplements and anabolic hormones.

Research Hypotheses

1. The knowledge level of participants regarding dietary supplements and anabolic hormones increases significantly following the intervention.
2. Participants' attitudes toward dietary supplements and anabolic hormones improve significantly after the intervention compared with their attitudes before the intervention.
3. The percentage of participants demonstrating safe supplement use significantly increases post intervention compared with pre-intervention levels.
4. The targeted health education intervention leads to a significant improvement in athletes' biochemical markers of liver and kidney functions after the intervention.

Methods

Design and Setting

A quasi-experimental, pre-post design with no control group was utilized to evaluate the effect of a targeted nursing educational intervention on dietary supplement and anabolic hormone use among athletes. This design was selected due to its feasibility in field settings and suitability for assessing intervention impact over time. The study was carried out in Beni-Suef governorate, Egypt.

Sample

The required sample size was calculated using Epi-Info (CDC, WHO, 2002), assuming a two-sided alpha of 0.05, 80% power, and an expected increase in knowledge from 30% to 60% after the intervention. Although the calculated minimum sample size was 88, a final sample of 100 was used.

After obtaining ethical approval and official permissions, the researchers contacted 10 licensed health clubs in the study area. Four clubs agreed to participate. An announcement was made within these clubs inviting athletes to take part in the study. Following this announcement, a list of 765 eligible athletes was included by convenience sampling technique. These athletes were screened for eligibility by the researchers based on inclusion and exclusion criteria.

Eligibility screening included athletes aged 18-50 years, who were regularly engaged in organized sports (at least 3-4 sessions per week) and had been using dietary supplements and/or anabolic hormones for at least one year. Athletes with diagnosed chronic illnesses were excluded. This initial recruitment and eligibility

screening process represents a convenience sampling approach, as participation was limited to athletes who were accessible and willing to participate from the selected health clubs.

From the list of 765 eligible athletes, a sample of 100 athletes was selected to meet the required sample size calculated using Epi Info software. The final selection of the 100 participants was conducted using systematic random sampling, whereby every eligible athlete was selected from the list after determining the sampling interval (765/100 ≈ 7). All selected participants were contacted by the research team, provided detailed information about the study, and signed written informed consent prior to participation. Participants then completed a self-administered questionnaire a safe use checklist and underwent biochemical testing.

Data Collection Methods

Tool I: Structured KA Questionnaire

This tool assessed participants' demographic data, knowledge, and attitudes. The demographic section included variables, such as age, gender, education level, … etc. The knowledge section consisted of 20 multiple-choice items addressing supplement and hormone types, risks, and indications. Each correct response received 1 point, while incorrect or "don't know" answers received 0 points, yielding a total possible score range of 0-20, with higher scores indicating greater knowledge.

The attitude section comprised 8 items rated on a three-point Likert scale (1 = disagree, 2 = neutral, 3 = agree), with higher scores reflecting more positive beliefs and attitudes toward supplement and hormone use.

The structured Knowledge and Attitude (KA) questionnaire was adapted from existing instruments used in previous studies, rather than being developed *de novo*. The content was derived from relevant literature addressing dietary supplement and anabolic hormone use among athletes. The questionnaire was initially developed in English and then translated into Arabic by bilingual experts, with a back-translation process ensuring semantic equivalence. Additionally, cultural adaptation was conducted by subject and cultural specialists who reviewed and adjusted the content to ensure that it was contextually relevant, free from bias, and resonated with local customs and health practices. Reliability testing indicated good internal consistency (Cronbach's $\alpha = 0.81$) (Alhomoud et al., 2016; Aljaloud et al., 2020).

Tool II: Athlete Supplement Safe Use Checklist

This checklist evaluated the practical application of safe supplement use across five domains: label reading, product selection, nutrition planning, health monitoring, and consultation with qualified specialists (such as physicians, dietitians, or pharmacists). It consisted of 12 items, each scored on a three-point scale (0 = not done, 1 = rarely done, 2 = usually done). The total score ranged from 0 to 24, with higher scores reflecting greater competency in safe supplement practices.

Scores were categorized as low (0-8), average (9-16), and high (17-24) competency levels. Reliability testing indicated good internal consistency (Cronbach's $\alpha = 0.85$) and strong interrater agreement ($\kappa = 0.82$). The checklist was developed by the researchers based on existing literature and expert reviews in nursing, pharmacology, and sport nutrition, ensuring both content validity and practical relevance (Buell et al., 2013; Wasa-Madge & Sesbreno, 2022; Ziegenhagen et al., 2020).

Tool III: Biochemical Analysis Instrument

Biochemical analysis served as the third tool for data collection and was conducted twice: at baseline during the pre-intervention assessment and again at the end of the six-month intervention period. Venous blood samples were obtained from all participants by trained laboratory personnel using sterile vacutainer tubes. Samples were immediately transported to a licensed and accredited clinical laboratory. Liver function tests, including alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP), were conducted to assess potential hepatotoxic effects associated with dietary supplements and anabolic hormone use. Renal function was evaluated *via* serum creatinine and blood urea nitrogen (BUN) measurements to examine possible impacts on kidney health procedures. All analyses adhered to established laboratory methods to ensure reliability, accuracy, and reproducibility of the results (Bordin et al., 2017; Sulaiman et al., 2023).

Pilot Study

A pilot study was conducted prior to the main data collection to assess the clarity, readability, and content validity of the study questionnaire and checklist, as well as to estimate the time required for data collection procedures. The pilot study was carried out in one

licensed health club that was not included in the main study sites, ensuring that pilot participants did not overlap with the final study sample. The pilot study was conducted by members in the research team, who administered the questionnaire, explained study procedures, and collected participants' feedback regarding item clarity and comprehensibility. A total of 15 athletes who met the inclusion criteria were recruited for the pilot study using the same recruitment procedures applied in the main study. Feedback obtained from the pilot participants was used to make minor wording modifications to improve clarity and cultural appropriateness of certain items. No major changes to the structure or scoring of the tools were required. Data obtained from the pilot study was used solely for tool refinement and feasibility assessment and was not included in the final data analysis.

Field of the Work

An evidence-based educational intervention was designed using a nursing-led approach and guided by recent scientific literature. To ensure accuracy and relevance, the content was reviewed and validated by a panel of experts that included nursing faculty members, pharmacists, and specialists in sport health education (American Cancer Society, 2021; Kozhuharov et al., 2022; Martin et al., 2018; Ministry of Health, Saudi Arabia, 2024)

The program was implemented over six months (October 1, 2024-March 30, 2025) and began with an intensive 4-week training phase, followed by ongoing evaluation. Before launching the educational sessions, a pretest assessment was conducted to establish baseline data. This included collecting venous blood samples to measure biochemical markers of liver and kidney functions, as well as administering the validated questionnaire to assess participants' baseline knowledge, attitudes, and practices regarding dietary supplements and anabolic hormones. In addition, the research team carried out a structured needs' assessment to identify participants' strengths, weaknesses, and specific gaps in understanding, which guided the refinement of the educational content.

The program adopted a hybrid delivery model, combining face-to-face sessions in fitness clubs with online sessions *via* secure video conferencing. A total of eight sessions (240 minutes) were delivered using multimodal teaching strategies, such as interactive lectures, multimedia presentations, group discussions, and both printed and digital learning resources. Sessions 1 and 2 (30 minutes each) introduced dietary supplements and anabolic hormones, covering their types, mechanisms of action, and common misconceptions. Sessions 3 and 4 (30 minutes each) incorporated lectures, educational videos, and discussions on health risks and adverse outcomes associated with misuse, supported by relevant local case examples to enhance understanding.

Post-test Evaluation

Data were collected at multiple time points depending on the type of variable assessed. Knowledge and attitudes regarding dietary supplements and anabolic hormones were evaluated at baseline or pre-intervention (T1), 3 months (T2), and 6 months (T3) post-intervention using validated questionnaires, allowing for assessment of both immediate and sustained changes in understanding and beliefs. Behavioral practices related to safe supplement use and biochemical parameters (liver and kidney functions) were assessed at baseline (T1) and 6 months' post-intervention (T3), as these outcomes are expected to change more gradually over time. This approach ensured a comprehensive evaluation of the educational program, capturing knowledge retention, attitude shifts, behavioral improvements, and physiological changes, and highlighting the overall effectiveness of the structured, nursing-led intervention in promoting safe supplement and hormone use among athletes.

Ethical Considerations

The FN-BSU REC has approved the study from the ethical point of view. The approval number is FNBSURECP/2801202530. The ethical standards of the research and the rights of the participants were carefully observed during the study. Verbal consent was obtained from each participant, and the participants were informed that the data collected would only be used for research purposes and that confidentiality would be guaranteed. They were given assurances of confidentiality and that they could withdraw from the study at any time without any consequences. To assess the biochemical parameters related to the use of dietary supplements and anabolic hormones, all participants underwent laboratory testing. A formal contract was established with a licensed laboratory, ensuring

standardized and accurate testing procedures.

Statistical Analysis

Data was coded, entered, cleaned, and analyzed using the Statistical Package for Social Sciences (SPSS), version 20. Descriptive statistics were computed in the form of frequencies, percentages, means, and standard deviations.

Inferential statistical analyses were selected based on the type of variables and study design:

- Chi-square (χ^2) test was used to examine differences in categorical variables, particularly to compare the distribution of competency levels (low, average, high) regarding safe supplement use before and after the intervention.
- Paired t-tests were used to compare mean scores measured repeatedly on the same participants at different time points (within-subject comparisons). This included:
- Biochemical parameters (pre-intervention *vs*. 6 months post-intervention)
- Knowledge and attitude scores across time points.

The use of paired t-tests was justified, because the same participants were assessed repeatedly. Comparisons were conducted between two time points at a time (T1 *vs*. T2 and T1 *vs*. T3). The objective was to evaluate change from baseline, rather than overall differences across three time points simultaneously. ANOVA was not used, because the primary interest was in pairwise comparisons against baseline (T1) rather than comparing all three time points simultaneously. Paired t-tests allowed clearer interpretation of intervention effects at 3 months (T2) and 6 months (T3) relative to baseline. Statistical significance was set at $p < 0.05$.

Results

The demographic data of the study participants, as presented in Table 1, shows that the majority of respondents were male (87%), while females comprised only 13% of the sample. The mean age of the participants was 33 years with a standard deviation of 4.6 years. In terms of educational background, a significant proportion of the participants had low educational attainment, with 38% being able to only read and write and 35% having completed secondary education. Only 27% had obtained a university-level education. Regarding marital status, the majority of the participants were married (76%), while (24%) were not married.

Table 1. Demographic data of the study participants

Items	N	%
Gender		
Male	87	87
Female	13	13
Age	**33±4.6**	
Educational stage		
Read and write	38	38
Secondary education	35	35
University education	27	27
Marital status		
Married	76	76
Not married	24	24

Table 2 highlights the types of hormonal and dietary supplements used by athletes, revealing notable trends in supplementation practices. Among hormonal supplements, testosterone was the most commonly used (33%), followed by anabolic steroids (21%) and growth hormones (12%), reflecting the potential reliance on performance-enhancing substances. In contrast, dietary supplements were more widely utilized, with protein powders leading at 40%, closely followed by creatine (35%) and BCAAs (26%). Multivitamins were also prominent at 29%, indicating a focus on general health. Notably, 27% of the participants reported combining hormonal and dietary supplements, underscoring the complex supplementation patterns among athletes. These findings highlight the need for targeted education on safe and effective supplement use.

Table 2. Types of hormonal and dietary supplements used by athletes (n = 100)

Category	Type	Frequency of Use (n)	Percentage (%)
Hormonal Supplements	Testosterone	33	33%
	Anabolic Steroids	21	21%
	Growth Hormones	12	12%
Dietary Supplements	Protein Powders	40	40%
	Creatine	35	35%
	BCAAs (Branched-Chain Amino Acids)	26	26%
	Multivitamins	29	29%
Combination Supplements	Hormonal + Dietary	27	27%

The findings presented in Table 3 demonstrate a clear pattern of physiological adaptation following the intervention. Significant improvements were observed in several long-term metabolic parameters. In particular, Alkaline Phosphatase (ALP) levels showed a marked and highly significant reduction ($p < 0.001$). Similarly, indicators of renal function exhibited notable normalization, with significant decreases in serum creatinine ($p = 0.038$) and blood urea nitrogen (BUN; $p = 0.019$), both approaching values within their respective clinical reference ranges after the intervention. Conversely, the intervention had a limited effect on short-term hepatic markers. Although mean levels of alanine aminotransferase and aspartate aminotransferase declined slightly post-intervention, these changes did not reach statistical significance ($p = 0.292$ and $p = 0.308$, respectively).

Table 3. Change in biochemical parameters of liver and kidney functions among athletes (mean ± SD) with reference ranges after 6 months

Biochemical Parameter	Pre-intervention (Mean ± SD)	Post-intervention (6-Month) (Mean ± SD)	Reference Range	T-test	P
ALT (U/L)	49.3 ± 4.2	47.8 ± 4.0	7 - 56	1.12	0.292
AST (U/L)	43.5 ± 3.7	42.1 ± 3.6	8 - 48	1.08	0.308
ALP (U/L)	139.4 ± 6.2	128.5 ± 6.0	40 - 130	4.91	**<0.001**
Creatinine (mg/dL)	1.45 ± 0.15	1.32 ± 0.14	0.6 - 1.3	2.45	**0.038**
Blood Urea Nitrogen (BUN) (mg/dL)	23.5 ± 2.8	20.8 ± 2.5	7 - 20	2.89	0.019

Table 4 demonstrates a significant improvement in participants' knowledge of dietary supplements and anabolic hormones over time. The mean score increased from 11 ± 1.3 at the pretest (T1) to 15.2 ± 1.7 one month post-intervention (T2), with a B-value of 3.8 and a highly significant p-value of <0.0001. At two months post-intervention (T3), the mean score further improved to 17.1 ± 0.9, with a B-value of 5.7 and a p-value of <0.0001. These results indicate that the educational intervention led to a substantial and statistically significant increase in knowledge, with a lasting impact over time. Additionally, Table 4 shows a significant increase in the mean scores over time, suggesting that attitudes toward dietary supplements and anabolic hormones became more positive from the pretest to 3 months and then further improved at 6 months. The high statistical significance ($p < 0.0001$) indicates that these changes are unlikely to be due to chance. The positive B values (+6.9 and +2.2) reflect the incremental changes in attitudes over each time period.

Table 4. Changes in the mean scores of knowledge and attitudes about dietary supplements and anabolic hormones over time

Items	M ± SD	B	P
Changes in the mean scores of attitudes toward dietary supplements and anabolic hormones			
T1. Pretest	11.4±1.3		
T2. 3 months	15.2±1.7	3.8	p < 0.001
T3. 6 months	17.1±0.9	5.7	p < 0.001
Note. B denotes the mean change from baseline (T1). *p*-values represent paired *t*-tests comparing T2 and T3 with baseline.			
Changes in the mean scores of attitudes toward dietary supplements and anabolic hormones over time			
T1. Pretest	14.2±2.1		
T2. 3 months	21.1±1.9	6.9	<0.001
T3. 6 months	23.3±2.6	2.2	<0.001
Note. B denotes the mean change from baseline (T1). *p*-values represent paired *t*-tests comparing T2 and T3 with baseline.			

Table 5 presents the comparison of participants' safe use of supplements before and after the intervention. The results indicate a significant improvement, with the percentage of participants demonstrating high competence increasing from 20% pre-intervention to 63% post-intervention. Conversely, those with low competence decreased from 41% to 16%, reflecting a positive shift in behavior. The test statistic (38.642) and the highly significant p-value (0.00001) confirm that these changes are statistically significant.

Table 5. Comparison of participants' competency regarding the safe use of supplements pre-and post-intervention (6 months)

Consultation with Nutrition Doctor	Pre-intervention (n, %)	Post-intervention (n, %)	Test	p-value
Low competence	41 (41%)	16 (16%)	X^2 38.642	p < 0.001
Average	39 (39%)	21 (21%)		
High	20 (20%)	63 (63%)		
Total	100 (100%)	100 (100%)		
Mean score	11±2.1	19±1.3	T 9.2	p < 0.001

Note: χ^2 = chi-square test for categorical competency levels. *t* = paired *t*-test for mean score comparison. Higher scores indicate greater competency in safe supplement use.

The correlation matrix in Table 6 demonstrates statistically significant relationships among knowledge score, attitude score, and safe practices following the intervention. A strong positive correlation (r = 0.65, p < 0.01) was found between knowledge and attitude scores. Additionally, a moderate positive correlation existed between knowledge and safe practices (r = 0.40, p < 0.01), and between attitude and safe practices (r = 0.45, p < 0.01).

Table 6. Correlation matrix showing relationships among knowledge score, attitude score, and safe practices after the intervention (6 months)

Variables	Knowledge Score	Attitude Score	Safe Practice
Knowledge Score	1.00	0.65**	0.40**
Attitude Score	0.65**	1.00	0.45**

Discussion

This study explored the awareness and safety concerns associated with dietary supplementation and anabolic hormone use among athletes in Egypt, emphasizing the importance of public health education. These findings contribute to the growing body of evidence on the role of educational interventions in promoting informed decisions and healthy practices among athletes. By targeting knowledge, attitudes, and consultation behaviors, the intervention aimed to mitigate the risks associated with the misuse of supplements and anabolic hormones, thereby fostering long-term athlete safety and well-being (Daher et al., 2021; Schlickmann et al., 2022).

Post-intervention results showed a substantial increase in athletes' knowledge scores, confirming the first hypothesis. The results of the current study align with literature that emphasizes the effectiveness of educational interventions in improving knowledge regarding dietary supplements and anabolic hormones. The educational program not only enhanced participants' immediate understanding, but also had a lasting impact over time, as evidenced by the continued improvement in knowledge scores. Similar studies corroborate these findings, showing that targeted educational interventions can significantly enhance knowledge of dietary supplements among college students. Their research highlighted that structured educational sessions provide the necessary tools for individuals to assess supplement-related information critically, fostering informed decision-making (Abdulhadi et al., 2018; Souza e Silva et al., 2019). Preceding studies demonstrated the efficacy of sport nutrition education in improving knowledge, attitudes, and practices among team sport athletes, emphasizing the role of tailored education in promoting responsible supplement use in sport settings (Chiba et al., 2020; Elias et al., 2018).

The current study's results are consistent with earlier findings of a study that evaluated the UK Athletics' Clean Sports Program. That study concluded that educational interventions targeting doping prevention could increase awareness and understanding of safe practices among athletes, thus preventing harmful behaviors (Hurst et al., 2019). Furthermore, previous work supported the value of nutrition education for athletes, noting significant improvements in sport nutrition knowledge and related outcomes among

NCAA Division I baseball players following an intervention program (Rossi et al., 2017). Together, these studies substantiate the impact of education on improving knowledge and awareness, as evidenced in the current study's findings. By effectively addressing knowledge gaps and misconceptions about dietary supplements and anabolic hormones, the intervention ensured a robust and sustained improvement in participants' understanding.

Improvements in attitudes toward safe supplement practices supported the second hypothesis. Athletes demonstrated greater caution about supplement use, particularly regarding consulting healthcare professionals and avoiding unverified sources. This finding aligns with earlier studies that have demonstrated the efficacy of educational interventions in shaping attitudes about health-related behaviors. For instance, a previous study on the Anti-Doping Values in Coach Education (ADVICE) mobile application highlighted significant improvements in doping knowledge and attitudes among grassroots coaches (Nicholls et al., 2020a). Similarly, the iPlayClean program demonstrated a reduction in doping susceptibility and an improvement in attitudes toward clean sport among adolescent athletes (Nicholls et al., 2020b).

These interventions underscore the critical role of education in addressing misinformation and promoting ethical and health-conscious behaviors. Additionally, Nishijima et al. (2019) support the results of the current study. Furthermore, studies targeting adolescents emphasized that skill-based and health-promotion interventions effectively alter attitudes and discourage the misuse of anabolic substances. Both the Swedish adolescent health program and the skill-based intervention in Iran reported significant shifts in participant attitudes, mirroring the findings of the current study (Allahverdipour et al., 2009).

The sustained improvement in attitudes observed here also echoes findings from the school-based doping prevention program in Spain and the anti-doping intervention, demonstrating that structured, contextually relevant educational programs led to lasting positive changes in attitudes among adolescents (Álvarez et al., 2019; Barkoukis et al., 2016). In addition, cultural considerations may play a role in the effectiveness of interventions, highlighting the impact of anti-doping education and personal experiences with doping control on attitudes and knowledge among Japanese university athletes (Murofushi et al., 2018). This emphasizes that culturally tailored programs, such as the one implemented in this study, are crucial for addressing specific population needs and optimizing outcomes.

The post-intervention results demonstrated significant improvements in athletes' knowledge and attitudes regarding dietary supplements and anabolic hormones. However, the baseline knowledge and attitude scores were relatively low. This finding may be explained by the educational profile of the participants, as a considerable proportion of them had only basic literacy or secondary education, limiting their prior exposure to health and nutrition information. Supporting this observation, Thapa et al. (2023) found that nutritional knowledge and attitudes among national athletes were significantly influenced by their educational level, with lower education associated with reduced awareness and understanding of safe dietary practices. Thus, the low baseline knowledge and attitudes in the current study can reasonably be attributed, at least in part, to the participants' limited formal education.

Following the educational intervention, the participants showed marked improvements in knowledge and attitudes, suggesting that structured, nurse-led programs can effectively overcome initial educational deficits. This emphasizes the importance of tailoring educational strategies to the learning needs of populations with diverse literacy levels, using multimodal approaches, including interactive sessions, practical demonstrations, and counseling in order to maximize comprehension and engagement.

The hypothesis that the percentage of participants practicing safe supplement use would significantly increase post intervention is supported by the study results, which show a notable improvement in participants' supplement safety practices. This behavioral change aligns with prior research demonstrating the efficacy of educational interventions in fostering positive health-related decisions among athletes. Existing literature emphasized the role of tailored messaging in enhancing awareness and promoting healthier choices, which could similarly encourage athletes to seek professional guidance for nutrition (Duncan & Hallward, 2019).

Similarly, earlier studies found that ethical decision-making training significantly influenced young athletes' attitudes, steering them toward responsible and

informed choices, such as consulting experts (Elbe & Brand, 2014). Furthermore, it was highlighted that sport nutrition education interventions not only improved knowledge, but also positively impacted attitudes and practices, such as seeking dietary advice from qualified professionals (Holtzman & Ackerman, 2021).

The results from this 6-month study underscore the time-dependent efficacy of the intervention on distinct physiological pathways. The statistically significant reductions in ALP, Creatinine, and BUN ($p < 0.001$, $p = 0.038$, and $p = 0.019$, respectively) provide strong evidence that the intervention successfully modulated sustained processes related to bone turnover and renal filtration. The normalization of Creatinine and BUN is of particular clinical relevance, indicating improved hydration status and glomerular function. Conversely, the non-significant changes in ALT and AST ($p > 0.05$) suggest that the intervention had a limited effect on the acute hepatocellular and musculoskeletal stress inherent to high-intensity training. The review by Chodkowski et al. (2024) comprehensively outlined how AAS usage is associated with detrimental alterations in liver function tests and can contribute to renal damage, highlighting the vulnerability of these organs to external chemical stressors. Furthermore, the work of Dukewich & Stolz (2024) specifically detailed the mechanisms of AAS-associated liver injury, which often involves cholestatic patterns that can elevate enzymes, like ALP.

The significant improvement in these markers in our study, therefore, reinforces the premise that the implemented intervention supported organ health and metabolic recovery, moving the athletes' profiles away from the pathological patterns described in the literature. This conclusion was supported by Aldalaykeh et al. (2023) who reported that healthy lifestyle and healthy choices as well as consulting the specialists are important in promoting health, reducing risk of chronic diseases and reducing earlier mortality.

Strengths and Limitations

The use of validated tools, biochemical measures, and longitudinal follow-up are key strengths that enhance the reliability of the findings. However, limitations, such as the absence of a control group, geographic restriction to one governorate, and gender imbalance, limit generalizability. Future research should employ randomized controlled trials and larger, more diverse samples to strengthen causal inference and assess broader applicability.

Implications for Nursing

This study underscores the critical role of nurses in preventing health risks associated with dietary supplement and anabolic hormone misuse among athletes. As frontline health professionals, nurses are uniquely positioned to conduct early screening and risk assessments, including routine biochemical monitoring and identification of early signs of liver and kidney dysfunction related to supplement or hormone use. They play a vital role in delivering culturally appropriate, evidence-based education, addressing misconceptions, guiding safe-use practices, interpreting product labels, and supporting nutrition planning. By fostering multidisciplinary collaboration with coaches, nutritionists, and pharmacists, nurses can help implement coordinated harm-reduction strategies and advocate for institutional policies that promote health education for supplement users. Moreover, nurses are essential in supporting ongoing behavioral change through follow-up counseling and applying behavior change theories to strengthen adherence to safe practices. Their role extends to community health promotion by leading outreach campaigns targeting young athletes, raising public awareness, and reinforcing the nursing presence in sports and exercise health promotion at broader levels. Finally, nurses can contribute to the advancement of evidence-based practice by supporting future studies that utilize randomized controlled designs and diversified sampling to enhance the generalizability and impact of interventions addressing supplement and hormone misuse.

Conclusion

This study provides compelling evidence of a critical public health issue among athletes in Egypt, characterized by alarming deviations in key health parameters—specifically elevated creatinine and blood urea nitrogen levels—alongside a demonstrated knowledge gap concerning dietary supplement and anabolic hormone use. The findings underscore a direct link between substance misuse and potential sub-clinical organ stress.

Crucially, the research establishes that a targeted, nurse-led educational intervention is a highly effective strategy for addressing this problem. The statistically significant post-intervention improvements in knowledge, attitudes, and reported safe-use practices demonstrate the intervention's capacity to empower

athletes with the information necessary for informed decision-making. The significant positive shift in attitudes is particularly important, as it suggests a move beyond mere awareness toward a deeper internalization of health risks and benefits.

Therefore, this study confirms that proactive health education is not merely beneficial, but also essential for safeguarding athlete well-being. The success of this intervention model highlights the pivotal role that nurses can play as educators and health promoters within athletic communities. Moving forward, integrating such structured, evidence-based educational programs into the standard framework of athletic training is imperative to mitigate health risks, promote long-term wellness, and ensure that the pursuit of athletic excellence does not come at the cost of long-term health.

Consent to Participate

All participants provided informed consent before their inclusion in the study. Written informed consent was obtained from each participant after explaining the study's objectives, procedures, potential risks, and benefits. Participation was voluntary, and individuals had the right to withdraw at any time without consequences.

Disclosure of Use

The authors used Quillpot for English language editing and paraphrasing during the preparation of this manuscript. All content produced with the assistance of the tool was carefully reviewed, verified, and approved by the authors to ensure its accuracy and integrity. The use of this generative AI tool was strictly limited to non-creative, supportive functions, including grammar refinement and style improvement. The tool was not employed to generate novel scientific content, data, analyses, or references. The authors retain full responsibility for the originality, validity, and reliability of all aspects of the submitted work.

Data Availability

The dataset used in the current study is available from the corresponding author upon reasonable request.

Authors' Contributions

Study Design: **SHH, NAM, MMM**. Data Collection: **MMAE-M, HAME, DAMG**. Data Analysis: **SHE, SAMA, EEHA**. Study Supervision: **GEAE, AAAH, YHA**. Manuscript Writing: **WT, SRE, MMAAG**. Critical Revision for Important Intellectual Content: **SHH, NAM, MMAE-M**.

Conflict of Interests

The authors have no competing interests to declare.

Funding or Sources of Financial Support

This study did not receive any funding from any source.

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