Artificial Intelligence in Sports Nutrition: Toward Personalized Dietary Strategies for Athletic Performance in Medan City, Indonesia

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Abstract

Objectives: This study aimed to explore the application of artificial intelligence (AI) in developing personalized dietary strategies to enhance athletic performance among athletes in Medan City, Indonesia.

Materials and Methods: This study used a mixed-method approach combining experimental and survey designs. A total of 45 athletes from various sports disciplines participated in an eight-week AI-based nutrition intervention. The AI-based nutrition system analyzed individual characteristics, including body composition, training load, and dietary habits, to generate personalized nutrition plans. Data were collected using VO_2max performance tests, body composition analysis, and athlete feedback questionnaires. Quantitative data were analyzed to determine changes in endurance and body composition, while survey data were used to describe athletes' adherence and satisfaction with the AI-based dietary recommendations.

Results: The results showed significant improvements in endurance performance after the intervention, as indicated by increased VO_2max scores **($p < 0.05$)**. The intervention also contributed to more optimized body composition and better adherence to dietary plans. In addition, athlete feedback showed higher satisfaction with the nutrition program because the recommendations were individualized according to training load, physical condition, and dietary habits.

Conclusions: AI-based personalized dietary strategies are an effective and innovative approach to supporting athletic performance. By providing individualized nutrition recommendations, AI systems can improve endurance, support body composition management, and increase dietary adherence among athletes. These findings provide practical implications for coaches, athletes, and sports nutrition practitioners in developing technology-based nutrition programs.

Keywords: Artificial Intelligence, Sports Nutrition, Personalization, Athletic Performance, Medan

Introduction

The advancement of digital technology has significantly transformed sports science, particularly in the field of sports nutrition (Blackwell et al., 2014; Buonocore et al., 2024; Dr. Neeraj Yadav, 2024). Artificial intelligence (AI) has emerged as an innovative tool that can process large and complex datasets to support more accurate decision-making in athlete nutrition management. In athletic performance, nutrition cannot be applied using a single general recommendation because each athlete has different physiological characteristics, body composition, metabolic responses, training loads, recovery needs, and dietary habits (Brewer, 2017). Therefore, personalized nutrition has become increasingly important to support performance optimization, recovery, and long-term athlete health(Blongkod, 2022; Bustamante-Sanchez et al., 2022; Casu et al., 2020).

Appropriate dietary strategies play a crucial role in maintaining energy availability, supporting muscle adaptation, reducing fatigue, and improving training quality(Boguszewski et al., 2016; Hawley et al., 2011; Kataoka et al., 2023). However, many athletes still rely on general dietary guidelines that may not fully match their individual needs. This issue is highly relevant in Medan City, where structured sports nutrition services and individualized dietary planning may not be equally accessible for athletes from different sports disciplines. As a result, mismatches between nutritional intake and training demands can affect endurance performance, body composition, recovery, and consistency in training adaptation(@ Charles et al., 2017; Adewale et al., 2024; Bf et al., 2020).

AI-based nutrition systems offer a potential solution by integrating various athlete-specific data, such as body composition, energy expenditure, training load, macronutrient requirements, food intake patterns, and recovery indicators (Kuswoyo, Lahinda, et al., 2020; Lochhead et al., 2024; Lopes et al., 2021). Through data-driven analysis, AI can generate dietary recommendations that are more individualized, adaptive, and responsive to changes in training demands. This approach may help athletes improve dietary adherence because the nutrition plan is designed according to their physiological condition, sport characteristics, and daily eating behavior.

Previous studies have shown that AI can be used in health monitoring, dietary assessment, and personalized nutrition planning. However, its application in sports nutrition, especially in regional athlete populations in Indonesia, remains limited. Most existing nutrition programs for athletes are still based on general recommendations, while empirical evidence on AI-based personalized dietary strategies in local sports contexts is scarce. This creates a research gap regarding how AI can be practically implemented to support athlete performance outside elite national or professional training environments(Kuswoyo, Wasa, et al., 2020).

The novelty of this study lies in its examination of AI-based personalized dietary strategies among athletes in Medan City, Indonesia. Unlike general nutrition interventions, this study uses an AI-based system to analyze individual athlete characteristics, including body composition, training load, and dietary habits, to generate personalized nutrition plans. This study also evaluates both performance outcomes and athlete feedback, making it relevant not only for physiological improvement but also for practical implementation and dietary adherence.

Based on this background, this study aims to investigate the application of AI in developing personalized dietary strategies and to examine its impact on endurance performance, body composition, and athlete adherence in Medan City, Indonesia.

Materials and Methods

Study Participants

This study used a mixed-method design combining quantitative experimental methods and qualitative survey approaches. The quantitative component was used to examine changes in endurance performance and body composition after the AI-based nutrition intervention. Meanwhile, the qualitative component was used to explore athletes' satisfaction, adherence, and perceptions of the personalized dietary recommendations.

A total of 45 athletes aged 17–25 years from several sports clubs in Medan City, Indonesia, participated in this study. Participants were selected using purposive sampling. The inclusion criteria were active athletes, aged 17–25 years, regularly participating in structured training programs, willing to use the AI-based nutrition application for eight weeks, and physically able to complete all testing procedures. Athletes with injuries, metabolic disorders, or incomplete participation during the intervention period were excluded from the study.

Before the study began, participants were informed about the objectives, procedures, and requirements of the research. Participation was voluntary, and all participant data were kept confidential.

Study Organization

The intervention was conducted over eight weeks. During this period, participants used an AI-based nutrition application designed to provide personalized dietary recommendations according to individual athlete characteristics and training demands.

At the beginning of the study, baseline data were collected, including body composition, dietary habits, and training load information. Body composition indicators included body mass index, body fat percentage, and muscle mass. Training load data were recorded based on daily activity and training frequency, duration, and intensity.

The AI-based nutrition application analyzed these data to generate individualized dietary plans. The recommendations included daily calorie needs, macronutrient distribution, meal timing, and hydration strategies. The nutrition plans were adjusted according to each athlete's body composition, training load, and performance goals.

Participants followed the AI-based dietary recommendations for eight weeks while continuing their regular sports training programs. Dietary adherence was monitored throughout the intervention period using daily tracking records in the application. At the end of the intervention, posttest measurements were conducted using the same procedures as the pretest.

Research Instruments

Endurance performance was measured using the VO_2max test through the Beep Test. This test was used to estimate aerobic capacity and evaluate changes in endurance performance before and after the AI-based nutrition intervention.

Body composition was measured using Bioelectrical Impedance Analysis. The measured indicators included body mass index, body fat percentage, and muscle mass. These variables were used to evaluate changes in physical composition after the personalized dietary program.

Athlete satisfaction was measured using a satisfaction questionnaire. The questionnaire assessed athletes' perceptions of the AI-based nutrition application, including ease of use, clarity of recommendations, perceived usefulness, and satisfaction with the personalized dietary plan.

Dietary adherence was monitored through daily tracking in the AI-based nutrition application. This tracking included food intake, hydration compliance, and consistency in following the recommended calorie and macronutrient targets.

Statistical Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Descriptive statistics, including mean and standard deviation, were used to describe VO_2max, body composition, dietary adherence, and satisfaction scores.

A paired sample t-test was used to compare pretest and posttest results for VO_2max and body composition indicators. The significance level was set at $p < 0.05$.

Qualitative data from athlete feedback were analyzed using thematic analysis. The analysis focused on identifying common themes related to usability, perceived benefits, dietary adherence, and challenges in using AI-based personalized nutrition. The qualitative findings were used to support and explain the quantitative results.

Results

The results showed significant improvements in endurance performance, body composition, and dietary adherence after the eight-week AI-based personalized nutrition intervention. Improvements were observed in VO_2max, body fat percentage, muscle mass, and adherence to dietary recommendations. These findings indicate that AI-based dietary planning contributed positively to both physiological and behavioral outcomes among athletes.

Table 1. Changes in Performance, Body Composition, and Dietary Adherence After the Intervention

Variable	Pretest Mean	Posttest Mean	Mean Difference	Percentage Change	p-value
VO_2max (ml/kg/min)	43.2	48.6	+5.4	+12.50%	0.001
Body fat (%)	18.5	15.9	-2.6	-14.05%	0.004
Muscle mass (kg)	52.1	54.3	+2.2	+4.22%	0.003
Dietary adherence (%)	65.0	88.0	+23.0	+35.38%	0.002

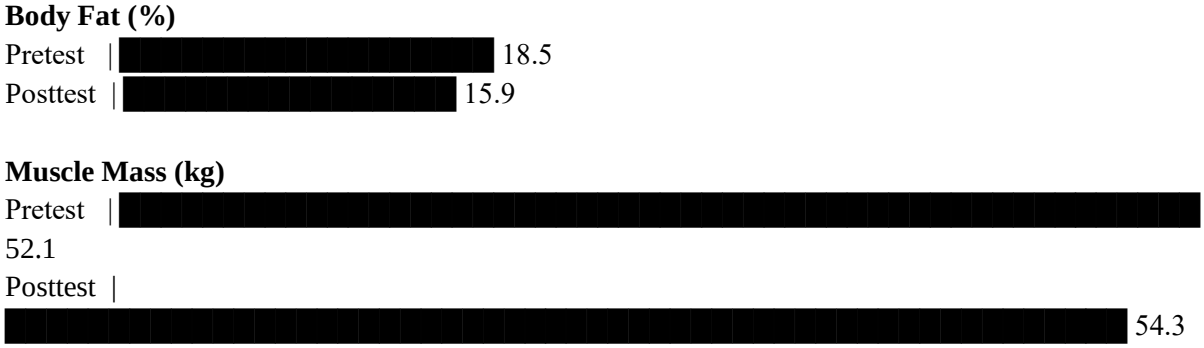
The VO_2max score increased from 43.2 ml/kg/min at pretest to 48.6 ml/kg/min at posttest, with a mean improvement of 5.4 ml/kg/min or 12.50%. This result indicates that the AI-based nutrition intervention was associated with improved endurance capacity.

Body fat percentage decreased from 18.5% to 15.9%, showing a reduction of 2.6 percentage points or 14.05%. In contrast, muscle mass increased from 52.1 kg to 54.3 kg, with a mean improvement of 2.2 kg or 4.22%. These changes suggest that personalized dietary recommendations helped optimize body composition by reducing fat mass while supporting lean muscle development.

Dietary adherence also increased substantially from 65.0% before the intervention to 88.0% after the intervention, representing a 35.38% improvement. This finding indicates that AI-based personalization may improve athletes' consistency in following dietary plans by providing recommendations that are more relevant to their training load, body composition, and nutritional needs.

Figure 1. Pretest and Posttest Comparison of VO_2max and Dietary Adherence

Figure 2. Pretest and Posttest Comparison of Body Composition



Qualitative Findings

The qualitative results supported the quantitative findings. Athletes reported that the AI-based nutrition system made dietary planning easier to understand and follow. Most participants stated that individualized recommendations increased their motivation because the dietary plans were adjusted to their body composition, training load, and performance goals.

Three main themes emerged from athlete feedback:

Table 2. Qualitative Themes of Athlete Feedback

Theme	Description
Personalized guidance	Athletes felt the dietary plans were more relevant to their individual needs.
Improved motivation	Athletes reported greater confidence and willingness to follow nutrition plans.
Better dietary awareness	Athletes became more aware of calorie intake, macronutrient balance, and hydration habits.

Overall, the findings indicate that AI-based personalized nutrition improved endurance performance, optimized body composition, and increased dietary adherence. The combination of objective physiological improvements and positive athlete feedback suggests that AI-based dietary strategies can be a practical and effective tool for supporting athletic performance.

Discussion

The results of this study indicate that AI-based personalized nutrition significantly improved athletic performance, body composition, and dietary adherence among athletes in Medan City. The increase in VO_2max suggests that individualized dietary planning helped support better endurance capacity(Bacon et al., 2013; Kuswoyo, Lahinda, et al., 2020). This improvement may be related to more appropriate energy intake, macronutrient distribution, hydration planning, and nutrient timing based on each athlete's training load and physiological needs.

The reduction in body fat percentage and the increase in muscle mass show that AI-generated dietary recommendations were effective in supporting more favorable body composition changes. Unlike generalized nutrition plans, AI-based systems can analyze individual characteristics such as body composition, activity level, dietary habits, and training demands. This allows nutrition recommendations to be more specific, adaptive, and relevant to each athlete's condition.

The improvement in dietary adherence is also an important finding. Athletes were more consistent in following dietary recommendations after using the AI-based system. This may be because the nutrition plans were perceived as more personal, practical, and aligned with their performance goals. From a behavioral perspective, individualized recommendations can increase motivation, confidence, and commitment because athletes feel that the program is designed for their own needs rather than based on general advice.

These findings highlight the potential of AI as an innovative tool in sports nutrition, especially in regional athlete development contexts such as Medan City. AI-based nutrition systems may help coaches, athletes, and nutrition practitioners make more accurate decisions in managing dietary intake and performance preparation. However, successful implementation requires adequate technological access, user literacy, and proper guidance from sports nutrition professionals. AI should be used as a supportive tool, not as a replacement for expert judgment.

This study has several limitations. The intervention period was relatively short, and the sample was limited to athletes from Medan City. Future studies should use longer intervention periods, larger samples, and sport-specific analysis to examine the long-term effectiveness of AI-based personalized nutrition. Further research should also consider psychological factors, recovery indicators, and the integration of AI systems with wearable training-load monitoring.

Conclusion

AI-based personalized nutrition significantly improved endurance performance, body composition, and dietary adherence among athletes in Medan City. The increase in VO_2max, reduction in body fat, improvement in muscle mass, and higher dietary adherence indicate that individualized dietary recommendations can support better athletic performance and physiological adaptation.

These findings suggest that AI-based nutrition systems can be used as an innovative supporting tool for coaches, athletes, and sports nutrition practitioners. However, their implementation should be accompanied by proper guidance, technological literacy, and professional supervision to ensure safe and effective use in sports training programs.

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