The relationship between micronutrient intake and cardiorespiratory endurance and speed in adolescent basketball athletes in Makassar

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Abstract. Adequate micronutrient intake is essential for supporting physiological processes related to aerobic capacity and speed performance in athletes, yet evidence regarding its association with cardiorespiratory endurance and sprint performance remains limited. This study aimed to examine the relationship between selected micronutrient intake and cardiorespiratory endurance (VO_2 max) and sprint speed in Sahabat Basketball Club athletes. A cross-sectional design was applied involving 20 athletes aged 17–19 years. Daily intake of iron, magnesium, calcium, zinc, vitamin B_1, and vitamin C was assessed using a 3×24-hour dietary recall. Cardiorespiratory endurance was evaluated using estimated VO_2 max, while speed performance was measured through a 30-m sprint test. Pearson correlation analysis was used to determine the associations between micronutrient intake and performance outcomes. The results showed that iron and magnesium intake were strongly and positively correlated with VO_2 max and negatively correlated with sprint time, indicating better aerobic capacity and faster sprint performance. Calcium intake was also significantly associated with both VO_2 max and sprint speed. Zinc and vitamin B_1 intake demonstrated moderate but significant relationships with aerobic capacity and speed, whereas vitamin C intake showed a weak association with VO_2 max and no significant relationship with sprint performance. In conclusion, adequate intake of key micronutrients, particularly iron, magnesium, calcium, zinc, and vitamin B_1, is associated with improved cardiorespiratory endurance and sprint performance in athletes, highlighting the importance of micronutrient adequacy in sports nutrition strategies aimed at optimizing athletic performance.

1 Introduction

Cardiorespiratory endurance and speed are fundamental components of physical fitness that play a crucial role in determining athletic performance, particularly in sports requiring a

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combination of aerobic and anaerobic capacities. Cardiorespiratory endurance, commonly assessed by maximal oxygen uptake (VO_2 max), reflects the body's ability to transport and utilize oxygen efficiently during prolonged physical activity (1). Meanwhile, speed represents the neuromuscular system's capacity to generate rapid and forceful muscle contractions, which is essential for explosive movements and short-duration high-intensity efforts. Optimization of these performance components is influenced not only by training programs but also by nutritional factors, especially the adequacy of micronutrient intake that supports key physiological processes related to energy metabolism and muscle function(2).

Micronutrients such as iron, magnesium, calcium, zinc, and vitamins from the B-complex group and vitamin C have well-established roles in supporting athletic performance. Iron is essential for hemoglobin and myoglobin synthesis, which are critical for oxygen transport and storage in muscle tissue; inadequate iron intake has been associated with reduced aerobic capacity and early onset of fatigue (3). Magnesium and calcium are involved in energy metabolism, neuromuscular transmission, and muscle contraction–relaxation mechanisms, thereby influencing both endurance and speed performance (4). Zinc functions as a cofactor for numerous metabolic enzymes and contributes to tissue repair and recovery, while vitamin B_1 (thiamine) plays a pivotal role in carbohydrate metabolism and energy production during moderate- to high-intensity exercise. Vitamin C, although not directly involved in energy generation, contributes to antioxidant defense and supports recovery by mitigating exercise-induced oxidative stress (5).

Despite their importance, insufficient or imbalanced micronutrient intake remains prevalent among athletes, particularly adolescents and young adults. High training loads, increased physiological demands, and suboptimal dietary patterns may predispose athletes to micronutrient inadequacies, potentially impairing physiological adaptations to training and limiting performance outcomes. Previous studies have reported associations between specific micronutrients and aerobic capacity or physical performance; however, findings remain inconsistent, and comprehensive analyses examining multiple micronutrients in relation to both cardiorespiratory endurance and speed are still limited (6).

In the present study, variability in micronutrient intake was observed among athletes, accompanied by differences in VO_2 max values and 30-meter sprint performance. Correlation analysis indicated significant associations between the intake of iron, magnesium, calcium, zinc, and vitamin B_1 with both cardiorespiratory endurance and sprint performance, whereas vitamin C demonstrated weaker relationships. These findings suggest that adequate intake of specific micronutrients may play a supportive role in optimizing aerobic capacity and speed-related performance parameters (7).

Therefore, this study aims to examine the relationship between micronutrient intake and cardiorespiratory endurance as well as speed performance in athletes. The results are expected to provide scientific evidence to support the development of targeted, evidence-based sports nutrition strategies and to inform coaches, sports nutritionists, and practitioners in optimizing athletic performance and overall athlete health.

2 Methods

This study employed a cross-sectional analytical design to examine the relationship between micronutrient intake and cardiorespiratory endurance and speed performance in athletes. The participants consisted of 20 male athletes aged 17–19 years who were recruited using purposive sampling from Sahabat Basketball Club. All participants were actively engaged in regular training with a minimum frequency of three sessions per week and had at least one year of continuous training experience. Athletes with a history of chronic disease, recent musculoskeletal injury, acute infection, or current use of micronutrient supplements were excluded. Prior to data collection, all participants received a detailed explanation of the study procedures and provided written informed consent, with additional parental or guardian consent obtained for those under 18 years of age.

Micronutrient intake was assessed using a 3 × 24-hour dietary recall conducted on three non-consecutive days, including two training day and one non-training day, to better represent habitual dietary intake. Dietary data were collected through face-to-face interviews by trained nutritionists using standardized household measures and food models to enhance recall accuracy. Nutrient intake analysis was performed using validated food composition tables, and the micronutrients examined included iron, magnesium, calcium, zinc, vitamin B_1 (thiamine), and vitamin C. The average daily intake for each micronutrient was calculated and used for statistical analysis.

Cardiorespiratory endurance was evaluated by measuring maximal oxygen uptake (VO_2 max), which was estimated using a standardized field-based testing protocol suitable for athletic populations. Participants were instructed to refrain from strenuous physical activity for at least 24 hours prior to testing. All measurements were conducted under similar environmental conditions and supervised by experienced assessors to ensure consistency and reliability. Cardiorespiratory values were expressed in millilitres per kilogram of body weight per minute. Speed performance was assessed using a 30-meter sprint test. After completing a standardized warm-up, each participant performed two maximal sprint trials on a straight track, with sufficient recovery time between trials to minimize fatigue. Sprint time was recorded using a digital stopwatch, and the fastest recorded time was used for analysis.

Statistical analysis was performed using appropriate statistical software. Descriptive statistics were used to summarize participant characteristics, micronutrient intake, and performance variables. Data normality was assessed using the Shapiro–Wilk test, and Pearson's correlation analysis was applied to determine the relationships between micronutrient intake and VO_2 max as well as sprint performance. Correlation coefficients and corresponding p-values were reported, with statistical significance set at $p < 0.05$.

3 Result and Discussion

The results of this study demonstrated significant associations between micronutrient intake and both cardiorespiratory endurance and speed performance among athletes. Correlation analysis revealed that iron, magnesium, calcium, zinc, and vitamin B_1 intakes were positively associated with VO_2 max, while these micronutrients showed negative correlations with 30-meter sprint time, indicating better speed performance with higher micronutrient intake. In contrast, vitamin C intake exhibited a weaker association with performance outcomes, particularly with sprint speed. These findings suggest that micronutrient adequacy plays an important role in supporting physiological mechanisms underlying aerobic capacity and high-intensity performance (8).

Iron intake showed a moderately strong positive correlation with VO_2 max and a significant negative correlation with sprint time, highlighting its central role in oxygen transport and utilization during exercise. Iron is a critical component of hemoglobin and myoglobin, which facilitate oxygen delivery from the lungs to working muscles and oxygen storage within muscle fibers. Adequate iron availability enhances mitochondrial oxidative capacity by supporting cytochrome enzymes involved in the electron transport chain. Consequently, athletes with sufficient iron intake are better able to sustain aerobic metabolism, delay the onset of fatigue, and maintain higher exercise intensities. Furthermore, improved oxygen delivery may indirectly support repeated high-intensity efforts by enhancing phosphocreatine resynthesis during recovery periods, which contributes to faster sprint performance (9). The result shown in above.

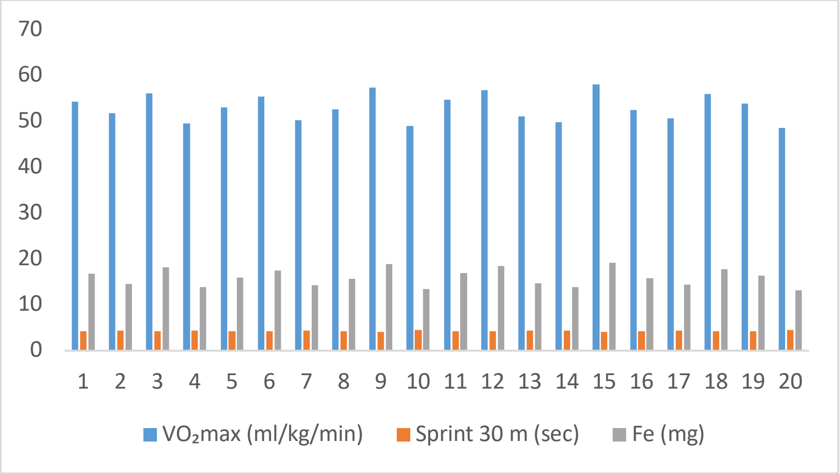

Fig. 1. The Comparison between Iron Intake and Athletes Performances

Magnesium demonstrated the strongest association with both VO_2 max and sprint performance in this study. From a metabolic perspective, magnesium acts as a cofactor for numerous enzymes involved in ATP synthesis and utilization, including those regulating glycolysis and oxidative phosphorylation. Magnesium-ATP complexes are required for muscle contraction, ion transport, and neuromuscular signaling. Adequate magnesium intake supports efficient energy transfer within muscle cells, enhances calcium handling in the sarcoplasmic reticulum, and reduces neuromuscular excitability that may lead to premature fatigue. These mechanisms explain the observed relationship between higher magnesium intake and superior aerobic capacity as well as improved speed performance (10). The result shown in above.

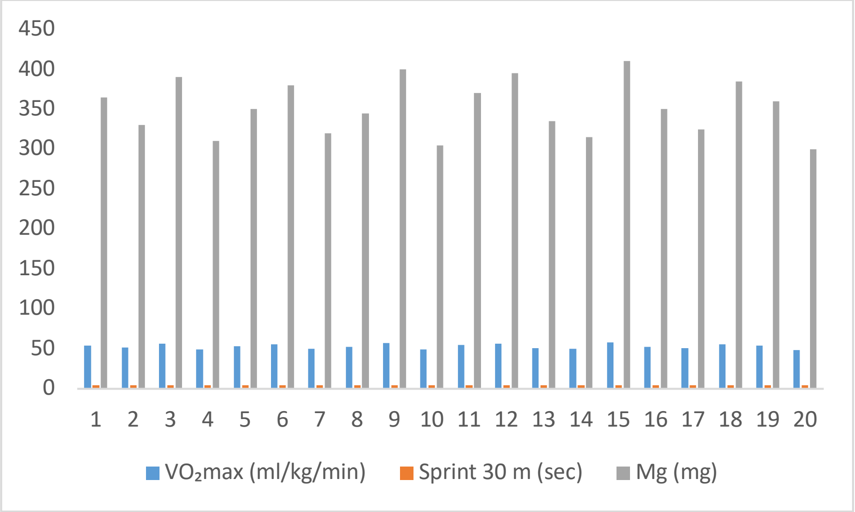

Fig. 2. The Comparison between Magnesium Intake and Athletes Performances

Calcium intake was also significantly associated with both cardiorespiratory endurance and sprint performance, with a particularly strong relationship observed for sprint speed. Calcium plays a fundamental role in excitation–contraction coupling, as the release of calcium ions from the sarcoplasmic reticulum initiates actin–myosin cross-bridge cycling and force production. Adequate calcium availability ensures optimal muscle fiber recruitment and contraction efficiency, which is essential for explosive movements such as sprinting. Additionally, calcium contributes to mitochondrial function and may indirectly support aerobic metabolism by influencing muscle fiber efficiency and endurance performance (11). The result shown in above.

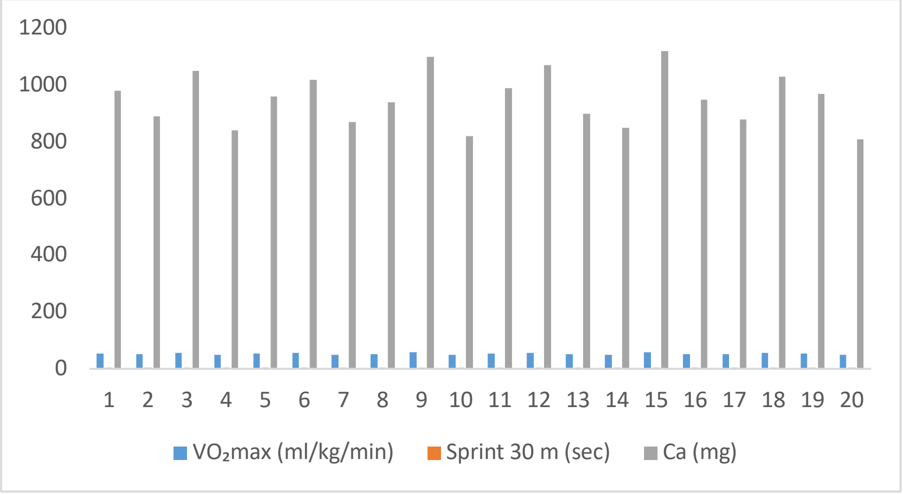

Fig. 3. The Comparison between Calcium Intake and Athletes Performances

Zinc intake showed moderate correlations with VO_2 max and sprint performance, reflecting its involvement in multiple metabolic and physiological processes. Zinc functions as a structural and catalytic component of numerous enzymes involved in macronutrient metabolism, protein synthesis, and antioxidant defense. During exercise, zinc contributes to the regulation of oxidative stress and supports tissue repair and recovery, which are critical for maintaining training adaptations and performance capacity. Insufficient zinc intake may impair mitochondrial enzyme activity and increase susceptibility to exercise-induced oxidative damage, thereby limiting both aerobic and anaerobic performance (12). The result shown in above.

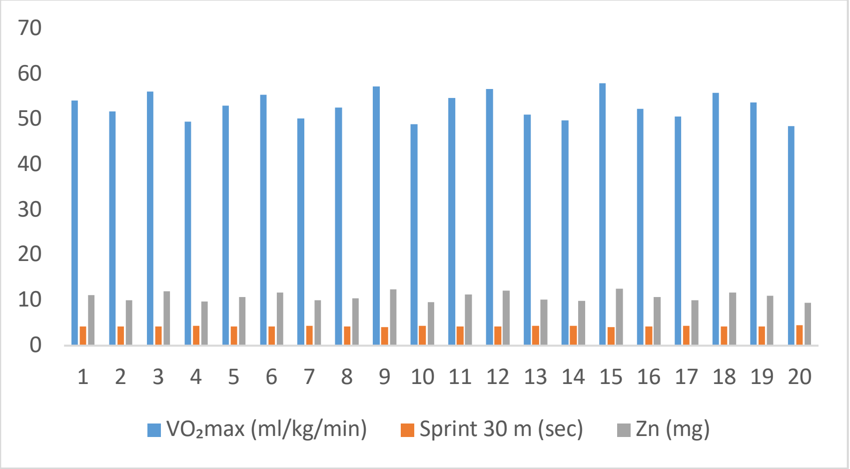

Fig. 4. The Comparison between Zinc Intake and Athletes Performances

Vitamin B_1 (thiamine) intake was significantly associated with VO_2 max and sprint performance, underscoring its essential role in carbohydrate metabolism. Thiamine acts as a coenzyme for key enzymes such as pyruvate dehydrogenase and α-ketoglutarate dehydrogenase, which link glycolysis to the tricarboxylic acid cycle. Adequate thiamine availability facilitates efficient conversion of carbohydrates into usable energy, supporting sustained aerobic exercise and high-intensity efforts. In athletes, optimal thiamine status is particularly important due to increased reliance on carbohydrate oxidation during training and competition (13). The result shown in above.

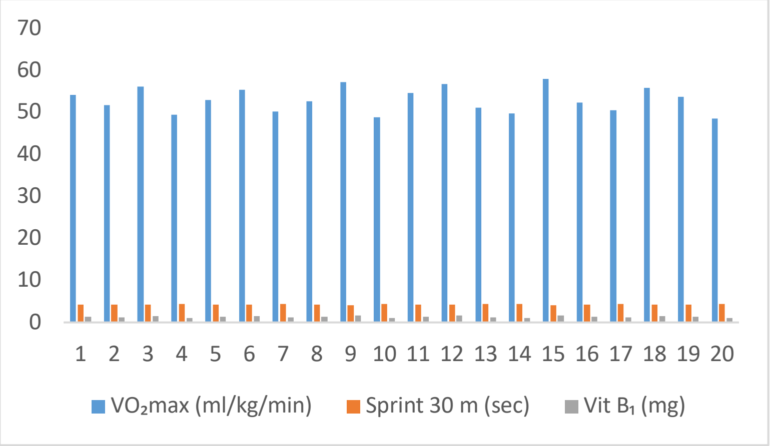

Fig. 5. The Comparison between Vitamin B_1 Intake and Athletes Performances

In contrast, vitamin C intake showed a weaker relationship with performance outcomes, particularly with sprint speed. While vitamin C plays an important role in antioxidant defense and collagen synthesis, its direct involvement in energy production is limited. The weaker association observed in this study suggests that vitamin C may contribute more to recovery processes and protection against oxidative stress rather than directly enhancing acute performance parameters such as speed. However, adequate vitamin C intake remains important for overall athlete health and long-term adaptation to training (13,14). The result shown in above.

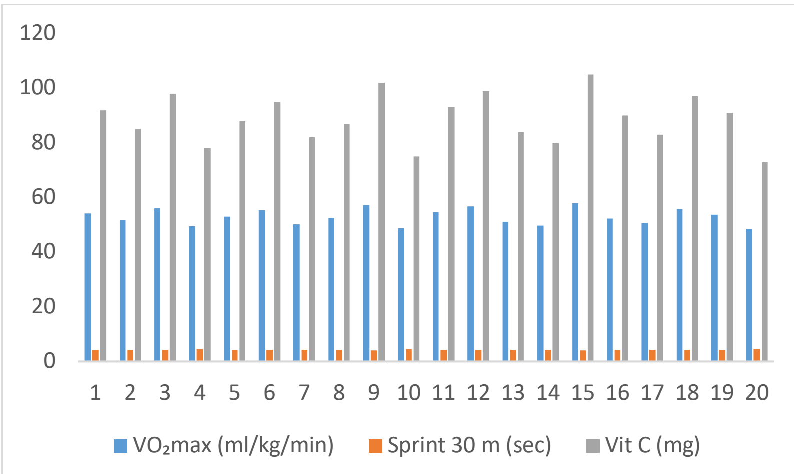

Fig. 6. The Comparison between Vitamin C Intake and Athletes Performances

Overall, the findings of this study highlight the importance of adequate micronutrient intake in supporting metabolic and physiological processes underlying cardiorespiratory endurance and speed performance. Micronutrients involved directly in oxygen transport, energy metabolism, and muscle contraction appear to have a stronger influence on performance outcomes (15). These results emphasize the need for comprehensive nutritional strategies that prioritize micronutrient adequacy as part of an integrated approach to optimizing athletic performance and physiological adaptation to training.

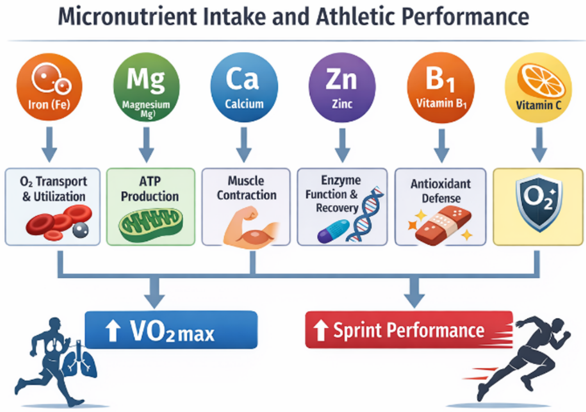

Fig. 7. Metabolic Pathways Influencing VO_2 max and Sprint Performance in Athletes

4 Conclusion

This study concludes that adequate micronutrient intake is significantly associated with cardiorespiratory endurance and speed performance in athletes. Iron, magnesium, calcium, zinc, and vitamin B_1 demonstrated meaningful relationships with VO_2 max and sprint performance, highlighting their essential roles in oxygen transport, energy metabolism, and muscle contraction. These micronutrients support mitochondrial function, ATP production, and neuromuscular efficiency, thereby contributing to improved aerobic capacity and faster sprint performance. In contrast, vitamin C showed a weaker association with performance outcomes, suggesting a more supportive role in recovery and oxidative stress regulation rather than direct performance enhancement. Overall, the findings emphasize the importance of ensuring sufficient micronutrient intake as part of comprehensive nutritional strategies to optimize physiological function, training adaptation, and athletic performance.

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