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The Correlation Between Macronutrient And Iron Intake And Cardiorespiratory Fitness Among Rugby Athletes Of UNESA Student Activity Unit

Athaillah Dihyan Wijaya[1) *], Desty Muzarofatus Sholikhah[2)]
[1,2)] Nutrition Study Program, Universitas Negeri Surabaya, Eastl Java, Indonesia

*Corresponding Author
Email : athaillah.22149@mhs.unesa.ac.id

Abstract

Cardiorespiratory fitness or VO2 max is an important component in supporting the performance of rugby athletes who require high endurance, but nutritional imbalances are still often found among athletes. This study aims to analyze the relationship between macro nutrient intake and iron intake with physical fitness (cardiorespiratory) among athletes of the Surabaya State University Rugby Club. This study used a quantitative cross-sectional design involving 33 athletes. Macronutrient intake was obtained through a 2x24-hour food recall, iron intake was measured using the Iron-Semi Quantitaive Food Frequency Questionnaire (Iron-SQFFQ), and physical fitness was measured using the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1). The average energy intake of athletes was 2040 ± 457.9 kcal/day, protein 88.3 ± 15.9 g/day, fat 78.2 ± 15.4 g/day, and carbohydrate intake 248.4 ± 75.8 g/day. The average iron intake was 13.7 ± 5.05 mg/day, with most athletes falling into the good category (81.8%). The average VO2 max value of the athletes was 45.0 ± 4.63 ml/kgBW/minute, with the dominant category being sufficient to very good. Data analysis used Spearman's rank correlation test. The correlation test results showed that energy intake (p= 0.008; r=0.451), fat intake (p= 0.004; r= 0.488), and iron intake (p= 0.008; r=0.451) were significantly related significantly with physical fitness, while protein intake (p= 0.133; r=0.267) and carbohydrate intake (p= 0.801; r=0.046) did not show a significant relationship. It was concluded that adequate energy, fat, and iron intake are related to the cardiorespiratory fitness of rugby athletes.

Keywords: Macronutrient Intake, Iron, Cardiorepiratory Fitness, Rugby Athletes.

INTRODUCTION

Sport is a structured physical activity aimed at improving skills, fitness, and overall body health (Ichsanudin et al., 2024). One sport that requires physical strength, endurance, and high technical skill is rugby. This sport is categorized as a field-based team sport with high contact, lasting 80 minutes, consisting of two halves of 40 minutes each, separated by a rest period of no more than 15 minutes (Posthumus et al., 2020). Rugby has three categories, namely 7's (seven versus seven), 10's (ten versus ten), and XV (fifteen versus fifteen) (Sani et al., 2022).

As a sport that demands a combination of strength and physical endurance, rugby athletes need to possess several fitness characteristics, such as strength, power, speed, and aerobic fitness, in order to perform optimally and meet the demands of the game (Posthumus et al., 2020). The higher the level of an athlete's physical fitness, the better their physical health will be, resulting in improved performance (Hasniyati et al., 2022). Endurance is one component of physical fitness associated with delayed fatigue and is related to aerobic capacity. Optimal endurance can be measured through cardiorespiratory capacity or VO_2 max (El Ghina et al., 2023; Aliman et al., 2023). During the 80-minute duration of a rugby match, athletes face periods of high- and low-intensity activity that place extreme demands on both aerobic and anaerobic systems (Meir et al., 2001). Therefore, rugby athletes require a high oxygen supply to support performance. The cardiorespiratory component (VO_2 max) reflects the body's capacity to utilize oxygen during intense physical activity and is considered more relevant because it can describe physiological demands and be measured objectively (Wijaya et al., 2024).

VO_2 max, as an indicator of aerobic capacity, plays an important role in supporting rugby athlete performance; however, several studies show that the level of cardiorespiratory physical fitness is still not optimal. A physical fitness survey of rugby athletes at Boyolali Club in 2020–2021 by Kurniawan et al. (2020) noted that there were no male athletes in the "very good" category, with the majority in the "moderate" category (50%). Meanwhile, among female athletes, 42% were in the moderate category, and 8% each were in the "poor" and "very poor" categories. Similar findings were reported by Urahman et al. (2022) in rugby athletes in East Kalimantan, where most athletes were in the "poor" (59%) and "very poor" (33%) categories. This relatively low level of fitness is also found in similar team sports, such as football and basketball. Research by Sa'adah et al. (2023) showed that the majority of football athletes at SSB Ganesha Putra FC Purwodadi had moderate physical fitness (53.8%), while Sufyan et al. (2024) found that most basketball athletes were in the poor category. These findings indicate that athlete fitness levels are generally still below the ideal category.

The combination of physical training and adequate nutritional intake influences athlete performance or physical fitness by 72.5% (Sa'adah et al., 2023). Therefore, athletes require a balanced diet that includes energy sources, protein, carbohydrates, fats, vitamins, and minerals (Maulida et al., 2023). Macronutrients consist of carbohydrates, proteins, and fats, which function as energy sources, energy reserves, and play roles in muscle synthesis and repair (Panggabean, 2020). Carbohydrate deficiency can disrupt aerobic energy metabolism and lead to glycogen depletion, resulting in faster fatigue and decreased performance (Noakes, 2022). Protein deficiency can cause impaired recovery, increased risk of injury, loss of muscle mass, and decreased functional capacity (Panggabean, 2020). Meanwhile, fat functions as an energy source in long-duration activities, supports metabolism, and aids the absorption of vitamins A, D, E, and K. Fat deficiency can reduce energy reserves and disrupt hormonal balance, while excessive intake can affect body composition and metabolic health (Panggabean, 2020; Roberts & Gough, 2024).

Iron also plays an important role in the formation of red blood cells and supports oxygen transport to muscle tissues (Hasniyati et al., 2022). The circulatory system carries oxygen from the lungs to all body tissues with the help of hemoglobin (Hardiansyah et al., 2024). Research by Sitoayu et al. (2020) shows a significant correlation between iron intake and physical fitness. Iron deficiency can hinder oxygen supply and energy production, resulting in fatigue, decreased endurance, slower recovery, and reduced concentration (Hall & Hall, 2021; Peeling et al., 2022).

The development of rugby in Indonesia shows a positive trend, as evidenced by achievements at national and international levels. The Indonesian women's rugby team participated in the Asia Rugby Sevens Trophy 2024 in Nepal. In East Java, development is also rapid, with achievements from Bojonegoro, Kodam V/Brawijaya Surabaya, and Universitas Negeri Surabaya, which won the National U-19 Rugby Championship in 2019.

Along with the rapid development of rugby, greater attention is needed toward factors supporting athlete performance, especially nutritional intake and physical fitness. However, studies examining this relationship in rugby athletes in Indonesia are still limited. Hasniyati et al. (2022) found a significant relationship between fat, carbohydrate, and iron intake and physical fitness. Sa'adah et al. (2023) also reported a relationship between carbohydrate intake and fitness levels, although nutrient intake had not met recommendations. Holway et al. (2024) found that rugby athletes experienced energy and micronutrient deficits and unbalanced dietary patterns. Recommendations for intake include carbohydrates 3–6 g/kgBW/day, protein 1.6–2.2 g/kgBW/day, and fat 20–35% of total energy intake. Preliminary research on UNESA rugby athletes showed that 66% had not met carbohydrate intake recommendations and 53% had not met fat intake recommendations, with 30% consuming it excessively. This indicates an imbalance in macronutrient intake. Based on this background, it is necessary to conduct research on the relationship between macronutrient and iron intake and physical fitness among non-elite rugby athletes at Universitas Negeri Surabaya.

RESEARCH METHODS

Study Design

This study employed a quantitative approach using a cross-sectional research design. The cross-sectional design was selected to enable data collection to be carried out at a single point in time within a defined period, thereby allowing the researcher to examine the relationship between variables simultaneously. This design is considered appropriate for identifying associations between macronutrient and iron intake and physical fitness levels among rugby athletes without involving follow-up observations. By using this approach, the study provides a snapshot of the current condition of the respondents, particularly in terms of nutritional intake and cardiorespiratory fitness.

Search Strategy

This study was conducted in December 2025 at the athletic field of Universitas Negeri Surabaya (UNESA). The selection of this location was based on the accessibility of the research subjects, namely athletes who are actively involved in rugby training activities under the Student Activity Unit (UKM) Rugby UNESA. The data collection process was carried out directly in the field setting to ensure accurate measurement of physical fitness and reliable collection of dietary intake data through direct interaction with respondents. Conducting the study within a specific time frame and location also ensured consistency in environmental conditions during data collection.

Eligibility Criteria

The population in this study consisted of all athletes from the UKM Rugby Universitas Negeri Surabaya, with a total of 35 active athletes based on data obtained from the head of UKM Rugby UNESA (Amin et al., 2023). The sample was determined using a total sampling technique, in which all members of the population were included as research subjects, as this method is suitable for relatively small populations and helps minimize sampling error (Sugiyono, 2022). During data collection, two athletes were excluded due to injuries that did not meet the inclusion criteria, resulting in a final sample of 33 respondents. The inclusion criteria required participants to be active students of Universitas Negeri Surabaya who were members of UKM Rugby UNESA, had participated in training regularly for at least three months with a minimum frequency of two sessions per week, and were willing to provide informed consent. Respondents were excluded if they withdrew from the study or experienced injury during data collection, and were considered drop-outs if their data were incomplete until the end of the study.

Data Extraction and Management

Data collection in this study played a crucial role in determining the validity and overall quality of the research findings (Sugiyono, 2022). The study utilized primary data sources, meaning that all required data were obtained directly from respondents through surveys and structured interviews using instruments such as the 2×24-hour food recall form, the Iron-Food Frequency Questionnaire (Iron-FFQ), and the Yo-Yo Intermittent Recovery Test Level 1. The process was conducted systematically, beginning with body weight measurements by trained enumerators, followed by structured interviews to collect dietary intake data through the 2×24-hour recall and Iron-FFQ, which were administered directly to ensure accuracy and completeness. The 2×24-hour recall was used to assess daily macronutrient intake, while the Iron-FFQ evaluated the frequency, quantity, and patterns of iron-rich food consumption. Physical fitness was subsequently measured using the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT 1), where respondents performed a standardized warm-up before the test and a cool-down afterward. During the test, each respondent was supervised by an enumerator responsible for ensuring proper procedures, providing instructions, and recording results based on the highest level and shuttle completed. The data collection process was considered complete once all respondents had participated in all stages and all data had been accurately recorded.

Quality and Risk-of-Bias Assessment

The instruments used in this study were carefully selected based on their established validity and reliability to ensure the accuracy of the collected data. Macronutrient intake was assessed using the 2×24-hour food recall method and analyzed with the Food Nutrition Content Analysis (FNCA) software based on the Indonesian Food Composition Table (TKPI) 2020, and the calculated energy intake was compared with individual energy requirements by considering basal metabolic needs along with correction factors such as Physical Activity Level (PAL), Metabolic Equivalent of Task (METs), and additional energy expenditure during training sessions. Iron intake was measured using the Iron-FFQ instrument, which captures the frequency and quantity of iron-rich food and beverage consumption and has demonstrated acceptable validity, particularly for food groups such as tubers, fish and seafood, legumes, vegetables, and dairy products; this instrument was adapted from previous research (Luftimas et al., 2021), which reported a validity coefficient ranging from 0.21 to 0.25, indicating moderate validity. Physical fitness was evaluated using the Yo-Yo Intermittent Recovery Test Level 1, which estimates VO_2 max as an indicator of cardiorespiratory fitness, and this method has been shown to have high reliability, with a coefficient of variation (CV) of 4.9% and an intraclass correlation coefficient (ICC) of 0.92, indicating consistent measurement results across repeated tests (Dobbin et al., 2021).

Data Synthesis

The collected data underwent several processing stages, including editing, coding, data entry, and cleaning, to ensure accuracy and consistency before analysis. The cleaned data were then presented in tabular form and analyzed statistically. Univariate analysis was performed to describe the characteristics of each variable, including macronutrient intake, iron intake, and physical fitness, using frequencies, percentages, and mean values. Bivariate analysis was conducted using the Spearman's Rank correlation test to examine the relationship between macronutrient and iron intake and physical fitness, as all variables were measured on an ordinal scale.

RESULTS AND DISCUSSION

Respondent Characteristics

The population in this study consisted of all active athletes who were members of the Rugby UKM, totaling 35 athletes. The sampling technique used was total sampling, considering the inclusion and exclusion criteria. During the data collection process, 2 athletes were included in the exclusion criteria due to injuries at the time of data collection, resulting in a total sample of 33 athletes used in this study, consisting of 26 male athletes and 7 female athletes. Data collection was conducted through structured interviews related to macronutrient intake (24-hour recall) and iron intake over the past month (Iron-FFQ), and by measuring respondents' VO_2 max using YYIRT1. The characteristics of respondents analyzed included age, gender, training frequency, smoking history, and supplement consumption history. Further details regarding the characteristics and their distribution can be seen in the following table:

Table 1. Frequency Distribution of Variable Characteristics

Respondent Characteristics		n(%)	Mean ± SD
Age (years)	17	7 (21,2)	
	18	8 (24,2)	
	19	5 (15,2)	
	20	8 (24,2)	18,9± 1,57
	21	2 (6,1)	
	22	3 (9,1)	
	Total	33 (100)	
Gender	Laki-laki	26 (78,8)	

Respondent Characteristics		n(%)	Mean ± SD
	Perempuan	7 (21.2)	
	Total	33 (100)	
Training Frequency	1-3x/minggu	33 (100)	
	Total	33 (100)	
Training Duration	2 jam	30 (90,9)	
	2.5 jam	3 (9.1)	
	Total	33 (100)	
Smoking History	Ya	11 (33,3)	
	Tidak	22 (66,7)	
	Total	33 (100)	
Supplement Consumption	Ya	11 (33.3)	
	Tidak	22 (66,7)	
	Total	33 (100)	

Table 1 presents the results of descriptive analysis of categorical variables using statistical software, displaying respondent characteristics with a 95% confidence interval. The results showed that most respondents were aged 18 and 20 years, with the youngest being 17 years old and the oldest 22 years old. Based on gender, the majority of respondents were male, totaling 26 athletes (78.8%), while female athletes accounted for 7 individuals (21.2%).

Based on training duration characteristics, most athletes trained for 2 hours per session (90.9%) with a frequency of 1–3 times per week. The results for smoking history indicated that the majority had no history of smoking (66.7%). Most athletes did not consume supplements, with only 11 athletes (33.3%) reporting supplement intake. The commonly consumed supplements among respondents were whey protein and creatine.

Univariate Analysis

Table 2. Univariate Analysis of Macronutrient Intake

Variabel		n(%)	Mean ± SD	Min - Max
Energy Intake	Kurang (<80% kebutuhan)	15 (45,5)	2040,0 ± 457,9 kkal	1173-2985 kkal
	Baik (80-119% kebutuhan)	18 (54,5)		
	Tinggi (>120% kebutuhan)	0 (0)		
	Total	33 (100)		
Protein Intake	Kurang (<80% kebutuhan)	11 (33,3)	88,3± 15,9 g/hari	42,6-110,9 g/hari
	Baik (80-119% kebutuhan)	20 (60,6)		
	Tinggi (>120% kebutuhan)	2 (6,1)		
	Total	33 (100)		
Fat Intake	Kurang (<80% kebutuhan)	3 (9,1)	78,2± 15,4 g/hari	55,8-108,4 g/hari
	Baik (80-119% kebutuhan)	22 (66,7)		
	Tinggi (>120% kebutuhan)	8 (24,2)		
	Total	33 (100)		
Carbohydrate Intake	Kurang (<80% kebutuhan)	24 (72,7)	248,4 ± 75,8 g/hari	129-392,5 g/hari
	Baik (80-119% kebutuhan)	9 (27,3)		

Variabel		n(%)	Mean ± SD	Min - Max
	Tinggi (>120% kebutuhan)	0 (0)		
	Total	33 (100)		

Based on the analysis of energy intake, it was found that the distribution of energy intake levels varied considerably. Most respondents were in the adequate category, totaling 18 athletes (54.5%), while 15 athletes (45.5%) were categorized as having insufficient intake. The average energy intake of respondents was 2040.0 kcal with a standard deviation of 457.9.

For protein intake, the majority of respondents were in the adequate category, totaling 20 athletes (60.6%), followed by the insufficient category with 11 athletes (33.3%) and the high category with 2 athletes (6.1%). The average protein intake was 88.3 g with a standard deviation of 15.9. The range of protein intake varied considerably, with a minimum value of 42.6 g and a maximum of 110.9 g. The characteristics of fat intake showed that most respondents were in the adequate category, totaling 22 athletes (66.7%), while 8 athletes (24.2%) were in the high category and 3 athletes (9.1%) were in the insufficient category. The average fat intake was 78.2 g, with a standard deviation of 15.4, a minimum value of 55.8 g, and a maximum of 108.4 g. Meanwhile, for carbohydrate intake, most respondents were in the insufficient category, totaling 24 athletes (72.7%), and only 9 athletes (27.3%) were in the adequate category. This indicates that carbohydrate intake was the macronutrient most frequently deficient among respondents in this study.

Table 3. Univariate Analysis of Iron Intake

Variabel		n(%)	Mean ± SD	Min - Max
Iron Intake	Kurang (<10 mg/hr)	6 (18,2)	13,7 ± 5,05 mg/hari	3,58-27,0 mg/hari
	Baik (10-30 mg/hr)	27 (81,8)		
	Tinggi (>30 mg/hr)	0 (0)		
	Total	33 (100)		

Based on the characteristics of iron intake, it was found that most respondents had adequate intake. A total of 27 athletes (81.8%) were categorized as adequate, while 6 athletes (18.2%) were categorized as insufficient. The average iron intake was 13.7 mg/day with a standard deviation of 5.05. The lowest recorded intake was 3.58 mg/day, while the highest reached 27.0 mg/day.

Table 4. Univariate Analysis of Physical Fitness

Variabel		n(%)	Mean ± SD	Min - Max
Physical Fitness (*VO_2 max*)	Sangat rendah	0 (0)	45,0 ± 4,63 ml/kgBB/mnt	38-55 ml/kgBB/mnt
	Rendah	0 (0)		
	Cukup	12 (36,4)		
	Baik	11 (33,3)		
	Sangat baik	10 (30,3)		
	Total	33 (100)		

Based on the characteristics of physical fitness measured through VO_2 max values, the largest distribution of Rugby UKM athletes was in the “moderate” category at 36.4%. The “good” and “very good” categories accounted for 33.3% and 30.3% of respondents, respectively, with no athletes categorized as having low fitness levels. These results indicate that most athletes had relatively good physical fitness levels. The average VO_2 max was 45.0 ml/kgBW/min with a standard deviation of 4.63, indicating that overall fitness levels were within the good category. The lowest VO_2 max recorded was 38 ml/kgBW/min, while the highest reached 55 ml/kgBW/min, reflecting variation in cardiorespiratory endurance capacity among athletes. Overall, these findings indicate that the majority of Rugby UKM athletes had physical fitness levels ranging from moderate to very good.

Bivariate Analysis

Table 5. Analysis of Macronutrient Intake and Physical Fitness

			Physical Fitness (*VO_2 max*)				Correlation Coefficient (r)	P Value
			cukup	baik	Sangat baik	Total		
Energy Intake	Low	n (%)	8 (53,3)	6 (40)	1 (6,7)	15 (100)	0,451	**0,008***
	Adequate	n (%)	4 (22,2)	5 (27,8)	9 (50)	18 (100)		
	Total	n (%)	12 (36,4)	11 (33,3)	10 (30,3)	33 (100)		
Protein take	Low	n (%)	5 (45,5)	4 (36,3)	2 (18,2)	11 (100)	0,267	0,133
	Adequate	n (%)	7 35)	7 (35)	6 (30)	20 (100)		
	High	n (%)	0 (0)	0 (0)	2 (100)	2 (100)		
	Total	n (%)	12 (36,4)	11 (33,3)	10 (30,3)	33 (100)		
Fat Intake	Low	n (%)	2 (66,7)	1 (33,3)	0 (0)	3 (100)	0,488	**0,004***
	Adequate	n (%)	9 (40,9)	9 (40,9)	4 (18,2)	22		
	High	n (%)	1 (12,5)	1 (12,5)	6 (75)	8 (100)		
	Total	n (%)	12 (36,4)	11 (33,3)	10 (30,3)	33 (100)		
Carbohydrate Intake	Low	n (%)	9 (37,5)	8 (33,3)	7 (29,2)	24 (100)	0,046	0,801
	Adequate	n (%)	3 (33,3)	3 (33,3)	3 (33,3)	9 (100)		
	Total	n (%)	12 (36,4)	11 (33,3)	10 (30,3)	33 (100)		

Table 5 presents the results of Spearman’s Rank correlation analysis in a cross-tabulation format, including correlation coefficients (r), p-values, and respondent counts. The analysis showed that energy intake had a significant relationship with physical fitness (VO_2 max), with a p-value of 0.008 ($p < 0.05$) and a correlation coefficient of 0.451, indicating a moderate positive correlation. This means that higher energy intake is associated with better physical fitness levels. Fat intake also showed a significant relationship with VO_2 max ($p = 0.004$, $r = 0.488$), indicating a moderate positive correlation. Meanwhile, protein and carbohydrate intake showed positive but non-significant relationships with VO_2 max, with p-values of 0.133 and 0.801, respectively ($p > 0.05$).

Table 6. Analysis of Iron Intake and Physical Fitness

			Physical Fitness (*VO_2 max*)				Correlation Coefficient (r)	P Values
			Moderate	Good	Very Good	Total		
Iron Intakae	Low	n (%)	5 (83,3)	1 (16,7)	0 (0)	6 (100)	0,451	**0,008***
	Adeqaute	n (%)	7 (26)	10 (37)	10 (37)	27 (100)		
	Total	n (%)	12 (36,4)	11 (33,3)	10 (30,3)	33 (100)		

Table 6 presents the results of the relationship between iron intake and physical fitness (VO_2 max) using Spearman's Rank correlation. The test results showed a significant relationship ($p = 0.008$, $p < 0.05$) with a correlation coefficient of 0.451, indicating a moderate positive relationship. This means that better iron intake is associated with higher physical fitness levels (VO_2 max).

Discussion

Macronutrient Intake Levels

Energy Intake

The univariate analysis showed that the adequacy of energy intake varied among respondents. Some athletes had energy intake that met their needs, while others had insufficient or excessive intake. Physiologically, energy is the main component required by the body to perform metabolic functions and support physical activity (Almatsier, 2015). Energy balance is achieved when energy intake equals energy expenditure through basal metabolism, physical activity, and training (Nolte et al., 2025).

Variations in energy intake adequacy among athletes have also been reported in previous studies, such as Hasniyati et al. (2023), which found that 15.5% of athletes had insufficient intake, 81.0% had adequate intake, and 3.4% had excessive intake. This indicates that although most athletes meet their energy needs, some still fail to achieve optimal energy balance.

Inadequate energy intake may lead to low energy availability, which can reduce training capacity, delay recovery, and negatively impact performance and fitness (Jeppesen et al., 2025; Nolte et al., 2025). Conversely, excessive intake may affect body composition and movement efficiency (Melin et al., 2024).

Based on recall data, energy sources were mainly from staple foods such as rice, noodles, and bread, along with snacks like fried foods and sugary drinks. Although total intake was generally adequate, carbohydrate intake was often insufficient, with significant contributions from fat and protein sources. Carbohydrates are the primary energy source during high-intensity activity, and both quality and timing of intake are important for maintaining performance (Morehen & Close, 2022).

Protein Intake

Protein is an essential nutrient that functions as a structural component of body tissues, particularly muscle, and plays a role in the synthesis of enzymes, hormones, neurotransmitters, and antibodies (Gropper, 2021). In athletes, protein requirements are highly important, especially in sports that demand strength and power, as protein contributes to the formation of muscle fibers that support increases in muscle mass. Meanwhile, in rugby athletes, which is an intermittent sport, protein is required to support adaptation to training, repair muscle fiber damage caused by repeated physical activity, and facilitate the formation of enzymes involved in energy metabolism (Gröber, 2009).

Based on the results of the study, the average protein intake of respondents was 88.3 grams, equivalent to 88.5% of the average athlete requirement of 103.2 grams. Based on Table 2, most Rugby UKM UNESA athletes had protein intake exceeding 80% of their requirements. The number of athletes with protein intake in the insufficient category was 11 individuals (33.3%), those in the adequate category totaled 20 individuals (60.6%), and those in the high or excessive category were 2 individuals (6.1%).

Based on the 2×24-hour food recall results, the protein sources consumed by athletes included milk, fish and processed fish products, eggs, tempeh, tofu, chicken, beef, and various processed meat products. The most common method of preparation was frying, although some respondents also used steaming. It was also reported that 33.3% of athletes used or consumed supplements such as whey protein and creatine. These findings indicate that respondents' protein intake was primarily derived from food sources, while supplements served as complementary rather than primary contributors.

The analysis results showed that the average protein intake of respondents was 1.4 g/kg body weight/day, with the lowest intake at 0.6 g/kg body weight/day and the highest at 2.2 g/kg body weight/day. These findings indicate variability in protein intake among athletes, where some respondents had not yet reached the recommended intake levels, while others had met or approached the upper limit of recommendations. In general, protein requirements for athletes vary depending on training frequency and intensity; athletes training 2–3 times per week are recommended to consume approximately 1.6 g/kg body weight/day, while those with high training intensity or muscle-building goals require protein intake of 1.7–2.2 g/kg body weight/day (Morehen & Close, 2022). Protein is recommended to contribute 10–15% of total daily energy intake, with suggested sources including lean meat, poultry, fish, eggs, dairy products, and plant-based proteins such as legumes (Almatsier, 2015).

Fat Intake]

Carbohydrates are the primary macronutrient that functions as a source of energy, not only to support physical activity but also as the main energy source for the central nervous system, including the brain. In the body, carbohydrates are stored in the liver and muscles in the form of glycogen, which serves as an energy reserve (Gropper, 2021). Athletes are recommended to consume adequate amounts of carbohydrates because optimal glycogen stores support endurance and performance during training and competition. Conversely, low glycogen stores can lead to faster fatigue, thereby reducing exercise intensity and performance (Morehen & Close, 2022).

The results of this study showed that most respondents experienced a deficit in carbohydrate intake. The average carbohydrate intake of respondents was 248.4 grams per day, equivalent to 67.6% of the average athlete requirement of 367.3 grams per day. A total of 24 athletes (72.7%) had carbohydrate intake in the insufficient category, while only 9 athletes (27.3%) were in the adequate category. According to Naufal et al. (2025), low carbohydrate intake in athletes is associated with suboptimal eating patterns, such as skipping meals and having a low frequency of snack consumption, where some athletes only eat twice a day without consuming snacks. In this study, some respondents reported frequently waking up late and skipping breakfast, and being accustomed to eating only twice a day without snacks.

Carbohydrate Intake

Carbohydrate requirements for rugby athletes are influenced by training intensity and phase, where during light to moderate training an intake of 3–6 g/kg body weight per day is recommended, while during the pre-competition phase the requirement can increase to more than 6 g/kg body weight per day. On match days, carbohydrate intake is recommended at 1–3 g/kg body weight at breakfast and 1–2 g/kg body weight 3–4 hours before competition, while during the match an intake of 30–60 grams per hour is required to maintain energy availability. During the recovery phase, a carbohydrate intake of approximately 1 g/kg body weight per hour for 3–4 hours is recommended to optimize muscle glycogen replenishment (Morehen & Close, 2022).

The results of this study showed that the average carbohydrate intake of respondents was 4 g/kg body weight per day, with a consumption range of 2.5–6.1 g/kg body weight per day, indicating that some athletes were within the recommended range, although there were still athletes with relatively low intake as well as those approaching the upper limit of requirements. Adequate carbohydrate intake is important considering that during rugby matches, muscle glycogen stores can decrease by up to approximately 40%, therefore sufficient carbohydrate intake plays a role in maintaining performance, delaying fatigue, and accelerating post-match recovery (Roberts & Gough, 2024).

Iron Intake Level

Table 3 presents an overview of respondents' iron intake, calculated as the total dietary iron consumption expressed in mg/day. Iron intake was estimated by analyzing the foods consumed by respondents over the past one month using the Iron-Food Frequency Questionnaire (Iron-FFQ) method. The intake data were subsequently processed using the Food Nutrition Content Analysis (FNCA) software, which is based on the Indonesian Food Composition Table (TKPI) 2020. According to Gröber (2009), the recommended dietary allowance of iron for endurance athletes ranges from 10–30 mg/day. The level of iron intake adequacy was classified into three categories: intake of less than 10 mg/day was categorized as low, intake between 10–30 mg/day as adequate, and intake above 30 mg/day as high.

In this study, statistical analysis showed that the majority of respondents had adequate iron intake, with 27 athletes (81.8%) classified in the adequate category and only 6 athletes (18.2%) categorized as having low iron intake, with no respondents classified in the high category. The average iron intake among respondents was 13.7 mg/day, which falls within the recommended adequacy range. These findings are consistent with previous studies, such as Listianasari et al. (2020), which reported that 64.9% of 37 soccer athletes had adequate iron intake, as well as Tasya et al. (2025), which found that 42.8% of university futsal athletes in Surakarta had adequate iron intake.

However, the results of the Iron-FFQ interviews indicated that the primary sources of iron consumed by respondents were predominantly non-heme iron rather than heme iron. Non-heme iron has lower bioavailability compared to heme iron because it lacks a specific transporter that facilitates direct absorption into the bloodstream (Piskin et al., 2022). The human body is capable of absorbing heme iron at approximately twice the rate of non-heme iron (Almatsier, 2015: 253). In contrast, non-heme iron is more difficult to release from its binding proteins, and only about 5% of dietary iron from such sources is readily absorbed (Piskin et al., 2022). Therefore, although most athletes demonstrated adequate total iron intake, the quality and source of iron consumed remain important considerations to ensure optimal iron status and support athletic performance.

Physical Fitness (VO_2 max)

Table 4 presents the characteristics of respondents' cardiorespiratory physical fitness levels. Physical fitness was measured using the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1), which is a field-based fitness test designed to assess cardiorespiratory endurance through repeated 2 × 20 meter shuttle runs following audio signals with progressively increasing speed, interspersed with 10 seconds of active recovery, until the participant is unable to maintain the required pace (Dobbin et al., 2021). Based on Tables 1 and 2, the level of physical fitness in this study was classified into five categories according to VO_2 max norms, namely very low, low, moderate, good, and very good.

The average VO_2 max value of UKM Rugby UNESA athletes was 45 ml/kg/min and was classified within the very good category. The results of this study indicate that the majority of athletes had good to very good levels of physical fitness, with 11 athletes categorized as good and 10 athletes categorized as very good. Meanwhile, 12 athletes were classified in the moderate category, and no athletes were found in the low or very low categories. Most respondents were within the late adolescent to early adulthood age range, with an average age of 18.9 years. The age range of 17–22 years represents a phase in which physical capacity, including cardiorespiratory fitness and adaptation to training, is relatively optimal, thereby supporting the achievement of good to very good VO_2 max levels.

Among young adult rugby athletes, several studies have reported that the average VO_2 max typically exceeds 50 ml/kg/min, with a range of approximately 48.6–56.4 ml/kg/min depending on playing position and competition level (Lesinski et al., 2020). In addition, the characteristics of respondents were predominantly male (78.8%), who physiologically tend to have higher aerobic capacity, greater muscle mass, and higher hemoglobin levels compared to female athletes, thereby contributing to the overall higher level of physical fitness observed among respondents (Lesinski et al., 2020; Strasser et al., 2021).

The Relationship between Macronutrient Intake and Physical Fitness (VO_2 max)

The Relationship between Energy Intake and Physical Fitness (VO_2 max)

The results of this study showed that energy intake has a significant relationship with cardiorespiratory physical fitness (VO_2 max), with a p-value of 0.008 ($p < 0.05$). This finding indicates that the better the adequacy of energy intake, the higher the VO_2 max level of the athletes, thus the research hypothesis (H1) is accepted. Energy is the main component in supporting physical activity, especially in rugby, which requires intermittent activity with moderate to high intensity over a relatively long duration. Both male and female athletes are at risk of decreased performance if their energy intake does not meet the demands of training and competition. Adequate energy intake plays an important role in maintaining optimal cardiovascular and respiratory function, allowing the processes of oxygen uptake, transport, and utilization during physical activity to occur efficiently. These findings are consistent with Rahmi (2022), who reported that adequate energy intake significantly contributes to improving the physical fitness of athletes in UPTD Kebakatan DISPORA West Sumatra.

The presence of athletes with VO_2 max values in the moderate category may be influenced by insufficient energy intake. Based on the cross-tabulation results in Table 5, respondents with inadequate energy intake tended to have lower levels of physical fitness. A total of 8 out of 15 respondents with low energy intake were categorized as having moderate physical fitness. Energy deficiency may lead to reduced availability of energy substrates for physical activity, causing the body to fatigue more quickly and reducing cardiorespiratory endurance capacity. Prolonged energy deficiency also increases the risk of chronic energy deficiency, which can disrupt energy metabolism through decreased activity of metabolic enzymes such as hexokinase and pyruvate kinase (Telisa & Eliza, 2020).

The Relationship between Protein Intake and Physical Fitness (VO_2 max)

Protein is a macronutrient that functions as a building and maintenance component of body tissues, as well as playing a role in the formation of enzymes, hormones, and antibodies. During physical activity, especially at moderate to high intensity, muscle contraction and micro-damage occur, requiring protein for the recovery process (Witard et al., 2025). However, based on Table 5, protein intake did not show a significant relationship with physical fitness, with a p-value of 0.267 ($p > 0.05$). This finding suggests that protein plays a more dominant role in muscle recovery and tissue adaptation rather than directly influencing cardiorespiratory capacity or VO_2 max. Although no significant relationship was found, the distribution results indicate that most athletes with good to very good levels of physical fitness had protein intake within the adequate category.

Based on Table 5, athletes with adequate protein intake were more likely to have good (7 athletes) and very good (6 athletes) levels of physical fitness compared to those with inadequate protein intake. This finding suggests that adequate protein intake still contributes to overall muscle function and supports the cardiorespiratory system during physical activity. This is consistent with Maulida et al. (2023), who also reported no significant relationship between protein intake and physical fitness among athletes in UPTD Kebakatan Olahraga, North Sumatra Province, with a p-value of 0.523 ($p > 0.05$). The study involved athletes from various sports, including soccer, athletics, gymnastics, taekwondo, karate, sepak takraw, wrestling, pencak silat, judo, boxing, archery, and cycling, indicating that the lack of a significant relationship between protein intake and physical fitness is also observed across diverse sports disciplines. This suggests that once minimum protein requirements are met, variations in protein intake do not directly impact athletic fitness. Nevertheless, protein remains essential for maintaining the function and integrity of muscle tissues, including cardiac muscle, and adequate intake is necessary to support physiological adaptation to training and to maintain overall cardiorespiratory fitness (Baranauskas et al., 2023).

The Relationship between Fat Intake and Physical Fitness (VO_2 max)

The results of this study showed that fat intake is positively associated with physical fitness. A p-value of 0.004 ($p < 0.05$) indicates a significant relationship between fat intake and physical fitness, with a correlation coefficient of $r = 0.488$, suggesting a moderate positive correlation. The data indicate that respondents with adequate to high fat intake mostly had very good levels of physical fitness (75%), whereas those with low fat intake were more likely to fall into the moderate fitness category (66.7%). This suggests that higher and adequate fat intake is associated with better physical fitness among athletes. The significance of this relationship may be explained by the role of fat as a major energy source in aerobic metabolism, particularly in supporting endurance and recovery during intermittent activities such as rugby, thereby contributing to increased VO_2 max capacity.

These findings are consistent with Hasniyati et al. (2023), who studied 58 athletes in UPTD DISPORA West Sumatra and reported a significant relationship between fat intake and physical fitness with a p-value of 0.034. In that study, nutrient intake was measured using the 2×24-hour food recall method, while physical fitness was assessed using the bleep test as an indicator of VO_2 max. Athletes with adequate and high fat intake tended to have better fitness levels compared to those with low fat intake, highlighting the important role of fat in supporting aerobic energy metabolism and maintaining endurance performance. However, fat intake is still recommended to be within 20–35% of total daily energy requirements to prevent negative effects on body composition and physical fitness (Pramesti et al., 2025).

The Relationship between Carbohydrate Intake and Physical Fitness (VO_2 max)

Based on Table 5, carbohydrate intake did not show a significant relationship with physical fitness, as indicated by a p-value of 0.801 ($p > 0.05$) and a correlation coefficient of $r = 0.046$. This suggests a very weak positive relationship, meaning that variations in carbohydrate intake among respondents had almost no direct influence on VO_2 max levels in this study. According to Naila et al. (2024), carbohydrate intake was also found to have no significant relationship with physical fitness ($p > 0.05$), although it showed a very weak positive correlation ($r = 0.015$). Similar findings were reported by Maulida et al. (2023), who found no significant relationship between carbohydrate intake and physical fitness among athletes ($p = 0.407$). The consistency of these findings suggests that physical fitness is not solely determined by the quantity of carbohydrate intake but is also influenced by other factors such as the quality and type of carbohydrates consumed, timing of intake, overall energy adequacy, and the intensity and pattern of training undertaken by athletes.

However, these results differ from the findings of Hasniyati et al. (2023), who reported a significant relationship between carbohydrate intake and physical fitness with a p-value of 0.008 ($p < 0.05$). These differences may be attributed to variations in research methods and subject characteristics, particularly in terms of sports disciplines and levels of physical activity, resulting in more heterogeneous carbohydrate intake distribution and a clearer statistical relationship.

The Relationship between Iron Intake and Physical Fitness (VO_2 max)

The relationship between iron (Fe) intake and athletes' cardiorespiratory physical fitness was analyzed using the Spearman's Rank correlation test, as presented in Table 3. Based on the statistical results, the p-value obtained was 0.008, indicating a significant relationship between iron intake and the physical fitness of UKM Rugby UNESA athletes. Furthermore, the correlation coefficient (r) was 0.451, suggesting that the relationship between the two variables is moderately strong and positive. This means that higher iron intake is associated with better levels of physical fitness (VO_2 max) among athletes.

This finding is consistent with the study conducted by Tasya et al. (2025), which reported a significant relationship between iron intake and physical fitness (VO_2 max) among university futsal athletes in Surakarta. This reinforces the importance of adequate iron intake in supporting the physical fitness of athletes engaged in high-intensity intermittent sports such as futsal, soccer, and rugby. However, contrasting results were reported by Pasa et al. (2024) in basketball athletes at the UKM basketball club of Universitas Negeri Surabaya, where no significant relationship was found between iron intake and VO_2 max ($p > 0.05$). This discrepancy suggests that the effect of iron intake on athletic fitness is not singular but may be influenced by various factors such as training intensity and duration, nutritional status, and other subject characteristics.

These differences can be further explained by the findings of Jegatheesan et al. (2025), which indicate that inadequate iron intake contributes to a higher prevalence of anemia, and athletes with such conditions tend to have lower levels of physical fitness. This suggests that the influence of iron intake on fitness may occur indirectly, particularly through its role in maintaining adequate hemoglobin levels and oxygen transport capacity.

The differences in findings between this study and that of Pasa et al. (2024) may also be attributed to differences in the methods used to measure iron intake and physical fitness. In the study by Pasa et al. (2024), iron intake was assessed using the SQ-FFQ over the past three months, while physical fitness was measured using the Multistage Fitness Test (MFT). In contrast, this study used the Iron-FFQ over a one-month period and assessed fitness using the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1).

The use of Iron-FFQ offers several advantages compared to SQ-FFQ, particularly because it is specifically designed to measure iron-rich food consumption in greater detail and specificity. The Iron-FFQ is capable of identifying variations in iron intake from both heme and non-heme sources, as well as factors that influence iron absorption, with higher sensitivity, thereby providing a more accurate assessment of the risk of iron deficiency among athletes (Luftimas et al., 2021). In contrast, the SQ-FFQ tends to describe general long-term dietary patterns, as used in the study by Pasa et al. (2024), which covered a three-month period, making it potentially less sensitive in detecting variations in iron intake that may affect physical fitness. The strengths and limitations of each method can influence the overall estimation of respondents' dietary intake.

Differences between the MFT and YYIRT1 methods are also evident in their testing approaches. The MFT measures physical fitness (VO_2 max) through continuous running without rest, thus reflecting general aerobic capacity. Meanwhile, the YYIRT1 incorporates intermittent running patterns with active recovery periods, which more closely resemble the characteristics of team sports. These methodological differences may contribute to the variation in research findings.

In addition to iron intake, several other factors may influence athletes' physical fitness levels. These include sex, age, macronutrient intake, and hemoglobin levels, all of which play important roles in determining cardiorespiratory fitness.

CONCLUSION

The findings of this study indicate that the macronutrient intake among UKM Rugby UNESA athletes is not yet fully optimal, particularly in terms of energy and carbohydrate intake, where a considerable proportion of athletes still fall below the recommended levels. In contrast, protein and fat intake were generally found to be within adequate to good categories. In terms of micronutrient intake, specifically iron, the majority of athletes were able to meet their daily iron requirements, indicating an overall adequate level of iron consumption.

The level of physical fitness, as measured by VO_2 max, showed that most athletes were categorized within good to very good fitness levels, with no athletes classified in the low fitness category. Furthermore, the analysis revealed that certain macronutrients have a significant relationship with physical fitness. Energy and fat intake were significantly associated with VO_2 max, suggesting their important role in supporting cardiorespiratory fitness. Meanwhile, protein and carbohydrate intake did not show a statistically significant relationship with physical fitness. Additionally, iron intake was found to have a significant relationship with the physical fitness of UKM Rugby UNESA athletes. This finding highlights the importance of adequate iron consumption in supporting optimal cardiorespiratory performance and overall athletic fitness.

REFERENCES

Aliman, R., Atiq, A., Haetami, M., Yunitaningrum, W., & Azazi. (2023). *VO_2 max level (Maximum Oxygen Volume) of Sepak Takraw Randa athletes*. Jurnal Dunia Pendidikan, 3(1).

Almatsier, S. (2015). *Basic Principles of Nutrition (9th ed.)*. Jakarta: PT Gramedia Pustaka Utama.

Amin, N., Sabaruddin, G., & Kamaluddin, A. (2023). *General concepts of population and sample in research*. Jurnal Pilar, 14(1).

Baranauskas, M., Kupčiūnaitė, I., & Stukas, R. (2023). Dietary intake of protein and essential amino acids for sustainable muscle development in elite male athletes. *Nutrients, 15*(18), 4003. https://doi.org/10.3390/nu15184003

Dobbin, N., Highton, J., Moss, S. L., Hunwicks, R., & Twist, C. (2021). Concurrent validity of a rugby-specific Yo-Yo intermittent recovery test (level 1) for assessing match-related running performance. *Journal of Strength and Conditioning Research, 35*(1). https://doi.org/10.1519/JSC.0000000000002621

El Ghina, M. F., Widawati, W., & Lestari, R. R. (2023). *Energy intake, protein, nutritional status, and VO_2 max of futsal athletes at MAN 1 Pekanbaru*. Jurnal Ilmu Gizi dan Dietetik, 2(3). https://doi.org/10.25182/jigd.2023.2.3.175-181

Gröber, U. (2009). Micronutrients: Metabolic tuning – prevention – therapy. *Drug Metabolism and Drug Interactions, 24*(2–4). https://doi.org/10.1515/dmdi.2009.24.2-4.331

Gropper, S. (2021). *Advanced nutrition and human metabolism (8th ed.)*. Cengage Learning.

Hall, J. E., & Hall, M. E. (2021). *Guyton and Hall textbook of medical physiology (14th ed.)*. Elsevier.

Hasniyati, R., Hasneli, H., & Rahmi, N. F. (2022). *Analysis of macro and micronutrient intake on athletes' physical fitness*. Jurnal Aisyah: Jurnal Ilmu Kesehatan, 8(1). https://doi.org/10.30604/jika.v8i1.1366

Holway, F. E., Campa, F., Petri, C., Spena, L. R., & Szydlowski, N. Y. (2024). Kinanthropometry and dietary habits of non-professional rugby players. *Frontiers in Sports and Active Living, 6*. https://doi.org/10.3389/fspor.2024.1439358

Ichsanudin, A. M. P., Hamdani, M. F. H., Prakoso, M. L. T., Nugraha, S. S., & Fu'adin, A. (2024). *Students' perspectives on the importance of exercise for health*. Pubmedia Jurnal Pendidikan Olahraga, 1(2). https://doi.org/10.47134/jpo.v1i2.283

Jegatheesan, S. L., Kumbamoorthy, S. S., Sanjaykumar, S., & Rajkumar, N. C. J. (2025). Unlocking the connection: hematological status, dietary iron intake and endurance in Indian female athletes. *Physical Activity and Nutrition, 29*(1), 31–37. https://doi.org/10.20463/pan.2025.0005

Jeppesen, J. S., Hellsten, Y., Melin, A. K., & Hansen, M. (2025). Short-term severe low energy availability in athletes: Molecular mechanisms, endocrine responses, and performance outcomes. *Scandinavian Journal of Medicine and Science in Sports, 35*(6). https://doi.org/10.1111/sms.70089

Kurniawan, D., Sunardi, & Waluyo. (2020). *Survey of physical fitness levels of rugby athletes in Boyolali*. Jurnal Ilmu Keolahragaan Universitas Sebelas Maret, 1(1).

Lesinski, M., Schmelcher, A., Herz, M., Puta, C., Gabriel, H., Arampatzis, A., Laube, G., Büsch, D., & Granacher, U. (2020). Maturation-, age-, and sex-specific anthropometric and physical fitness percentiles of German elite young athletes. *PLOS ONE, 15*(8), e0237423. https://doi.org/10.1371/journal.pone.0237423

Listianasari, Y., Gizi, J., Kesehatan, P., & Tasikmalaya, K. (2020). *Iron intake, hemoglobin levels, and VO_2 max in football athletes in Sleman, Yogyakarta*.

Luftimas, D. E., Lucita, A., Wiramihardja, S., & Rusmil, V. K. (2021). Validation of iron-food frequency questionnaire for assessing iron intake in women of reproductive age. *Jurnal Gizi dan Pangan, 16*(2). https://doi.org/10.25182/jgp.2021.16.2.63-70

Maulida, F., Hanum, F. N., & Arta, R. D. (2023). *Relationship between macronutrient intake and* *physical fitness of athletes*. Jurnal Gizi dan Kesehatan Indonesia, 3(4). https://doi.org/10.37887/jgki.v3i4.30143

Meir, R., Newton, R., Curtis, E., Fardell, M., & Butler, B. (2001). Physical fitness qualities of professional rugby league football players. *Journal of Strength and Conditioning Research, 15*(4).

Melin, A. K., Areta, J. L., Heikura, I. A., Stellingwerff, T., Torstveit, M. K., & Hackney, A. C. (2024). Direct and indirect impact of low energy availability on sports performance. *Scandinavian Journal of Medicine and Science in Sports, 34*(1).

Morehen, J. C., & Close, G. (2022). Nutritional requirements for rugby players.

Naila Fitrah, F., & Desy Putriningtyas, N. (2024). *Relationship between macronutrient intake and physical fitness of athletes*.

Naufal Adipati Fawwaz, & Cleonara Yanuar Dini. (2025). *Factors affecting eating behavior in non-elite athletes with macronutrient deficit*.

Noakes, T. D. (2022). Evidence that dietary macronutrient composition influences exercise performance. *Nutrients, 14*(4).

Nolte, J., Kirmse, M., de Marées, M., & Platen, P. (2025). Effects of short-term low energy availability. *Nutrients, 17*(2).

Panggabean, M. S. (2020). *The role of nutrition for athletes*. Cdk-282, 47(1).

Pasa, W. N., Bahar, A., Mayasari, N. R., Dini, C. Y., Pratama, S. A., & Wahjuni, E. S. (2024). *Relationship between iron intake and hemoglobin levels with VO_2 max*. Jurnal Gizi Kerja dan Produktivitas, 5(1).

Peeling, P., et al. (2022). Iron and the athlete.

Piskin, E., et al. (2022). Iron absorption: Factors and improvement methods. *ACS Omega, 7*(24).

Posthumus, L., et al. (2020). Physical and fitness characteristics of rugby players. *Sports, 8*(6).

Radita Pramesti, & Satwika Arya Pratama. (2025). *Relationship between macronutrient intake and body composition with physical fitness*.

Rahmi, N. F. (2022). *Analysis of macro and micronutrient intake on athletes' fitness*.

Roberts, C. J., & Gough, L. A. (2024). Dietary intake in rugby union players. *Nutrients, 16*(17).

Sa'adah, U., Hardiansyah, A., & Darmuin, D. (2023). *Relationship between nutrition knowledge and macronutrient intake with physical fitness*.

Sani, F. M., Rahmat, Z., & Sarwita, T. (2022). *Evaluation of physical condition of rugby athletes*.

Sitoayu, L., Yuslaili, N., & Kuswari, M. (2020). *Relationship between iron intake, hemoglobin, and physical fitness*.

Strasser, B., et al. (2021). Nutrition for older athletes. *Nutrients, 13*(5).

Sufyan Hidayat, W., et al. (2024). *Physical condition of basketball athletes*.

Sugiyono. (2022). *Quantitative, qualitative and R&D research methods*. Alfabeta.

Tasya, A., et al. (2025). *Relationship between iron intake and nutrition knowledge with physical fitness*.

Telisa, I., & Eliza, E. (2020). *Macronutrient intake, iron intake, hemoglobin, and chronic energy deficiency risk*.

Urahman, T., Ismawan, H., & Rifai, M. (2022). *Survey of rugby athletes' physical condition during COVID-19*.

Wijaya, H. H., et al. (2024). *Relationship between body fat, nutritional status, and VO_2 max*.

Witard, O. C., Hearris, M., & Morgan, P. T. (2025). Protein nutrition for endurance athletes. *Sports Medicine*, *55*(6).