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A Correlational Study of Body Mass Index (BMI) and Hemoglobin Levels with Cardiovascular Endurance in KOP Taekwondo Athletes at Universitas Negeri Jakarta

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Abstract

This cross-sectional correlational study aimed to analyze the relationship between Body Mass Index (BMI) and hemoglobin levels with cardiovascular endurance among athletes of the Achievement Sports Club (KOP) Taekwondo, State University of Jakarta. The research employed a quantitative approach with a correlational design. The sample consisted of 22 athletes selected through purposive sampling based on the inclusion criteria of being 19–21 years old and actively training for at least the last three months. BMI was obtained from body weight and height measurements, hemoglobin levels were measured using a digital EasyTouch GCHb device, and cardiovascular endurance was assessed using the Balke Test to estimate VO_2max values. Data analysis included the Kolmogorov–Smirnov normality test, linearity test, and Spearman and Pearson correlation tests according to the characteristics of the data. The results revealed no significant relationship between BMI and VO_2max ($r = -0.029$; $p = 0.900$) nor between hemoglobin levels and VO_2max ($r = 0.262$; $p = 0.238$). In conclusion, BMI and hemoglobin levels were not proven to significantly contribute to the cardiovascular endurance of KOP Taekwondo athletes. These findings suggest that coaches should monitor multiple physiological parameters beyond BMI and hemoglobin to optimize cardiovascular conditioning in taekwondo athletes.

Keywords: body mass index, cardiovascular endurance, hemoglobin, taekwondo.

Introduction

In combat sports like taekwondo, physiological factors such as BMI and hemoglobin play a critical role in performance, endurance, and recovery during multi round matches. Body Mass Index (BMI) or Indeks Massa Tubuh (IMT) is a simple indicator used to assess nutritional status based on the ratio of body weight to height. Although it has limitations, such as its inability to distinguish between muscle mass and fat, BMI remains one of the most widely used parameters in health and sports monitoring. In the athletic context, the use of BMI often sparks debate, as it may classify highly muscular athletes as overweight, even though physiologically they are healthy and fit (Nuttall, 2015). Recent studies have suggested adjusting BMI thresholds for athletic populations to more accurately represent their nutritional and health status (Nevill et al., 2021). Nevertheless, BMI continues to serve as a primary screening indicator due to its practicality, affordability, and ease of calculation, making it widely utilized in fitness and sports health research (García-Hermoso et al., 2019).

In the field of competitive sports, BMI is associated with muscle efficiency, body mass proportion, and athletic performance. Athletes with excessively high BMI may experience increased cardiac workload, limited mobility, and reduced metabolic efficiency. Conversely, a low BMI can indicate a lack of muscle mass and energy reserves, both essential for sustaining high-intensity activities (Salazar & Lankford, 2020). Research on collegiate athletes has shown that those with a normal BMI tend to demonstrate better fitness performance compared to those classified as obese or underweight (Li et al., 2022).

Aside from body composition, cardiovascular endurance or cardiorespiratory fitness is another crucial component of athletic performance. Cardiovascular endurance reflects the ability of the heart, lungs, and circulatory system to deliver oxygen to body tissues during physical activity. The primary indicator of this capacity is VO_2max, the maximum amount of oxygen the body can utilize during high-intensity exercise (Joyner & Coyle, 2018). In martial arts such as taekwondo, a high VO_2max is essential to support explosive movements, speed, and short recovery intervals. Athletes with low cardiovascular endurance tend to fatigue more quickly, leading to reduced technical accuracy and an increased risk of injury (Bridge et al., 2014). Recent studies also report that higher VO_2max values are a significant predictor of success for taekwondo athletes in multi-round competitions (Rocha et al., 2022).

Another physiological factor closely linked to cardiovascular endurance is hemoglobin concentration. Hemoglobin, a protein in red blood cells responsible for oxygen transport, plays a key role in delivering oxygen to muscle tissues. Higher hemoglobin levels increase the blood's oxygen-carrying capacity, thereby enhancing VO_2max (Faude et al., 2018). Conversely, low hemoglobin levels reduce oxygen supply to muscles, accelerating fatigue (Sharma & Marwaha, 2021). Studies on adolescent taekwondo athletes have demonstrated a positive relationship between hemoglobin concentration and cardiorespiratory fitness, with athletes possessing optimal hemoglobin levels performing better in fitness tests compared to those with lower levels (Istiqomah et al., 2022). This finding aligns with previous literature identifying hemoglobin as a key determinant of aerobic capacity and athletic performance (Burtscher et al., 2019).

In the context of university sports development, monitoring BMI and hemoglobin levels is crucial for designing safe and effective training programs. The Taekwondo Performance Sports Club (KOP) at Universitas Negeri Jakarta serves as a platform for nurturing student athletic talent and requires physiological data to ensure a structured training process. However, to date, there has been no specific study examining the relationship between BMI, hemoglobin levels, and cardiovascular endurance among collegiate taekwondo athletes. Such information is essential as a scientific foundation for developing training programs tailored to athletes' physiological needs (Tuan et al., 2020). Despite prior studies on general athletes, no study has specifically examined how BMI and hemoglobin levels related to cardiovascular endurance in collegiate taekwondo athletes, limiting evidence base training design. This study hypothesizes that BMI and hemoglobin levels are significantly related to cardiovascular endurance among taekwondo athletes.

Methods

Research Design

This study employed a quantitative approach with a cross-sectional correlational design, conducted from June to July. The purpose of this design was to analyze the relationship between Body Mass Index (BMI), hemoglobin levels, and cardiovascular endurance in athletes. Ethical approval was obtained from the Research Ethics Committee, Faculty of Sport Science, Universitas Negeri Jakarta.

Participants

The research population consisted of 50 active athletes registered in the Taekwondo Performance Sports Club (KOP) at Universitas Negeri Jakarta. The sample was selected using a purposive

sampling technique based on the following inclusion criteria: (1) active athletes aged 19–21 years, and (2) having participated in regular training for at least the past three months. Based on these criteria, a total of 22 athletes (7 males and 15 females) were included in the study.

Instrument

Body Mass Index (BMI), hemoglobin levels, and cardiovascular endurance were measured using validated and reliable instruments. Body weight was assessed using a digital scale, while body height was measured with a stadiometer (±0.1 cm), and BMI was calculated using the WHO (2004) formula. These anthropometric instruments demonstrate high reliability (ICC > 0.95) and the BMI formula has been widely validated in athletic populations. Hemoglobin levels were obtained using a portable EasyTouch GCHb device through fingertip capillary blood sampling, following WHO (2010) procedures. Portable hemoglobin analyzers have shown excellent reliability (ICC = 0.94–0.97) and strong validity when compared with laboratory hematology analyzers, with typical measurement bias below 1 g/dL (Von Schenck et al., 1986). Cardiovascular endurance was assessed using the Balke 15-minute running test, in which total distance covered was converted to VO_2max using the formula developed by McArdle, Katch, and Katch (2015). The Balke Test has been shown to possess high reliability (ICC = 0.86–0.90) and strong validity (r = 0.80–0.90) relative to direct gas analysis.

Procedure

Data collection followed a standardized chronological sequence. Participants first completed an informed consent form. Subsequently, anthropometric measurements (body weight and height) were recorded, followed by hemoglobin assessment and finally the Balke running test. All measurements were conducted between 15:00–17:00 WIB under stable environmental conditions (27–29°C, outdoor synthetic track). Athletes were instructed to avoid strenuous physical activity for 24 hours prior to testing and to maintain normal hydration.

Data Analysis

Data were analyzed using SPSS. The Kolmogorov–Smirnov test was used to examine data normality. Linearity between variables was tested using ANOVA-based regression analysis. Pearson correlation was used for normally distributed and linear variables, while Spearman correlation was applied to variables with non-normal distributions or non-linear relationships. Statistical significance was set at $p < 0.05$, and results were interpreted based on correlation coefficients (r) and significance values to determine the presence or absence of relationships among BMI, hemoglobin levels, and VO_2max.

Results

This study was conducted on athletes who are members of the Taekwondo Performance Sports Club (KOP) at Universitas Negeri Jakarta. The total number of subjects in this research was 22 athletes (based on available data). The variables examined included Body Mass Index (BMI), hemoglobin levels, and VO_2max as an indicator of cardiovascular endurance.

The Kolmogorov–Smirnov normality test was conducted to examine whether the distribution of the research variables met the assumption of normality. The results (Table 1) indicated that hemoglobin ($p = 0.200$), VO_2max ($p = 0.116$), and BMI ($p = 0.200$) were normally distributed, as all p-values exceeded the significance threshold of 0.05. These findings confirm that the three variables showed no significant deviation from a normal distribution, allowing the use of parametric statistical procedures for subsequent correlation analyses.

The normal distribution of all physiological variables suggests consistent performance characteristics among the Taekwondo athletes, with no extreme outliers affecting the dataset. This supports the stability and representativeness of the measurements.

The linearity test was conducted to determine whether the relationships between the independent variables and VO_2max met the assumption of linearity. The results indicated that BMI did not meet the linearity assumption ($p = 0.002$), as illustrated in Figure 1. Meanwhile, hemoglobin demonstrated a linear relationship with VO_2max ($p = 0.069$), which is shown in Figure 2. These results indicate that parametric correlation analysis (Pearson) is appropriate for hemoglobin–VO_2max, whereas non-parametric analysis (Spearman) is more suitable for the BMI–VO_2max relationship due to its non-linear pattern.

The linearity test indicated that the relationship between BMI and VO_2max was non-linear ($p < 0.05$). Therefore, the relationship between these variables could not be analyzed using the Pearson correlation test. Instead, the analysis was conducted using the Spearman correlation test, which is more appropriate for data that are non-normally distributed or exhibit a non-linear relationship.

Because BMI and VO_2max did not meet the linearity assumption, the non-parametric Spearman correlation test was used. The results (Table 2) showed a correlation coefficient (r) of –0.029 with a significance value of 0.900 (> 0.05), indicating a very weak, negative, and statistically

Table 1
Tests of Normality

Variable	Kolmogorov–Smirnov Statistic	df	Sig.	Shapiro–Wilk Statistic	df	Sig.
Hemoglobin (HB)	.123	22	.200	.925	22	.098
VO_2max	.166	22	.116	.941	22	.206
Body Mass Index (BMI)	.117	22	.200	.944	22	.235

Note. Lilliefors significance correction applied.

Table 2
Spearman Correlation Between BMI and VO_2max

Variable	1	2
1. Body Mass Index (BMI)	—	−.029
2. VO_2max	−.029	—
Spearman's rho		
p (2-tailed) = .900		
N = 22		

Table 3
Pearson Correlation Between Hemoglobin Levels and VO_2max

Variable	1	2
1. VO_2max	—	.262
2. Hemoglobin (HB)	.262	—
Pearson correlation		
p (2-tailed) = .238		
N = 22		

insignificant relationship. Moreover, the negative sign of the coefficient indicates an opposite direction of the relationship; however, due to its minimal strength, this direction has no practical implication. The significance value far above 0.05 confirms that the observed relationship is not statistically significant. Therefore, it can be concluded that BMI has no meaningful influence on cardiovascular endurance among athletes of the Taekwondo Performance Sports Club (KOP) Universitas Negeri Jakarta.

The linearity test indicated that the relationship between hemoglobin levels and VO_2max was linear (p > 0.05). Therefore, the analysis of the relationship between these two variables was conducted using the Pearson correlation test, which is appropriate for normally distributed data and linear relationships.

Based on the interpretation guidelines above, the researcher concluded that the relationship between BMI and VO_2max (r = −0.029; p = 0.900) is very weak and not significant. As shown in Table 3, the correlation coefficient was r = 0.262 with p = 0.238 (> 0.05), indicating a weak and statistically insignificant relationship.

The results of the Pearson correlation analysis showed a correlation coefficient (r) of 0.262 with a significance value of 0.238. The r-value, which falls within the range of 0.20–0.39, indicates a positive but weak relationship, meaning that an increase in hemoglobin levels tends to be followed by an increase in VO_2max, although the relationship is not strong. However, since the significance value is greater than 0.05, this relationship is not statistically significant and cannot be generalized to a larger population. Therefore, it can be concluded that hemoglobin levels do not have a significant effect on cardiovascular endurance among KOP Taekwondo UNJ athletes.

Figure 1
Results of the Linearity Test Between BMI and VO_2max (SPSS Output)

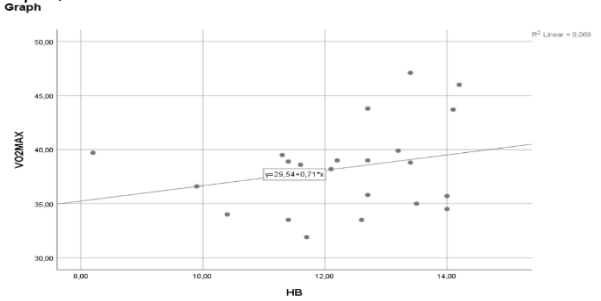
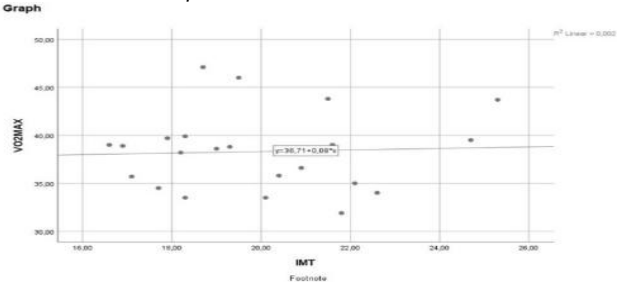


Figure 2
Results of the Linearity Test Between Hemoglobin Levels and VO_2max (SPSS Output)



Discussion

The findings of this study indicate that neither Body Mass Index (BMI) nor hemoglobin levels showed a significant relationship with cardiovascular endurance (VO_2max) among KOP Taekwondo athletes. These results contrast with several previous studies that reported a negative association between higher BMI and lower aerobic capacity, particularly in athletes whose sports require repeated high-intensity movements. For example, Bridge et al. (2014) and Salazar & Lankford (2020) highlight that excess body mass may increase metabolic cost during movement in combat sports, thereby reducing endurance efficiency. Similarly, Li et al. (2022) and Wang et al. (2021) found that higher BMI tends to correlate with lower physical fitness levels in university and youth athletes.

However, the non-significant findings in the current study are also consistent with research suggesting that BMI is often an imprecise predictor of endurance because it cannot differentiate between fat mass and lean mass. Combat sports athletes—including Taekwondo practitioners—typically possess higher lean mass due to strength and conditioning training. As shown in Nevill et al. (2021), BMI frequently misclassifies muscular athletes as overweight even when their physiological performance is optimal. This aligns with the characteristics of the sampled athletes, where BMI may not accurately reflect their functional body composition or endurance potential.

The absence of a significant correlation between hemoglobin and VO_2max also differs from studies demonstrating that higher hemoglobin enhances oxygen-carrying capacity and improves aerobic performance. Meta-analyses by Burtscher et al. (2019) and reviews by Faude et al. (2018) and Sharma & Marwaha (2021) provide strong evidence of a positive relationship between hemoglobin levels and endurance capacity. More specifically, research on Taekwondo athletes by Istiqomah et al. (2022) showed that higher hemoglobin concentrations were associated with better physical fitness performances in adolescents. In contrast, the current study found no such relationship, suggesting that other factors may be influencing VO_2max more strongly in this population.

A possible explanation is the relatively narrow range of hemoglobin values within the sample, which reduces the variability necessary to detect significant associations. Restricted-range effects are common in trained athletes who generally maintain healthy hematological profiles due to regular training (Joyner & Coyle, 2018). This homogeneity may have limited the ability of hemoglobin to statistically differentiate VO_2max performance among participants.

Several confounding factors may also explain why no significant relationships were observed. Training intensity, frequency, and periodization may not have been uniform across athletes, potentially influencing VO_2max independently of BMI or hemoglobin. Nutritional factors—including iron intake—may have affected hemoglobin concentration, as noted by Sharma & Marwaha (2021). Hydration status can also influence blood parameters and endurance test performance. These uncontrolled variables may have introduced noise into the dataset, masking relationships that have been documented in controlled laboratory studies (Zouhal et al., 2019).

Despite these non-significant findings, the study still fulfills its research objective by providing empirical evidence on the relationship between BMI, hemoglobin levels, and cardiovascular endurance in a university Taekwondo population. The absence of correlations contributes to the growing understanding that BMI and hemoglobin—although useful for general health monitoring—may not serve as primary determinants of endurance performance in competitive Taekwondo athletes. This aligns with the recommendations by Bridge et al. (2014) and Rocha et al. (2022), who emphasize that Taekwondo performance depends more heavily on sport-specific conditioning, explosive power, and recovery ability rather than basic anthropometric or hematological measures alone.

From a practical perspective, coaches should interpret these results as a reminder that athlete monitoring should extend beyond basic markers such as BMI and hemoglobin. Regular aerobic capacity assessments through field-based or laboratory-based VO_2max tests, combined with body composition analysis and training load monitoring, may offer more meaningful insights into performance progression (García-Hermoso et al., 2019). Maintaining healthy BMI and hemoglobin levels remains important for overall readiness, but they should be considered supportive rather than decisive indicators of endurance performance.

This study has several limitations, including a relatively small sample size, which may have reduced statistical power to detect subtle associations. The use of an indirect VO_2max estimation (Balke Test) may introduce measurement error compared with more precise laboratory methods. Additionally, the study did not control for dietary intake, hydration status, training load, or body composition—variables that have been shown to influence endurance performance in past research (Tuan et al., 2020). Future studies should involve larger samples, incorporate direct

VO_2max measurement techniques, include detailed body composition analysis, and control for key physiological and nutritional variables to provide a more comprehensive understanding of endurance determinants in Taekwondo athletes.

Conclusions

This study found no significant relationship between Body Mass Index (BMI) or hemoglobin levels and cardiovascular endurance (VO_2max) among KOP Taekwondo athletes at Universitas Negeri Jakarta. BMI showed a very weak and insignificant negative association with VO_2max ($r = -0.029$; $p = 0.900$), while hemoglobin demonstrated a weak but statistically insignificant positive association ($r = 0.262$; $p = 0.238$). These findings indicate that neither BMI nor hemoglobin meaningfully contributes to aerobic capacity variation in this athlete population.

Practically, the results suggest that Taekwondo coaches should not rely on BMI or hemoglobin as primary indicators of endurance performance but should instead prioritize more specific physiological and performance-based assessments. For applied practice and future research, it is recommended to conduct regular monitoring of athletes' nutritional and hematological status, increase sample size, include additional variables such as body fat percentage, lung function, or hematocrit, and employ direct VO_2max measurement methods to enhance accuracy and deepen understanding of endurance determinants in combat sport athletes.

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