

The Influence of Body Mass Index, Hemoglobin, and Blood Pressure on VO_2 max of Elite-Pro Karatekas in South Sulawesi

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Abstract

The lack of knowledge and the need for additional information regarding the physical health aspects of karate athletes prompted this study, which aims to examine the causal relationships—both direct and indirect—between Body Mass Index (BMI), Hemoglobin (Hb), and Blood Pressure (Bp) on the VO₂max of Elite-Pro Karatekas. This research employed path analysis, with BMI (X1) and Hb (X2) as independent variables, Bp (X3) as an intervening variable, and VO₂max (Y) as the dependent variable. Data collection methods included BMI through height and weight measurements; Hb via Easy Touch GCHB tests; Bp using a digital sphygmomanometer; and VO₂max assessed through the Bleep Test. The findings are as follows: (1) BMI and Hb significantly affect Bp. This is consistent with previous studies, though there are conflicting findings—particularly regarding BMI's effect on Bp. (2) BMI, Hb, and Bp significantly influence VO₂max. Again, while some studies support these findings, others contradict them, especially concerning the effects of BMI and Hb on VO₂max. (3) BMI and Hb significantly influence VO₂max through Bp. Conclusion: These three findings highlight discrepancies with existing literature and justify the need for further studies. Moreover, the role of Bp deserves further exploration, as it has both direct and indirect effects on VO₂max.

Keywords: body mass index; hemoglobin; blood pressure; VO₂max; karateka.

1. Introduction

There are numerous predictors of success in developing, enhancing, and maintaining athletes' performance beyond just technical, physical, mental, and tactical training. One such predictor is a thorough understanding and maintenance of physical health aspects (Balyi, Way, & Higgs, 2013; Bompá & Buzzichelli, 2019; Dahlan & Khemal, 2019). Physical health components such as cardiovascular system adaptation during physical activity are currently a primary concern among sports physiology specialists and sports physicians (Cherkesov et al., 2021). Clubs, coaches, and athletes striving for success must collaborate with health and nutrition experts, as a healthy lifestyle and balanced, adequate nutrition are crucial to athletic performance (Göbel, 2023).

The significance of physical health also applies to the sport of karate. The better the heart rate, heart rate reserve, cardiac output, blood pressure, and maximum oxygen uptake capacity, the better the rest quality of elite-pro karatekas (Hayirl & Ayar, 2023). Height, body mass index (BMI), and body fat percentage are strongly related to the training performance of beginner karatekas (Arslan et al., 2024). There is a positive correlation between body fat percentage, muscle mass, and bone mass with the punching speed of karatekas (Mulia et al., 2024). Ideally, karatekas should maintain a normal blood pressure level to support their performance (Wati & Simanjuntak, 2020).

However, research on the importance of physical health aspects in karate remains limited and is recommended by various studies to be explored further and in more depth. The effects of karate on neurophysiology, dynamic balance reactions, and clinical health aspects still require further documentation (Dahmen-Zimmer & Jansen, 2017; Jansen et al., 2017). More research is needed on

blood pressure effects in karatekas, whether related to recovery phases or during and after training sessions (Guzii et al., 2021). Additionally, further study is required on the physiological (Chaabène et al., 2012), and anthropometric characteristics of karatekas (Vujacic et al., 2021).

This research gap is also evident in our literature review of 60 SINTA-indexed journals (Science and Technology Index) in the field of sports science. We found that the topic of physical health in karate is underrepresented compared to other themes: physical training (52 articles), technical training (21 articles), mental training (17 articles), and other topics such as management, instrument development, and talent scouting (14 articles). Only 3 articles specifically addressed physical health in karatekas: the effect of training on BMI and stamina (Prakoso, 2024), hemoglobin levels in athletes (including karate) at the Pre-PON level (Samodra et al., 2022), and the relationship between hydration status and VO₂max in karatekas (Sulastio et al., 2022).

Beyond the SINTA database, other studies have also addressed the importance of physical health in karate and other martial arts: descriptions of blood pressure, prehypertension, and hypertension in elite-pro karatekas (Wati & Simanjuntak, 2020), anemia, nutrient intake, and BMI in adolescent karatekas (Cahyani et al., 2024), the effect of training on blood pressure (Guzii et al., 2021), cardiorespiratory functions, heart rate, and blood pressure (Youssef, 2021), systolic blood pressure and heart rate in adolescent Muay Thai athletes (Saraiva et al., 2022), rest quality in elite-pro karatekas (Hayirl & Ayar, 2023), cardiometabolic factors, oxidative stress, and obesity (de Souza et al., 2022), The relationship between height and body mass index (BMI) in beginner karatekas (Arslan et al., 2024), as well as the influence of BMI on the technical skills of karatekas (Fadhila et al., 2024), and various relationships among somatotypes, anthropometric profiles, hemoglobin, menstruation, and VO₂max in karatekas (Vujacic et al., 2021), Iron levels, menstruation, and VO₂max in female karatekas (Chania et al., 2022), body fat, muscle mass, bone mass, and technical ability in elite/professional karatekas (Mulia et al., 2024), the VO₂max consumption levels and injury risks in beginner karatekas (Kunabal et al., 2024), the neurophysiological and clinical health aspects of karatekas (Dahmen-Zimmer & Jansen, 2017; Jansen et al., 2017), and aerobic and anaerobic capacity in karatekas (Doria et al., 2009; Nema et al., 2024; Nickytha, Fitri, & Sultoni, 2019; Chaabène et al., 2012; Chaabène et al., 2015; Nema et al., 2024).

This study addresses an urgent problem—namely, the lack of knowledge and limited research concerning the physical health aspects of karatekas. The variables deemed important and frequently studied include Body Mass Index, Hemoglobin, Blood Pressure, and VO₂max. Furthermore, few studies have examined or understood in depth the causal relationships, both direct and indirect, among these variables. We propose Blood Pressure as an intervening variable because research on the relationship between Bp and VO₂max remains very limited and is generally approached through traditional scientific perspectives (Pesova et al., 2023). Based on these considerations, the aim of this study is to examine the causal relationship—both direct and indirect—between Body Mass Index, Hemoglobin, and Blood Pressure on the VO₂max of elite-pro karatekas

2. Method

This research employed a survey method using path analysis. The variables proposed and tested in this study include: Body Mass Index, denoted as BMI (X1); Hemoglobin, denoted as Hb (X2); and Blood Pressure, denoted as Bp (X3), with VO₂max (Y) representing the dependent variable. In this model, Bp (X3) functions as an intervening variable, while BMI (X1) and Hb (X2) are considered independent variables, and VO₂max (Y) is the dependent variable.

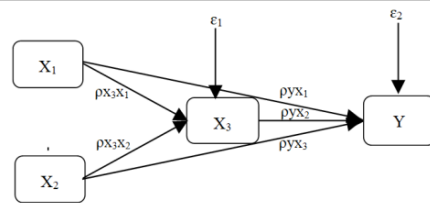


Figure 1. Theoretical Model

The sampling technique used was total sampling, involving the entire population of elite-pro kumite karatekas in South Sulawesi Province, Indonesia, totaling 30 athletes. All participants signed an informed consent form, and this study received ethical approval from the Ethics Committee of the State University of Makassar. The research was conducted throughout 2024 and took place at the Indonesian National Sports Committee (KONI) office in South Sulawesi Province. Data collection methods included: BMI (X1) measured through height and weight tests; Hb (X2) measured using the EasyTouch GCHB test device; Bp (X3) measured with a digital sphygmomanometer; and VO₂max (Y) measured using the Bleep Test. Data analysis was conducted using correlational regression tests with the help of SPSS version 24.

3. Result

The descriptive analysis results for the tested variables—BMI (X1), Hb (X2), Bp (X3), and VO₂max (Y)—are as follows:

Table 1. Descriptive Statistics of BMI (X1), Hb (X2), Bp (X3), and VO₂max (Y) of Elite-Pro Kumite Karatekas in South Sulawesi Province

Statistic	Age	BMI (X ₁)			Hb (X ₂)	Bp (X ₃)		VO ₂ max (Y)		
		Height	Body Weight	Score		Systolic	Diastolic	Score	Level	Score
Mean	20,73	1,742	67,17	22,08	15,68	122,97	83,67	6,20	8,87	44,61
Std. Deviation	1,285	,048	12,914	3,907	1,177	6,941	4,901	2,007	1,889	6,579
Maksimum	23	1,80	90	30,48	17	139	90	9	12	55,99
Minimum	19	1,66	49	16,33	14	110	75	3	5	32,14
N					30					

BMI (X₁) has 22,08 mean, 3,907 deviation standard, 16,33 Minimum value, 30,48 maximum. Hb (X₂) has 15,68 mean, 1,177 deviation standard, 14 minimum value, 17 maximum. Bp (X₃) has 6,20 mean, 2,007 deviation standard, 3 minimum value, 9 maximum. VO₂max (Y) has 44,61 mean, 6,579 deviation standard, 32,14 minimum value, 55,99 maximum.

Model Test

Substruktur 1

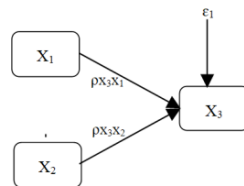


Figure 2. Substruktur 1

Table 2. Coefficient of Determination for Substructure1

Model	R	R Square	Adjusted Coefficient of determination	Std. Error
1	,793 ^a	,629	,602	1,266

Table 2 shows that the R-Square value is 0.793a, indicating that the variables BMI (X1) and Hb (X2) simultaneously contribute 62.9% to explaining the variation in the Bp (X3) variable, while the remaining 37.1% is influenced by other variables outside the model. Based on the ANOVA (F-test), the independent variables collectively have a significant effect on the dependent variable of training motivation, with a significance value of 0.000^b, which is less than the 5% alpha level.

Table 3. Analysis of Multivariate Regression Model Substructure 1

Model	Variable	Correlation Coefficient	T	P
1	X ₁	,267	2,213	,036 < 0,05
	X ₂	,687	5,700	,000 < 0,05
	Constanta			,023

Table 3 shows that the coefficient value for the BMI (X1) variable is 0.267, or approximately 26%, with a t-value of 2.213. Statistically, BMI (X1) has a significant effect on the Bp (X3) variable, as indicated by a significance value of 0.036, which is less than the 5% alpha level. Another finding indicates that the coefficient value for the Hemoglobin (Hb) variable (X2) is 0.687 or 68%, with a t-value of 5.700. Statistically, Hb (X2) has a significant effect on the Bp (X3) variable, as shown by a significance value less than the 5% alpha level ($p = 0.000$).

The effect of other variables outside the model can be determined using the following equation:

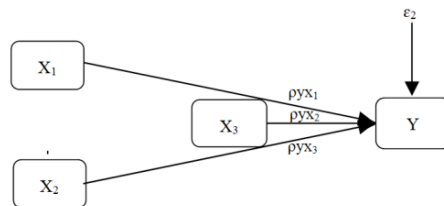
$$\epsilon_1 = \sqrt{1 - R^2} \dots\dots\dots (R1)$$

Thus, the path equation is as follows:

$$X_3 = \rho_{X_3X_1} + \rho_{X_3X_2} + \epsilon_1$$

$$X_3 = 0,267 X_1 + 0,687 X_2 + 0,6092 \dots\dots\dots (1)$$

Substructure 2

**Figure 3. Substructure 2****Table 4. Coefficient of Substructure Determination2**

Model	R	R Square	Adjusted Determination Coefficient	Std. Error
2	,929 ^a	,863	,848	2,569

Table 4 shows that the R-Square value is 0.929a, indicating that the variables BMI (X1), Hb (X2), and Bp (X3) collectively contribute 92% to explaining the variance in VO₂max (Y), while the remaining 8% is accounted for by variables outside the model. Based on the ANOVA (F-test), the independent variables simultaneously have a significant effect on the training motivation variable, with a significance value of 0.000^b, which is less than the 5% alpha level.

Table 5. Multivariate Regression Analysis of Model 2 (Substructure 2)

Model	Variable	Correlation coefficient	T	P
2	X ₁	,467	5,760	,000 < 0,05
	X ₂	,551	4,629	,000 < 0,05
	X ₃	,505	4,560	,000 < 0,05
	Constanta			,003

Table 3 shows that the coefficient value for the BMI (X₁) variable is 0.267, or approximately 46%, with a t-value of 5.760. Statistically, BMI (X₁) has a significant effect on the VO₂max (Y) variable, as indicated by a significance value of 0.000, which is less than the 5% alpha level. Furthermore, the coefficient value for the Hemoglobin (Hb) variable (X₂) is 0.551 or 55%, with a t-value of 4.629. Statistically, Hb (X₂) has a significant effect on VO₂max (Y), as indicated by a significance value of 0.000, which is less than the 5% alpha level. Our next finding shows that the coefficient value for the Blood Pressure (Bp) variable (X₃) is 0.505 or 50%, with a t-value of 4.560. Statistically, Bp (X₃) has a significant effect on VO₂max (Y), as indicated by a significance value of 0.000, which is less than the 5% alpha level.

The influence of other variables outside the model (ϵ_1) can be determined by the following formula:

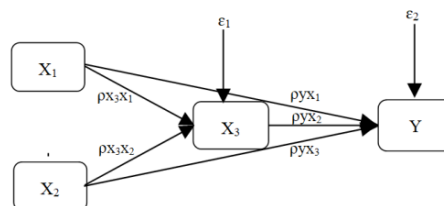
$$\epsilon_1 = \sqrt{1 - R^2} \quad \text{..... (R2)}$$

Thus, the path equation is as follows:

$$Y = \rho_{YX_1} + \rho_{YX_2} + \rho_{YX_3} + \epsilon_2$$

$$Y = 0,467 X_1 + 0,551 X_2 + 0,505 X_3 + 0,1369 \quad \text{..... (2)}$$

By combining Substructure Model 1 and Substructure Model 2, the resulting structure is shown in Figure 4.

**Figure 4. Test Result Model of Substructure 1 and Substructure 2**

Based on the results of combining Substructure Model 1 and Substructure Model 2, the resulting structure is shown in Figure 4, and the substructure equations can be formulated as follows:

$$X_3 = \rho_{X_3X_1} + \rho_{X_3X_2} + \epsilon_1$$

$$X_3 = 0,267 X_1 + 0,687 X_2 + 0,6092$$

$$Y = \rho_{YX_1} + \rho_{YX_2} + \rho_{YX_3} + \epsilon_2$$

$$Y = 0,467 X_1 + 0,551 X_2 + 0,505 X_3 + 0,1369 \quad \text{..... (3)}$$

To understand the findings from the combination of Substructure Models 1 and 2, the results can be further formulated in the form of hypothesis testing, as presented in Table 5 below:

Table 5. Hypothesis Testing Results Based on the Combination of Substructure Models 1 and 2

Hypothesis	Coefficient β	α
1	0,267	,036 < 0,05
2	0,687	,000 < 0,05
3	0,467	,000 < 0,05
4	0,551	,000 < 0,05
5	0,505	,000 < 0,05
6	0,601	,000 < 0,05
7	0,897	,000 < 0,05

Based on Table 5, it is known that the direct effect of BMI (X1) on VO₂max (Y) is 0.467, while the indirect effect of BMI (X1) on VO₂max (Y) through blood pressure (Bp) (X3) is the product of the β value of BMI (X1) on VO₂max (Y) and the β value of Bp (X3) on VO₂max (Y) [$0.267 \times 0.505 = 0.134$]. Subsequently, the direct effect of BMI (X1) on VO₂max (Y) is added to the indirect effect of BMI (X1) on VO₂max (Y) through Bp (X3) [$0.467 + 0.134 = 0.601$]. This means that the indirect effect of BMI (X1) on VO₂max (Y) through Bp (X3) is greater than the direct effect of BMI (X1) on VO₂max (Y) [$0.601 > 0.467$]. Therefore, BMI (X1) through Bp (X3) has a significant influence on VO₂max (Y).

Furthermore, it is known that the direct effect of Hb (X2) on VO₂max (Y) is 0.551, while the indirect effect of Hb (X2) on VO₂max (Y) through Bp (X3) is the product of the β value of Hb (X2) on VO₂max (Y) and the β value of Bp (X3) on VO₂max (Y) [$0.687 \times 0.505 = 0.346$]. Subsequently, the direct effect of Hb (X2) on VO₂max (Y) is added to the indirect effect through Bp (X3) [$0.467 + 0.346 = 0.879$]. This means the indirect effect of Hb (X2) on VO₂max (Y) through Bp (X3) is greater than the direct effect [$0.879 > 0.551$]. Therefore, Hb (X2) through Bp (X3) has a significant effect on VO₂max (Y).

4. Discussion

a. BMI significantly affect Bp

Our findings are consistent with previous research conducted on athlete samples, where a correlation was found between BMI and Bp [$p = 0.466$ ($\alpha = 0.000$)], suggesting that the more ideal the BMI, the more likely the blood pressure (BP) is within a normal range (Arini & Wijana, 2020). An increase in both BMI and Bp was observed over the course of one year of training (Silado & Wirawan, 2021). Additionally, there is a relationship between sodium intake, nutritional status, and physical training activity with the incidence of hypertension (Musyarofah et al., 2023).

The findings are also in line with previous studies that used non-athlete samples; both BMI and age were found to be contributing factors to elevated Bp (Chen et al., 2022), moderate correlation was identified between BMI and blood pressure—systolic [$r = 0.466$] and diastolic [$r = 0.340$] (Lubis, 2021), significant relationship between BMI and Bp was observed among hypertensive patients, with $p = 0.001$ and $R = 0.451$ (Sinurat et al., 2023). Moreover, BMI and body fat percentage were significantly associated with Bp ($p = 0.001$ and $p = 0.000$, respectively) (Guntara, 2022). Another study reported a strong correlation [$r = 0.629$] between BMI and Bp among hypertensive patients in several cardiac clinics (Sari et al., 2023).

Based on both our findings and supporting studies, it is crucial for all stakeholders involved in the development of sports branches—including karate—to carefully consider athletes' training loads and nutritional intake. An unbalanced or non-ideal BMI significantly contributes to various health problems such as hypertension (Rohkuswara & Syarif, 2017), and elevated levels of low-density lipoprotein (LDL) cholesterol (Aprilia & Saraswati, 2024).

However, our research findings contrast with those of other studies, which observed that over two years of training, both male and female university-level karatekas experienced an increase in BMI accompanied by a decrease in Bp (Bayu et al., 2023). Another study found no relationship between training, protein intake, gender, BMI, and systolic and diastolic blood pressure among athletes (Myra et al., 2024). These contradictory results highlight the need for further investigation, especially considering that the correlation between BMI and Bp among athletes tends to be inconsistent.

b. Hb significantly affect Bp

Athletes who undergo intense training tend to experience increased hemoglobin levels and altered vascular properties, both of which are associated with changes in pulse wave velocity and systolic blood pressure, in both adult and junior athletes (Komka et al., 2022; Grabitz et al., 2023). On the other hand, prolonged and excessive training loads can lead to a progressive and significant decrease in hemoglobin levels (hypohemoglobinemia), which may cause hypotension due to reduced oxygen-carrying capacity of red blood cells throughout the body (Liu & Liu, 2023).

Therefore, regular health monitoring for athletes is essential, along with reconsidering the common practice of imposing high physical training loads on very young athletes, due to the associated risks of elevated blood pressure. High blood pressure in athletes has been shown to be the most common risk factor contributing to sudden cardiac death on the field (Purdom et al., 2023). Proper recognition and management of hypertension can improve athletic performance and reduce the risk of heart-related complications (Komka et al., 2022; Afaghi et al., 2024). Regarding this particular finding, we did not encounter any contradictions with previous studies.

c. BMI significantly influence VO_{2max}

Our findings are consistent with previous studies, which reported a positive relationship between BMI and VO_{2max} (Wiecha et al., 2023), including a study that found a Pearson correlation of -0.674 with a significance level of 0.004 between BMI and VO_{2max} among futsal athletes (Saputri et al., 2024). This supports the view that an increase in BMI tends to result in a decrease in VO_{2max} , and vice versa (Aqmain & Irsyada, 2022; Shabrina et al., 2022; Rahadiani, 2022; Nasrulloh et al., 2021). There is an interactive relationship between VO_{2max} and BMI, where VO_{2max} has the potential to reduce chronic inflammation and visfatin triggered by non-ideal BMI (Su et al., 2024). This is reinforced by findings indicating that athletes with a BMI of 25 undergoing endurance training show a correlation with increased VO_{2max} (Listyowati et al., 2023). Normalizing BMI is key to reducing visceral fat, which is essential for achieving higher maximal oxygen consumption (Rodríguez-García et al., 2024).

On the other hand, our findings differ from other research which found no significant correlation between BMI and VO_{2max} , while age was positively associated with VO_{2max} (Pranata et al., 2024). Another study found no relationship between BMI and VO_{2max} , although exercise helped normalize BMI and thereby improved VO_{2max} (Gawali et al., 2025). These contradictory findings highlight the need for further investigation, especially since VO_{2max} is influenced by many variables. This is crucial, as factors affecting cardiorespiratory endurance include genetics, gender, age, physical training, body composition, hemoglobin levels, and dietary intake (Arisanty et al., 2024).

d. Hb significantly influence VO_{2max}

Our findings align with previous studies indicating a positive relationship between VO_{2max} , plasma concentration, white blood cells, red blood cells, and hemoglobin during and after exercise in both athletes and non-athletes (Gwotmut, 2023). Hemoglobin levels can predict cardiorespiratory endurance and muscular strength in athletes (Eli-Cophie et al., 2024). Hemoglobin and lung vital capacity together contribute to VO_{2max} capacity (Lawanis et al., 2024), and both hemoglobin concentration and its fluctuations positively influence VO_{2max} (Grzebisz-Zatońska, 2024). Absolute

hemoglobin parameters—including hemoglobin concentration, mass, and hematocrit—are also positively associated with VO_2max (Webb et al., 2023). A significant relationship between Hb levels, BMI, and VO_2max has been reported (Ningrum & Dewi, 2024).

However, our findings differ from studies that found no significant relationship between VO_2max and changes in hemoglobin and erythrocyte levels (Ming, 2024). Additionally, fat intake, body fat percentage, and hemoglobin levels were not statistically associated with VO_2max (Arisanty et al., 2024). These differences warrant further investigation, as VO_2max is influenced by multiple variables. Literature reviews also indicate that genetics and gender affect VO_2max , although empirical evidence remains limited (Webb et al., 2023).

e. Bp significantly influence VO_2max

Our results are consistent with prior research that found a relationship between blood pressure and hemoglobin levels with VO_2max among Pencaksilat athletes (Safitri, 2023). The link between Bp and VO_2max can also be seen from studies showing that high-intensity VO_2max -dependent training can lead to reduced systolic blood pressure (Carlén et al., 2022). During prolonged aerobic activity, systolic blood pressure tends to increase to a peak and then gradually decrease due to vasodilation in active muscles (Pesova et al., 2023). Well-designed aerobic training programs have been shown to enhance skeletal muscle oxidative capacity and safely regulate blood pressure—and the reverse also holds true (Smolensky et al., 2022). We did not observe any contradictory findings between our study and previous research; in fact, the relationship between Bp and VO_2max remains an underexplored area, often limited to traditional scientific inquiry (Pesova et al., 2023).

f. BMI significantly influence VO_2max through Bp

BMI through Bp has a significant effect on VO_2max , as the more ideal the BMI and Bp values are, the better the VO_2max tends to be (Arini & Wijana, 2020; Silado & Wiriawan, 2021; Lubis, 2021; Chen et al., 2022; Guntara, 2022; Sinurat et al., 2023; Musyarofah et al., 2023; Sari et al., 2023). However, this finding shows some resistance when compared with other studies (Rohkuswara & Syarif, 2017; Aprilia & Saraswati, 2024). One possible explanation for this inconsistency is that during prolonged aerobic activity, there is an increase in systolic blood pressure, which tends to reach a peak as the intensity increases, and then gradually decreases due to vasodilation in active muscles (Pesova et al., 2023). Moreover, other research has found that athletes with a BMI of 25 who undergo endurance training show a correlation with VO_2max (Listyowati et al., 2023). In other words, such resistance may occur due to the aerobic physical activity or training not reaching its peak, leaving elevated blood pressure levels. Additionally, aerobic training at a certain BMI level may influence the increase in VO_2max . These arguments, of course, require further study and in-depth analysis.

g. Hb significantly influence VO_2max through Bp

Hb (X2) through Bp (X3) has a significant influence on VO_2max (Y); the higher the Hb, the higher the Bp, and vice versa. The same applies in reverse: increased blood pressure correlates with higher hemoglobin levels and vice versa (Komka et al., 2022; Grabitz et al., 2023; Liu & Liu, 2023). Both of them have an effect on VO_2max (Gwotmut, 2023; Eli-Cophie et al., 2024; Lawanis et al., 2024; Grzebisz-Zatońska, 2024; Webb et al., 2023; Ningrum & Dewi, 2024). However, this finding also faces resistance when compared to other studies (Ming, 2024); (Arisanty et al., 2024). One argument for this discrepancy is that VO_2max is influenced by many variables. Factors affecting cardiorespiratory endurance include genetics, sex, age, physical training, body composition, and nutritional intake (Arisanty et al., 2024); (Webb et al., 2023).

In this context, we also consider the importance of discussing the role of Bp as an intervening variable, which has been proven to mediate the indirect effect of the independent variables on the dependent variable. For athletes undergoing intense aerobic activity and endurance training, Bp tends to increase to a peak level and then gradually decrease. Related to this, careful attention must be paid to exercise load, as fluctuations in Bp can have negative consequences. Prehypertension and hypertension affect athletic performance (Wati&Simanjuntak, 2020). Properly identifying and managing high blood pressure can enhance performance and reduce the risk of heart-related issues in athletes (Komka et al., 2022; Afaghi et al., 2024). High blood pressure has been shown to be the most common risk factor contributing to sudden cardiac death among athletes during competition (Purdom et al., 2023). Therefore, alongside careful training, periodic health assessments for athletes should also be prioritized.

5. Conclusion and Recommendation

As the objective of this study is to contribute to and expand the body of knowledge regarding the importance of physical health aspects in the sport of karate, this research provides new information to stakeholders and parties involved in the development of karate as follows: (1) BMI and Hb have a significant influence on Bp. Our findings align with some previous studies, although there is also resistance in other research, particularly regarding the influence of BMI on Bp. This discrepancy could serve as a foundation for further investigation. (2) BMI, Hb, and Bp have a significant effect on VO_{2max} . These findings are consistent with previous research; however, discrepancies were also found in other studies, especially concerning the effects of BMI and Hb on VO_{2max} . These inconsistencies similarly justify the need for further research. (3) BMI and Hb significantly influence VO_{2max} through Bp. Our findings confirm that Bp, as an intervening variable, effectively mediates the indirect effect of the independent variables on the dependent variable.

These three key findings highlight that the role of Bp should be further understood and explored, as it can exert both direct and indirect effects on VO_{2max} . We also conclude that the body of knowledge concerning physical health aspects in karate can serve as a valuable reference for improving athlete performance while simultaneously acting as an indicator for reducing injury risks—particularly the most critical risk: sudden cardiac death during competition.

References

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