

The relationship between macronutrient intake and cardiometabolic indicators in college students who regularly exercise

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ABSTRACT

Background: Macronutrient intake plays a crucial role in determining body composition and cardiovascular health. Studies that simultaneously examine macronutrient intake and various cardiometabolic indicators in physically active populations without a clinical history remain limited. Objective: This study aims to analyze the relationship between macronutrient intake and BMI, blood pressure, and heart rate among a gymnastics community at Semarang State University. Methods: The study used a cross-sectional design involving 30 students (12 males and 18 females) aged 18–35 years, selected through purposive sampling. Macronutrient intake data were collected using a 2×24-hour food recall method, while BMI, blood pressure, and heart rate were measured using calibrated instruments. Statistical analysis was performed using Pearson's correlation test with SPSS version 25. Result: The results showed no significant association between macronutrient intake (protein, fat, or carbohydrates) and BMI, heart rate, or systolic and diastolic blood pressure ($p > 0.05$). It was concluded that variations in macronutrient intake among members of the exercise community were not significantly associated with these cardiometabolic indicators. Conclusion: These findings suggest that in a physically active young adult population, cardiometabolic status is likely influenced more by factors other than macronutrient intake, such as physical activity levels, cardiorespiratory fitness, and overall lifestyle.

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Introduction

Nutritional status is one of the key health indicators for both individuals and our society. Dietary patterns, particularly macronutrient intake, play a major role in determining an individual's nutritional status and cardiovascular health (Kurniyanti et al., 2022; Nurrohman & Trang, 2026). Macronutrients consist of carbohydrates, proteins, and fats, which serve as the body's primary energy sources. An imbalance in macronutrient intake can lead to various health problems, including overweight, hypertension, and cardiovascular disorders (Sari et al., 2014; Sunyari & Setiawan, 2023). Ma et al. (2024) and Zhang et al. (2023) state that energy metabolism, body composition, and cardiovascular function are highly dependent on macronutrient intake. Globally, accumulated epidemiological evidence from more than five million participants in prospective studies indicates that macronutrient consumption patterns that do not align with recommendations are consistently associated with an increased risk of cardiovascular morbidity and mortality. These findings confirm that the quality and proportions of macronutrients in the daily diet are not merely a matter of body weight, but rather direct determinants of cardiovascular health.

Imbalances in the proportions of these three macronutrients have been shown to contribute significantly to changes in Body Mass Index (BMI), increased blood pressure, and changes in heart rate (Koemel et al., 2024; Nuraini et al., 2024; Wati et al., 2023). Fat intake, particularly saturated fat,

contributes to elevated blood pressure through mechanisms involving endothelial dysfunction and increased peripheral vascular resistance (Amalia et al., 2023). There is a complex relationship between protein intake and BMI. Although adequate protein intake supports body composition, excessive consumption of animal-based sources can increase total body fat mass (Sistia et al., 2023). The correlation between these macronutrient intakes and nutritional status indicates that unbalanced dietary patterns—such as high-fat, low-carbohydrate diets—significantly increase energy surplus, thereby leading to weight gain (Fachruddin & Pratiwi, 2024; Siwi & Paskarini, 2019). The results of a recent meta-analysis of randomized controlled trials also demonstrate that a carbohydrate-restricted diet combined with macronutrient replacement significantly reduces systolic and diastolic blood pressure, as well as various body composition (Solikah et al., 2024) markers, in overweight adults (Feng et al., 2025).

The ongoing national nutritional transition further exacerbates the issue of an unbalanced diet among Indonesia's young adult population. A cross-sectional study of 600 Jakarta residents found that consumption of foods high in saturated fat and low in fiber was significantly correlated with an increased prevalence of obesity and hypertension (Sakir et al., 2024). Traditional Indonesian cooking practices, which heavily rely on reused cooking oil and coconut milk, also contribute to high intakes of unhealthy fats among urban populations (Anyanwu et al., 2022). In this context, college students who are members of campus fitness communities find themselves at a unique crossroads: on the one hand, they are actively engaged in structured physical activity; on the other hand, they remain vulnerable to unbalanced dietary patterns due to the availability of food on campus, limited time for cooking, and high academic pressure. Studies among active young adults have shown that the type and intensity of exercise are closely related to specific patterns of macronutrient intake (Zhang et al., 2023). Given this finding, campus sports communities represent a relevant group for further comprehensive study.

Data from the 2023 Indonesian Health Survey (SKI) indicate that 37.4% of Indonesians aged 10 and older are classified as physically inactive, with the main reasons being time constraints and low motivation (Kementerian Kesehatan Republik Indonesia, 2023). In this context, college aerobics communities represent an ecosystem that actively seeks to bridge this gap. Studies of aerobic exercise communities in various cities across Indonesia consistently show that regular participation in aerobic exercise positively impacts members' cardiovascular endurance, weight loss, and waist circumference (Mukarromah et al., 2025; S et al., 2025; Sukendro et al., 2022). However, the physiological benefits of this physical activity can be optimized or, conversely, undermined by the quality of the macronutrient intake. A network meta-analysis comparing various dietary patterns with different macronutrient proportions found that a diet with a high-protein and moderate-carbohydrate composition provides the most beneficial effects on both body weight and cardiovascular risk (Lou et al., 2025). These findings confirm that appropriate nutritional interventions, when combined with structured exercise programs, can provide synergistic health benefits to members of the university gymnastics community.

Previous studies have explored various aspects of the relationship between nutrient intake, nutritional status, and health parameters in diverse populations. Andari et al. (2021) found that among manufacturing workers in Indonesia, only about 10% had macronutrient intakes in line with recommendations, with appropriate carbohydrate intake at 11.7%, fat at 12.5%, and protein at 10%. The study also revealed that protein intake significantly affects workers' physical capacity or fitness ($p = 0.02$). Meanwhile, Ali et al. (2020) in a cross-sectional study of homemakers in Tegal Regency, Central Java, found that 35% of the subjects were obese, 45% were pre-obese, and 40% suffered from stage two hypertension. These findings illustrate that the problem of nutritional imbalance and its impact on cardiovascular health remain significant issues in Indonesia. In line with this, a survey of first-year students at three major universities in Indonesia showed that the prevalence of overweight or obesity was 34.7%, with irregular eating habits and low physical activity as the main risk factors (Vidiawati et al.,

2025). This situation shows that even young adults in college are not immune to the burden of excess weight, which can affect their cardiovascular health at an early age.

However, these studies have three theoretical gaps that remain unaddressed. First, previous findings have been inconsistent: some studies report a strong correlation between protein intake and BMI, while others find no significant association (Moon et al., 2021; Sistia et al., 2023). Second, no study has simultaneously examined the relationship between the three macronutrients—protein, fat, and carbohydrates—and three cardiometabolic indicators (BMI, blood pressure, and heart rate) within a single analytical framework. Third, the macronutrient–cardiometabolic relationship model in a non-clinical, active young adult population within an Indonesian university setting has not been scientifically documented; therefore, findings from clinical populations or professional athletes cannot be directly generalized.

Given these gaps, this study offers a unique approach by integrating the assessment of macronutrient intake (carbohydrates, protein, and fat) with measurements of BMI, blood pressure, and heart rate among the gymnastics community at Semarang State University within a single research design. This approach is expected to provide a comprehensive picture of how macronutrient intake patterns relate to nutritional status and basic cardiovascular parameters in a physically active group, not in a clinical or professional athletic setting. The results of this study are also expected to serve as a basis for designing more targeted nutrition and physical activity interventions for the campus gymnastics community and to contribute to the development of health promotion policies within the university environment. Furthermore, the body of literature on lifestyle-based preventive health among student populations and the academic community can be expanded by incorporating additional variables into a single analytical framework, thereby enabling the identification of broader patterns of relationships.

Based on the above, this study was conducted to analyze the relationship between macronutrient intake and BMI, blood pressure, and heart rate among the gymnastics community at Semarang State University. The objectives of this article are: (1) to describe the profile of macronutrient intake and cardiometabolic indicators among physically active students; and (2) to analyze the relationship between macronutrient intake and BMI, blood pressure, and heart rate in this community. The study results are expected to make a scientific contribution by providing empirical data on the relationship between macronutrients and cardiometabolic factors in an active, non-clinical population, while also providing an evidence-based foundation for designing on-campus nutritional interventions.

Method

Research Design

This study employed a cross-sectional design, collecting data at a single point in time to examine the relationship between macronutrient intake and BMI, blood pressure, and heart rate among the gymnastics community at Semarang State University. This design was chosen because it is suitable for observing natural relationships between variables without intervention or manipulation, thereby allowing researchers to obtain an empirical understanding of those relationships based on data collected under actual conditions. A correlational study examines how two or more variables interact with one another (Sugiyono, 2016). It is expected that this approach will reveal the relationship between macronutrient intake and BMI, blood pressure, and heart rate among the aerobics community at Semarang State University.

Participants

The study population consisted of 68 members of the gymnastics community registered with the Gymnastics Community at Semarang State University. The sample was selected using purposive sampling. Sampling was based on the following inclusion criteria: (1) members of the Semarang State University gymnastics community, and (2) having participated in regular training for 2 months. Exclusion criteria included those with a history of chronic conditions or specific medical conditions, such as

hypertension, cardiovascular disease, or other metabolic disorders that affect BMI, blood pressure, and heart rate. Based on these criteria, a total of 30 students (12 males and 18 females) were included in this study.

Ethical Approval Statement

Ethical approval was obtained prior to data collection from the Research Ethics Committee of Universitas Negeri Malang under Approval Number 7.5.18/UN32.14/PB/2026 dated May 8, 2026. All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Participant data were anonymized prior to analysis to ensure confidentiality and privacy.

Research Instruments

Body weight was measured with an Onemed EF812 digital scale, and height with an Onemed stature meter; BMI was calculated from these measurements. Blood pressure was measured using a calibrated Omron HEM8712 digital sphygmomanometer. Heart rate was measured using a calibrated Omron HEM8712 digital sphygmomanometer. Macronutrient intake was assessed using the 2×24-hour food recall method through structured interviews conducted on two different days—one weekday and one weekend day. The data collected included foods and beverages consumed over 24 hours. Analysis of macronutrient content (protein, fat, and carbohydrates) was performed using Nutrisurvey 2007 software, which was adapted to the Indonesian Food Composition Table.

Data Analysis

Data were analyzed using SPSS version 25. Normality was assessed using the Shapiro-Wilk test for all variables. The results of the normality tests showed that all variables (BMI, systolic blood pressure, diastolic blood pressure, and heart rate) were normally distributed ($p > 0.05$). In contrast, the variables for protein intake ($p = 0.007$), fat intake ($p = 0.004$), and carbohydrate intake ($p < 0.001$) were not normally distributed. Therefore, the analysis of the relationship between macronutrient intake and BMI, blood pressure, and heart rate was conducted using the Spearman rank correlation test, since some variables did not meet the assumption of normality.

Results and Discussion

Results

This study involved 30 students from Semarang State University, consisting of 12 male students (40%) and 18 female students (60%). Standardized instruments and protocols were used to measure macronutrient intake, BMI, blood pressure, and heart rate. Descriptive statistics for the participants are presented in [Table 1](#). The average age of the participants was 21.4. The macronutrients—protein, fat, and carbohydrate—had average values of 38.69, 40.60, and 63.15, respectively. The average height and weight were 163 cm and 61.7 kg, respectively, resulting in a BMI of 22.9 kg/m². The average heart rate was 85 bpm, and the average blood pressure was 120/75.4 mmHg.

Based on [Table 1](#), a total of 30 respondents participated in this study. The mean age of the respondents was 21.40 ± 3.11 years, with an age range of 19–35 years. The average height and weight of the respondents were 163.40 ± 7.86 cm and 61.73 ± 13.03 kg, respectively. The average BMI of the respondents was 22.99 ± 3.73 kg/m², with a minimum of 16 kg/m² and a maximum of 32 kg/m².

Regarding macronutrient intake, the average intake of protein, fat, and carbohydrates was 38.69 ± 16.53 g, 40.60 ± 16.94 g, and 63.15 ± 24.00 g, respectively. Meanwhile, the respondents' average heart rate was 85.00 ± 13.96 bpm, ranging from 60 to 115 bpm. The average systolic and diastolic blood pressures were 120.00 ± 7.03 mmHg and 75.43 ± 3.66 mmHg, respectively, which generally remained within the normal range for the young adult population.

Table 1. Descriptive statistics of the main variables

Variable	N	Minimum	Maximum	Mean $\pm$ SD
Age (years)	30	19	35	21.40 $\pm$ 3.11
Height (cm)	30	150	180	163.40 $\pm$ 7.86
Weight (kg)	30	42	94	61.73 $\pm$ 13.03
BMI (kg/m ²)	30	16	32	22.99 $\pm$ 3.73
Protein (g)	30	12	91	38.69 $\pm$ 16.53
Fat (g)	30	21	95	40.60 $\pm$ 16.94
Carbohydrates (g)	30	32	150	63.15 $\pm$ 24.00
Heart Rate (bpm)	30	60	115	85.00 $\pm$ 13.96
Systolic blood pressure (mmHg)	30	109	135	120.00 $\pm$ 7.03
Diastolic blood pressure (mmHg)	30	69	85	75.43 $\pm$ 3.66

Table 2. Nutritional status categories based on BMI

Category	BMI (kg/m ²)	Frequency	Percentage (%)
Underweight	<18.5	2	6.7%
Normal	18.5 – 24.9	22	73.3%
Overweight	25.0–29.9	5	16.7%
Obesity	30.0–34.9	1	3.3%

Table 3. Heart Rate Classification Categories

Category	Heart Rate (bpm)	Frequency	Percentage (%)
Bradycardia	< 60	0	0%
Normal	60–100	26	86.7%
Tachycardia	> 100	4	13.3%

Table 3 shows the resting heart rate measurements for all subjects, indicating that the majority—26 (86.7%)—fell within the normal range of 60–100 bpm. A total of 4 subjects (13.3%) fell into the tachycardia category (>100 bpm), and none had bradycardia (<60 bpm).

Table 4, based on systolic blood pressure measurements, shows that the majority of respondents fell into the normal category (53.33%), followed by the elevated category (40.00%). Only a small proportion fell into the stage 1 hypertension category (6.67%), and no respondents were found to have stage 2 hypertension. This pattern indicates that, in general, the respondents' systolic blood pressure levels were relatively good.

Table 4. Systolic Blood Pressure Classification Categories

Category	Systolic (mmHg)	Frequency	Percentage (%)
Normal	< 120	16	53.3%
Elevated	120–129	12	40.0%
Stage 1 Hypertension	130–139	2	6.67%
Stage 2 Hypertension	$\geq$ 140	0	0%

Based on diastolic blood pressure measurements, the normal category also predominated (56.67%) (Table 5). The elevated category accounted for 36.67% of respondents, while stage 1 hypertension was only 6.67%, and no one reached stage 2. These findings reinforce the picture that the majority of respondents have diastolic blood pressure within normal limits, but a group remains at risk of elevated blood pressure.

Table 5. Diastolic Blood Pressure Classification Categories

Category	Systolic (mmHg)	Frequency	Percentage (%)
Normal	< 80	17	56.7%
Elevated	< 80	11	36.67%
Stage 1 Hypertension	80–89	2	6.67%
Stage 2 Hypertension	≥ 90	0	0%

Table 6. Relationship Between Macronutrient Intake and BMI, Heart Rate, and Blood Pressure

Variable	BMI	Heart Rate	Systolic	Diastolic
Protein	-0.244 (0.194)	-0.049 (0.798)	0.024 (0.901)	-0.166 (0.380)
Fat	-0.190 (0.315)	-0.221 (0.240)	0.086 (0.650)	-0.119 (0.531)
Carbohydrates	-0.310 (0.096)	-0.226 (0.230)	-0.082 (0.668)	-0.296 (0.112)

Based on the results of the Spearman correlation test in [Table 6](#), no significant relationship was found between macronutrient intake and BMI, heart rate, or blood pressure ($p > 0.05$). Protein intake showed a weak negative correlation with BMI ($r = -0.244$; $p = 0.194$), heart rate ($r = -0.049$; $p = 0.798$), and diastolic blood pressure ($r = -0.166$; $p = 0.380$), as well as a very weak positive correlation with systolic blood pressure ($r = 0.024$; $p = 0.901$). However, none of these relationships was statistically significant.

Fat intake also showed no significant relationship with BMI ($r = -0.190$; $p = 0.315$), heart rate ($r = -0.221$; $p = 0.240$), systolic blood pressure ($r = 0.086$; $p = 0.650$), or diastolic blood pressure ($r = -0.119$; $p = 0.531$). Similarly, carbohydrate intake was not significantly associated with BMI ($r = -0.310$; $p = 0.096$), heart rate ($r = -0.226$; $p = 0.230$), systolic blood pressure ($r = -0.082$; $p = 0.668$), or diastolic blood pressure ($r = -0.296$; $p = 0.112$).

Overall, the results of this study indicate that variations in protein, fat, and carbohydrate intake among members of the Semarang State University gymnastics community are not significantly associated with nutritional status (as measured by BMI), physiological responses (such as heart rate), or cardiovascular parameters (such as blood pressure).

Discussion

This study aimed to analyze the relationship between macronutrient intake (protein, fat, and carbohydrates) and cardiometabolic indicators, including BMI, heart rate, and blood pressure, among members of the Semarang State University gymnastics community. The results of the Spearman correlation analysis showed that none of the macronutrient intake variables were significantly associated with BMI, heart rate, or blood pressure ($p > 0.05$). These findings indicate that variations in macronutrient intake among respondents cannot account for the observed differences in nutritional status or cardiovascular parameters.

The lack of a significant association between protein intake and BMI is consistent with the study by [Ilyas et al. \(2021\)](#), which reported that the relationship between macronutrient consumption and BMI may vary across population groups and is influenced by factors such as physical activity, total daily energy intake, and body composition. In this study, the majority of respondents had normal nutritional status (73.3%), so the relatively narrow range of BMI values may have reduced the statistical strength of the association between protein intake and BMI. Additionally, members of the exercise community routinely engage in physical activity, which can increase protein utilization for muscle tissue maintenance and repair; consequently, this is not always reflected in an increase in BMI.

The study results also indicate that fat and carbohydrate intake are not significantly associated with BMI. These findings differ from several studies reporting that excessive consumption of fat and carbohydrates contributes to weight gain and obesity ([Fachruddin & Pratiwi, 2024](#); [Koemel et al., 2024](#)).

This discrepancy in results is likely due to the characteristics of the respondents, who constitute an active, exercise-oriented group. Regular physical activity can increase energy expenditure, thereby reducing the impact of excess macronutrient intake on weight gain. Additionally, the 2×24-hour food recall method captures short-term consumption and may not necessarily represent long-term dietary patterns, which have a greater influence on changes in BMI.

Regarding cardiovascular parameters, this study found no significant association between protein, fat, or carbohydrate intake and systolic or diastolic blood pressure. These findings suggest that other factors, such as genetics, stress levels, sleep quality, sodium intake, smoking habits, or physical fitness, are more likely to influence participants' blood pressure. These results differ from those of the studies by [Koemel et al. \(2024\)](#), which reported an association between macronutrient composition and blood pressure. However, the majority of participants in this study fell into the normal and mildly elevated blood pressure categories, resulting in relatively small variations in blood pressure that may have prevented the detection of a statistically significant association.

The relationship between macronutrient intake and heart rate was also not statistically significant. This finding can be explained by the fact that resting heart rate is influenced by many factors other than dietary intake, such as cardiorespiratory fitness level, recovery quality, psychological state, hydration, and the intensity of exercise performed the previous day. Most respondents had heart rates in the normal range (86.7%), indicating good physiological adaptation due to regular exercise. Thus, the effect of macronutrient intake on heart rate is likely smaller than the effect of physical fitness.

In general, the results of this study indicate that among young, physically active adults, the relationship between macronutrient intake and cardiometabolic indicators is not always directly observable. These findings support the view that cardiometabolic health results from multifactorial interactions among diet, physical activity, lifestyle, environmental factors, and individual characteristics ([Aloraini et al., 2025](#); [Ma et al., 2024](#)). Therefore, health promotion approaches in campus sports communities should not only focus on regulating macronutrient intake but also consider increasing physical activity, improving sleep quality, managing stress, and providing comprehensive education on healthy lifestyles.

Limitations of Study

This study has several limitations. First, the sample size is relatively small, which may reduce statistical power in detecting relationships between variables. Second, the cross-sectional design does not allow researchers to determine cause-and-effect relationships. Third, measuring dietary intake with a 2×24-hour food recall may introduce recall bias and may not reflect long-term consumption patterns. Therefore, future studies are advised to use a larger sample size, more comprehensive methods for assessing dietary intake, and to consider other variables such as total energy intake, physical activity, body composition, and micronutrient intake.

Conclusions

Based on the study results, there is no significant association between protein, fat, and carbohydrate intake and BMI, heart rate, systolic blood pressure, or diastolic blood pressure among members of the Semarang State University gymnastics community. Although the majority of respondents had nutritional status, heart rate, and blood pressure within the normal range, the observed variations in macronutrient intake were not significantly associated with these cardiometabolic indicators.

These findings suggest that in a young, physically active adult population, cardiometabolic status is likely influenced by factors beyond macronutrient intake, including physical activity levels, cardiorespiratory fitness, lifestyle, and individual factors. Further research with a longitudinal design and a larger sample size is needed to gain a more comprehensive understanding of the relationship between macronutrient intake patterns and cardiometabolic health in physically active populations.

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Authors' contributions

Y.F.Y. conceived and designed the study, collected and assembled the data, performed the data analysis and interpretation, drafted the manuscript, critically revised the manuscript, and approved the final version of the article. A.L. and B.K.P. contributed to data collection and assembly, performed the data analysis and interpretation, and approved the final version of the article. S.B.M. and A.S. contributed to the study conception and design, participated in manuscript preparation, critically revised the manuscript, and approved the final version of the article. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

AI Disclosure Statement

During the preparation of this manuscript, the authors used Grammarly to proofread the English text. All AI-generated outputs were critically reviewed and thoroughly edited by the authors to ensure factual accuracy, clarity of expression, and compliance with academic standards. The authors take full responsibility for the integrity and content of this manuscript.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available because they contain information that could compromise the privacy of research participants.

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