Original Research Article
ISSN (Print): 2303-1921
ISSN (Online): 2722-0443
Volume 14, Number 2, Pages 589-594 (2026)
DOI: https://doi.org/10.24843/mifi.000000976

Heart Rate Recovery After Exercise Among Overweight Young Adults: A Cross-Sectional Study

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Received 9 November 2025; Revised 18 November 2025; Accepted 18 November 2025; Published 16 May 2026.

Abstract
Background: Overweight is associated with reduced cardiovascular fitness, and heart rate recovery (HRR) after exercise serves as a simple marker of autonomic and cardiovascular function. However, evidence comparing post-exercise HRR between overweight and normal-weight young adults remains limited.
Objective: This study aimed to compare post-exercise HRR between overweight and normal-weight university students.
Methods: This comparative cross-sectional analytical study involved 40 university students (20 overweight and 20 normal-weight) aged 19–22 years from the Faculty of Health Sciences, Muhammadiyah University of Surakarta, Indonesia. Participants were classified as normal-weight (body mass index [BMI] 18.5–25.0 kg/m²) or overweight (BMI ≥25.01 kg/m²) according to the Indonesian Ministry of Health criteria. All participants performed a standardized bout of 15 jumping jacks. Heart rate was measured at rest (HR1), immediately after exercise (HR2), and 1 minute post-exercise (HR3) using a pulse oximeter. HRR was calculated as HR2 − HR3 (beats per minute). Data were analyzed using independent t-tests and repeated-measures ANOVA ($\alpha = 0.05$).
Results: Mean HRR was significantly lower in overweight participants than in normal-weight participants (17.85 ± 6.14 vs 26.05 ± 7.40 bpm, $p = 0.001$). Within-group analyses demonstrated significant changes in heart rate over time in both groups ($p < 0.001$).
Conclusion: Overweight status is associated with slower post-exercise HRR in young adults, suggesting less efficient cardiovascular recovery and potentially greater cardiometabolic risk. HRR may serve as a simple and practical marker for screening cardiovascular fitness in university settings.

Keywords
Heart Rate; Overweight; Exercise; Physical Fitness; Young Adult.

Introduction

Overweight is a condition characterized by excess body weight resulting primarily from increased adipose tissue, often accompanied by disturbances in energy metabolism and lifestyle-related factors.[1] In the health context, overweight is considered an important public health problem because it is associated with an increased risk of cardiometabolic disorders, musculoskeletal problems, and reduced quality of life. Contributing factors include genetic predisposition, unhealthy dietary patterns, physical inactivity, low nutrition literacy, and an overall unhealthy lifestyle.[1] In Indonesia, recent surveys reported that the prevalence of overweight and obesity among adults reached 23.6% in 2022, influenced by work-related stress, irregular sleep patterns, and inconsistent nutritional intake.[2]

From a cardiovascular perspective, overweight individuals generally present with lower cardiovascular fitness than those with normal body weight. During physical activity, the heart must pump more blood to supply oxygen to a larger body mass, thereby increasing cardiac workload in overweight subjects compared with individuals with normal weight.[3,4] When this condition persists, it may lead to reduced efficiency of cardiovascular responses to exercise and slower recovery after physical exertion.

Heart rate recovery (HRR) after exercise is a simple and non-invasive indicator used to assess autonomic and cardiovascular function.[4,5] HRR is usually defined as the decrease in heart rate from peak exercise to a specified recovery time point, commonly at 1 or 2 minutes post-exercise.[6] A faster decline in heart rate reflects more efficient parasympathetic reactivation and sympathetic withdrawal, whereas a slower HRR is associated with autonomic imbalance and increased cardiovascular risk. Previous work suggests that a reduction of around 20 beats per minute or more in the first minute after exercise may be considered a favourable HRR in adults, whereas lower values may indicate impaired cardiovascular fitness and higher risk of adverse outcomes such as stroke and coronary heart disease.[5,7,11]

In Indonesia, stroke and coronary heart disease remain leading causes of mortality, with national data reporting hundreds of thousands of deaths over the last decade.[8] Given this burden, simple markers that can identify early autonomic and cardiovascular dysfunction especially in younger populations at risk, such as overweight university students are highly relevant for prevention.

HRR can also be used as a practical parameter in exercise prescription, helping clinicians and exercise professionals to tailor intensity and monitor training responses.[4] However, most previous HRR studies have focused on athletes or individuals with normal weight, and there is relatively little evidence regarding HRR among overweight young adults, particularly in Indonesian university settings. Some studies have investigated the relationship between body composition, physical fitness, and HRR,[10,11] but data specifically comparing overweight and normal-weight students after a standardized simple exercise protocol remain scarce.

Therefore, there is a need to better understand how overweight status affects HRR following a brief bout of standardized exercise in young adults. Such information may support early screening, risk stratification, and targeted interventions for weight management and cardiovascular health in this population.

The present study aimed to compare post-exercise heart rate recovery between overweight and normal-weight university students using a simple jumping jacks protocol. We hypothesized that overweight individuals would exhibit lower HRR values, indicating slower cardiovascular recovery, compared with their normal-weight peers.

Methods

This was a comparative cross-sectional analytical study with a pre–post exercise protocol, comparing HRR after a standardized bout of exercise between overweight and normal-weight young adults. The reporting of this study follows the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guideline for observational studies. The study was conducted at the Faculty of Health Sciences, Muhammadiyah University of Surakarta, Indonesia, in 2025, after obtaining ethical approval from the institutional Research Ethics Committee. All exercise testing and heart rate measurements were performed in a controlled indoor environment in the university's exercise physiology laboratory.

The study population consisted of male and female university students aged 16–30 years enrolled at Muhammadiyah University of Surakarta. Potential participants were approached using a purposive and convenience sampling strategy through classroom announcements and flyers posted in the Faculty of Health Sciences. Initially, 47 students were screened for eligibility. Of these, 7 were excluded because they did not meet the inclusion criteria (n = 4) or declined to participate (n = 3), resulting in a final sample of 40 participants who completed all measurements and were included in the analysis.

Participants were categorized into two groups based on body mass index (BMI) according to the Indonesian Ministry of Health classification. The normal-weight group consisted of individuals with a BMI of 18.5–25.0 kg/m² (n = 20), while the overweight group included participants with a BMI of ≥25.01 kg/m² (n = 20). The inclusion criteria were: (1) male or female students aged 16–30 years; (2) classified as normal-weight or overweight based on the above BMI cut-offs; (3) not smoking and not consuming caffeine for at least 2 hours prior to testing; and (4) willing to participate and sign written informed consent.

The exclusion criteria were: (1) mobility limitations such as arthritis, recent musculoskeletal injury, or any condition that restricted safe performance of jumping jacks; (2) history of major surgery; (3) known cardiovascular diseases such as coronary heart disease, arrhythmias, or uncontrolled hypertension; and (4) pregnancy or breastfeeding. There was no a priori sample size calculation; the sample size was determined by the number of eligible and consenting students during the data collection period. This limitation is addressed in the Discussion.

The main exposure variable was weight status (overweight vs normal-weight), defined according to BMI categories as described above.[12] BMI was calculated as body mass (kg) divided by height squared (m²), and treated both as a continuous variable (for descriptive purposes) and as a categorical variable (normal-weight vs overweight).

The primary outcome variable was heart rate recovery (HRR), defined as the difference between the heart rate measured immediately after exercise (HR2) and the heart rate measured 1 minute after exercise (HR3), calculated as HRR = HR2 − HR3 (beats per minute). Secondary heart rate variables included HR1, representing the resting heart rate measured immediately before exercise; HR2, the heart rate measured immediately after completing the jumping jacks; and HR3, the heart rate recorded exactly 1 minute post-exercise.

Additional descriptive variables included age (years) and sex (male/female). No other potential confounders, such as habitual physical activity, dietary habits, or baseline cardiorespiratory fitness, were assessed in this study, and these omissions are noted as limitations.

This study used a simple aerobic exercise in the form of jumping jacks as the exercise stimulus. Aerobic exercise is an activity that improves heart and lung endurance through repetitive, rhythmic movements requiring a substantial oxygen supply.[13] Jumping jacks were chosen because they are a whole-body movement that can effectively increase heart rate in a short period of time, while remaining feasible and safe for untrained young adults.

In this study, each participant performed a single bout of 15 jumping jacks at a comfortable, self-paced tempo under the supervision of the researcher. The total duration of the bout was kept within a maximum of approximately 15 minutes for the entire testing session, but the actual execution time of the 15 repetitions was considerably shorter (within seconds). No additional sets or repetitions were performed. The use of 15 repetitions was based on typical teaching and research modules in which beginners or untrained individuals are prescribed low-volume sets of approximately 10–20 repetitions.

In this study, the inclusion criteria specifically targeted untrained overweight and normal-weight individuals; therefore, a relatively low exercise volume was selected to minimize discomfort and reduce the risk of exercise-related injury while still providing an adequate stimulus to increase heart rate. All participants, regardless of group, performed the same exercise protocol with identical instructions and supervision.

Heart rate was measured using a portable pulse oximeter. Pulse oximeters have been shown to have high reliability and concurrent validity for heart rate assessment in healthy adults, with intra-session intraclass correlation coefficients (ICC) greater than 0.93 and low coefficients of variation.[14]

For each participant, HR1 was measured in a standing or upright position immediately before starting the jumping jacks, after at least 5 minutes of quiet rest. HR2 was measured immediately upon completion of the 15th jumping jack (within approximately 10–15 seconds), and HR3 was measured exactly 1 minute after the end of exercise. All measurements were performed using the same device by the same researcher to reduce measurement variability.

The data collection procedure is summarized in Figure 1 (respondent flow chart). First, participants who met the age and BMI criteria were invited to participate and screened against the inclusion and exclusion criteria. After providing written informed consent, participants' height and body weight were measured to calculate BMI, and they were then assigned to the normal-weight or overweight group based on BMI cut-offs.

On the testing day, participants were reminded to avoid smoking and caffeine intake for at least 2 hours before the session. After a brief explanation of the procedures, participants rested quietly for at least 5 minutes. HR1 was then measured using the pulse oximeter. Participants subsequently performed one bout of 15 jumping jacks at their own comfortable pace under supervision. Immediately upon completion of the last repetition, HR2 was measured.

Participants then rested in a standing or seated position, and HR3 was recorded exactly 1 minute after exercise. HRR was calculated as HR2 − HR3. The same standardized procedure was used for both the overweight and normal-weight groups. There were no missing data for any of the variables.

Data were analyzed using IBM SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). Continuous variables (age, BMI, HR1, HR2, HR3, HRR) were summarized as mean ± standard deviation (SD), and categorical variables (sex, weight status) as frequencies and percentages.

Normality of continuous variables was assessed using the Shapiro–Wilk test, and homogeneity of variances between groups was examined using Levene's test. As the assumptions of normality and homogeneity were met, between-group comparisons of HRR and baseline characteristics were performed using independent samples t-tests.

Within-group changes in heart rate over time (HR1, HR2, HR3) were evaluated using repeated measures ANOVA. The significance level was set at $\alpha = 0.05$ for all analyses, and two-tailed p-values were reported. No multivariable adjustment or subgroup analyses were conducted because of the limited sample size; therefore, all results represent unadjusted estimates.

Results

This study was conducted to determine whether body weight affects cardiovascular recovery after physical activity, as assessed by HRR. A total of 47 students were initially screened. Seven did not participate in the final analysis because they did not meet the inclusion criteria (n = 4) or declined to participate (n = 3), leaving 40 eligible participants (20 overweight and 20 normal-weight) who completed the study (Figure 1).

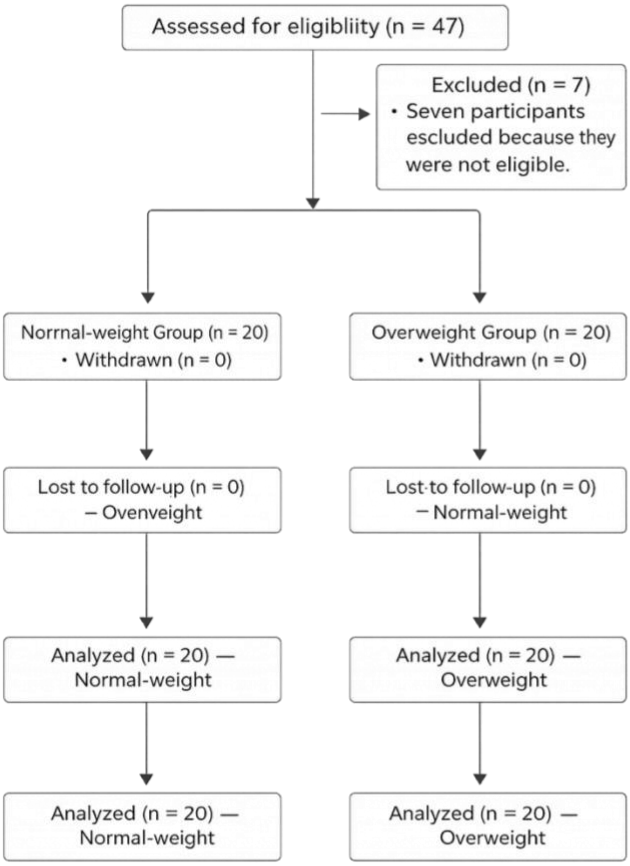

Figure 1. Respondent Flow Chart

To provide a clearer understanding of the participant profile and the physiological responses observed in this study, several tables are presented below. Table 1 outlines the demographic characteristics and baseline heart rate profiles of all participants. Table 2 presents the analysis of Heart Rate Recovery (HRR) and the changes in heart rate following the exercise intervention. Meanwhile, Table 3 describes the within-group differences across various heart rate measurements, offering insight into the adaptive responses between overweight and ideal-weight individuals. Together, these tables support the interpretation of the study findings and highlight key patterns relevant to cardiovascular fitness.

Table 1. Demographic and heart rate characteristics of participants

Variable	Group A (Overweight)				Group B (Normal-weight)			
	n	Min	Max	Mean (SD)	n	Min	Max	Mean (SD)
Age (years)	20	19	22	20.4 (0.66)	20	19	22	20.0 (0.77)
Sex, n (%)								
Male	15	–	–	75.0%	13	–	–	65.0%
Female	5	–	–	25.0%	7	–	–	35.0%
BMI (kg/m²)	20	25.15	35.49	27.74 (3.20)	20	18.90	22.58	20.94 (1.41)
HR1 (bpm)	20	74	98	87.0 (8.37)	20	74	100	85.7 (8.29)
HR2 (bpm)	20	88	163	119.45 (16.70)	20	91	141	116.55 (11.98)
HR3 (bpm)	20	73	145	101.60 (18.62)	20	66	118	91.00 (13.92)
HRR (bpm)	20	4	29	17.85 (6.14)	20	15	38	26.05 (7.40)

SD: standard deviation; BMI: body mass index; HR1: heart rate immediately before exercise; HR2: heart rate immediately after exercise; HR3: heart rate 1 minute after exercise; HRR: heart rate recovery (HR2 − HR3); bpm: beats per minute.

As shown in Table 1, each group consisted of 20 participants, with a higher proportion of males in both groups (75.0% in the overweight group and 65.0% in the normal-weight group). The mean age was similar between groups (20.4 ± 0.66 years in the overweight group and 20.0 ± 0.77 years in the normal-weight group). As expected, BMI differed substantially between groups, with the overweight group having a mean BMI of 27.74 ± 3.20 kg/m² compared with 20.94 ± 1.41 kg/m² in the normal-weight group, confirming clear differences in nutritional status.

Baseline resting heart rate (HR1) was slightly higher in the overweight group (87.0 ± 8.37 bpm) than in the normal-weight group (85.7 ± 8.29 bpm). After exercise, HR2 increased to 119.45 ± 16.70 bpm in the overweight group and 116.55 ± 11.98 bpm in the normal-weight group. At 1 minute post-exercise (HR3), heart rate decreased to 101.60 ± 18.62 bpm in the overweight group and 91.00 ± 13.92 bpm in the normal-weight group. The calculated HRR (HR2 − HR3) indicated better recovery in the normal-weight group (26.05 ± 7.40 bpm) compared with the overweight group (17.85 ± 6.14 bpm). There were no missing data for any variable.

Table 2. Analysis of HRR and heart rate changes

Variable	Group A (Overweight) Mean (SD)	Group B (Normal-weight) Mean (SD)	Independent t-test p-value
HRR (bpm)	17.85 (6.14)	26.05 (7.40)	0.001

HRR: heart rate recovery (HR2 − HR3); bpm: beats per minute.

Independent t-test analysis showed that HRR was significantly lower in the overweight group compared with the normal-weight group (mean difference −8.20 bpm, p = 0.001), indicating slower cardiovascular recovery in overweight participants.

Table 3. Differences between heart rate measurements within each group

Comparison	Group A (Overweight) Mean difference (bpm)	p-value	Group B (Normal-weight) Mean difference (bpm)	p-value
HR1 − HR2	−32.45	<0.001	−30.85	<0.001
HR1 − HR3	−14.60	0.002	−5.30	0.108
HR2 − HR3	17.85	<0.001	25.55	<0.001

HR1: heart rate immediately before exercise; HR2: heart rate immediately after exercise; HR3: heart rate 1 minute after exercise; bpm: beats per minute.

Repeated measures analyses and pairwise comparisons (Table 3) showed significant changes in heart rate across time in both groups. In the overweight group, HR increased sharply from HR1 to HR2 (mean difference −32.45 bpm, p < 0.001) and then decreased from HR2 to HR3 (17.85 bpm, p < 0.001), but HR3 remained higher than HR1 (difference −14.60 bpm, p = 0.002), indicating incomplete recovery within 1 minute.

In the normal-weight group, HR also increased significantly from HR1 to HR2 (mean difference −30.85 bpm, p < 0.001) and decreased significantly from HR2 to HR3 (25.55 bpm, p < 0.001). However, the difference between HR1 and HR3 was smaller and not statistically significant (−5.30 bpm, p = 0.108), suggesting that heart rate at 1 minute post-exercise had almost returned to its pre-exercise level in normal-weight participants.

Overall, these results demonstrate that both groups exhibited the expected increase in heart rate in response to exercise, followed by recovery, but the magnitude of recovery was greater and more complete in the normal-weight group than in the overweight group.

Discussion

This study aimed to compare post-exercise heart rate recovery between overweight and normal-weight university students following a simple jumping jacks protocol. The main finding was that overweight participants had significantly lower HRR values than their normal-weight peers (17.85 vs 26.05 bpm, p = 0.001), indicating slower cardiovascular and autonomic recovery during the first minute after exercise.

HRR is widely recognized as an important indicator of autonomic function and cardiovascular fitness. During exercise, activation of the sympathetic nervous system increases heart rate to meet the higher oxygen demands of working muscles. When exercise stops, heart rate should decrease rapidly, primarily due to parasympathetic reactivation and gradual sympathetic withdrawal.[4,7,15] A slower decline in heart rate suggests impaired autonomic modulation, with relatively higher sympathetic tone and/or reduced parasympathetic activity, and has been associated with increased risk of cardiovascular morbidity and mortality.

In this study, normal-weight participants showed a larger decrease in heart rate from immediately after exercise to 1 minute post-exercise (HR2 − HR3), and HR3 was closer to their pre-exercise HR1, indicating more efficient recovery. In contrast, overweight participants exhibited a slower HRR and a higher HR3 relative to HR1, suggesting that their cardiovascular system remained more activated 1 minute after exercise.

These findings are consistent with the physiological understanding that overweight and obesity are associated with increased cardiac workload, insulin resistance, systemic inflammation, and autonomic imbalance.[6,7,16] Excess adiposity may lead to elevated sympathetic activity and reduced parasympathetic tone, which in turn can delay heart rate recovery after physical exertion.

Several previous studies support the association between body composition and HRR. Kirmawanto et al. reported that HRR, fitness, and physical activity capacity were significantly influenced by body composition among male medical students, with higher body fat associated with slower HRR.[7] Dimkpa et al. showed that individuals with higher adiposity levels had higher heart rates at rest, during exercise, and in early recovery, reflecting greater cardiovascular strain.[6] Although the present study used a relatively simple exercise protocol, the pattern of slower HRR in overweight participants aligns with these earlier findings.

Our results also resonate with studies comparing trained and untrained individuals. In a previous study on overweight subjects, untrained participants were found to have lower HRR compared with more physically active or trained individuals, even when body weight was similar. However, when comparing overweight individuals to normal-weight individuals with better body composition, HRR tends to be more favourable in the latter group, suggesting that both body composition and habitual physical activity contribute to autonomic and cardiovascular recovery.

Beyond autonomic function, overweight is frequently linked with unhealthy lifestyle behaviours such as excessive caloric intake, sedentary behaviour, and low physical activity levels.[1,17,18] These factors further reduce cardiorespiratory fitness and contribute to the development of cardiovascular diseases. If left unaddressed, overweight individuals are at higher risk of hypertension, coronary heart disease, stroke, and other cardiometabolic conditions.[8,9,16] The slower HRR observed in the overweight group in this study may thus represent an early marker of increased cardiometabolic risk, even in young adults who are otherwise clinically healthy.

From a practical standpoint, the use of a simple exercise such as 15 jumping jacks, combined with HRR assessment using a pulse oximeter, offers an accessible and inexpensive way to screen cardiovascular recovery in community and educational settings. Pulse oximeters are widely available, easy to use, and have demonstrated good reliability and validity for heart rate measurement.[14] For physiotherapists, sports practitioners, and health educators, this approach can be incorporated into routine assessments to identify individuals who may benefit from more comprehensive evaluation and targeted interventions to improve fitness and manage body weight.

This study has several strengths. First, it focuses on a relatively under-studied population: overweight and normal-weight university students in an Indonesian context. Second, it uses a simple, standardized exercise protocol (15 jumping jacks) that is easy to implement in real-world settings. Third, HRR was measured using a device with documented reliability, and the same protocol was applied identically to both groups.

However, several limitations should be acknowledged. First, the study used a comparative cross-sectional design, which precludes causal inferences regarding the relationship between overweight status and impaired HRR. Second, the sample size was relatively small (n = 40) and drawn from a single faculty at one university, which limits the generalizability of the findings to other age groups, institutions, or populations with different ethnic and socioeconomic backgrounds.

Third, no a priori sample size calculation was performed; therefore, the study may be underpowered to detect smaller differences or to conduct subgroup analyses (e.g., by sex or finer BMI categories). Fourth, important potential confounders such as habitual physical activity, dietary patterns, sleep quality, and baseline cardiorespiratory fitness were not measured or controlled for. These unmeasured variables may partly explain the observed differences in HRR between groups and contribute to residual confounding.

Fifth, HRR was assessed only at 1 minute after exercise, and only one simple exercise protocol (jumping jacks) was used. Future studies could incorporate HRR at multiple time points (e.g., 1 and 2 minutes), employ graded exercise tests, or directly measure maximal oxygen uptake (VO_2max) to provide a more comprehensive assessment of cardiovascular fitness. Finally, heart rate measurements were obtained in a single session, without repeated testing to assess test–retest reliability in this specific protocol.

Despite these limitations, the present study provides useful preliminary evidence that overweight status is associated with slower HRR after a brief bout of exercise in young adults. For clinicians and physiotherapists, HRR may be incorporated as a simple screening tool to identify young overweight individuals who could benefit from early lifestyle interventions focusing on weight management and regular aerobic exercise. Promotion of physical activity with a frequency of 3–5 times per week and duration of 20–60 minutes per session has been recommended to improve physical fitness and cardiovascular health.[18]

Future research should include larger, more diverse samples, collect detailed information on physical activity and lifestyle factors, and consider longitudinal designs to explore whether improvements in body composition and fitness are associated with changes in HRR over time. Intervention studies examining the effects of structured exercise programs or weight loss strategies on HRR in overweight young adults would also be valuable.

Conclusion

This study showed that overweight university students had significantly lower post-exercise heart rate recovery compared with their normal-weight peers, after performing a simple bout of 15 jumping jacks. The overweight group exhibited slower autonomic and cardiovascular recovery during the first minute after exercise, as indicated by lower HRR values and a higher heart rate remaining one minute after activity.

These findings suggest that excess body weight negatively affects cardiovascular recovery efficiency in young adults and may reflect early signs of increased cardiometabolic risk. Normal-weight individuals, who typically have more favourable body composition, demonstrated faster HRR and more efficient autonomic regulation following exercise.

HRR, measured with a simple protocol and a pulse oximeter, may thus serve as an accessible and practical physiological marker for screening cardiovascular fitness in educational and community settings. Maintaining an ideal body weight through appropriate nutritional habits and regular aerobic exercise is likely to improve heart rate recovery and reduce the long-term risk of cardiovascular diseases such as hypertension, coronary heart disease, and stroke.

Future studies with larger and more diverse samples, longitudinal designs, and more detailed assessment of lifestyle and fitness are needed to confirm and extend these findings. Nonetheless, the present results underscore the importance of early preventive strategies targeting body weight and physical activity in young adults to promote optimal cardiovascular health.

Author Contribution

Muhammad Naufal Firdaus: Conceptualization, Writing review and editing.
Farid Rahman: Data curation, Writing original draft.

Acknowledgments

I would like to express my sincere gratitude to Mr. Farid Rahman, Lecturer in Physiotherapy at Universitas Muhammadiyah Surakarta and research supervisor, for his invaluable guidance and support throughout the completion of this study. My appreciation also extends to all volunteers who kindly participated in this research. I am deeply thankful to my father, mother, brother, and all my beloved friends and family for their unwavering encouragement. Your continuous support has been a source of strength for me during the entire process of writing and completing this research.

Conflict of Interest Statement

The authors declare no conflict of interest.

Funding Sources

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics Statement

This study was approved by the Research Ethics Committee of Muhammadiyah University of Surakarta (approval number: 1241/KEPK-FIK/V/2025). The study adhered to the seven ethical standards proposed by the World Health Organization in 2011 and the detailed guidance from the 2016 CIOMS guidelines, including scientific validity, social value, risk–benefit balance, fair participant selection, voluntary participation, confidentiality and privacy, and informed consent. Before participation, all respondents received clear information regarding the study objectives, procedures, potential risks, and benefits, and written informed consent was obtained from all participants.

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