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Original Article

Determining Cardiovascular Endurance in Post-COVID Individuals and Its Association With Physical Activity

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ABSTRACT

Background: Post-COVID individuals may experience persistent fatigue, dyspnea, reduced exercise tolerance, physical inactivity, and impaired cardiovascular endurance, which can affect functional recovery and long-term health. Objective: This study aimed to determine the association of physical activity level and body mass index category with cardiovascular endurance among post-COVID individuals. Methods: A cross-sectional observational study was conducted among 179 post-COVID individuals aged 18–40 years from January to June 2024 in Lahore. Participants were selected using convenience sampling. Physical activity level was assessed using the International Physical Activity Questionnaire, while cardiovascular endurance was assessed using the Harvard Step Test. BMI was calculated and categorized using standard BMI groups. Data were analyzed using IBM SPSS Statistics version 23. Descriptive statistics were reported as mean ± standard deviation and frequency with percentage. Associations between categorical variables were assessed using chi-square tests, with statistical significance set at $p < 0.05$. Results: The mean age of participants was 24.95 ± 4.55 years, and mean BMI was 23.39 ± 3.41 kg/m². Among participants, 34 (19.0%) were inactive, 91 (50.8%) were minimally active, and 54 (30.2%) were fully active. Physical activity level was significantly associated with cardiovascular endurance, $\chi^2(8) = 113.43$, $p < 0.001$, Cramer's V = 0.563. BMI category was also significantly associated with cardiovascular endurance, $\chi^2(12) = 40.19$, $p < 0.001$, Cramer's V = 0.274. Conclusion: Lower physical activity and higher BMI burden were associated with poorer cardiovascular endurance among post-COVID individuals. Simple screening of physical activity, BMI, and endurance may help guide post-COVID rehabilitation and lifestyle counseling. Keywords: Physical Activity; Cardiovascular Endurance; COVID-19; Post-COVID Condition; Body Mass Index; Harvard Step Test.

INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2, has produced substantial acute and long-term health consequences across respiratory, cardiovascular, neuromuscular, and functional domains. Although many individuals recover from the acute infection, a proportion continue to experience persistent symptoms such as fatigue, dyspnea, reduced exercise tolerance, sleep disturbance, pain, and impaired daily functioning, which may collectively restrict participation in routine physical activity and delay restoration of cardiorespiratory fitness (1). These sequelae are clinically important because cardiovascular endurance is a core component of functional recovery, and reduced endurance may limit return to work, education, exercise, and independent daily activities after COVID-19 infection (2).

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Physical activity declined substantially during and after the pandemic because of infection-related symptoms, social restrictions, closure of gyms and recreational spaces, fear of exertional intolerance, and changes in daily routines. Reduced physical activity is particularly concerning in post-COVID populations because inactivity may contribute to deconditioning, weight gain, impaired cardiometabolic health, and lower aerobic capacity, all of which may further compromise functional recovery (3). Conversely, regular physical activity and structured endurance-based exercise are associated with better cardiopulmonary function, improved vascular health, lower inflammatory burden, and improved physical performance, making physical activity assessment a relevant component of post-COVID rehabilitation screening (4).

Body mass index may further influence this relationship because overweight and obesity are associated with lower physical efficiency, poorer exercise tolerance, and increased cardiometabolic load. In post-COVID individuals, higher BMI may interact with reduced activity behavior and residual symptoms, resulting in a higher likelihood of poor cardiovascular endurance. Previous literature has shown that physical fitness, cardiopulmonary function, persistent post-COVID symptoms, and physical activity are interrelated; however, much of the available evidence has focused on symptom burden, hospitalization risk, or cardiopulmonary testing rather than simple field-based endurance assessment in young adult post-COVID populations (5). In addition, university and community-based populations in local settings remain underrepresented, despite being accessible groups in whom early screening of physical activity and endurance may support preventive rehabilitation and lifestyle counseling (6).

The International Physical Activity Questionnaire provides a practical method for categorizing physical activity level, while the Harvard Step Test offers a feasible field-based measure of cardiovascular endurance through recovery response after standardized exertion (7,8). Together, these tools can help identify whether physically inactive post-COVID individuals demonstrate poorer cardiovascular endurance than minimally active or fully active individuals, and whether BMI categories show a parallel association with activity and endurance. However, the direction and strength of these associations remain insufficiently described in local young adult post-COVID samples using accessible clinical tools.

Therefore, this study aimed to determine the association of physical activity level and body mass index category with cardiovascular endurance among post-COVID individuals aged 18–40 years. The study was guided by the research question: among young adult post-COVID individuals, are physical activity level and BMI category significantly associated with cardiovascular endurance measured using the Harvard Step Test?

MATERIALS AND METHODS

This cross-sectional observational study was conducted over six months, from January to June 2024, at the University of Management and Technology, UMT Health Sciences Campus, and Surraya Azeem Hospital, Lahore. The study was designed to evaluate the association of physical activity level and body mass index category with cardiovascular endurance among individuals with a history of COVID-19 infection during the preceding three years. A cross-sectional design was appropriate because the objective was to assess the distribution and association of exposure variables, including physical activity level and BMI category, with cardiovascular endurance at a single point in time rather than to establish temporal or causal relationships.

The study included male and female participants aged 18–40 years who had a previous history of COVID-19 infection and were able to perform the required physical assessment. Participants were selected using non-probability convenience sampling from the study settings during the data collection period. Individuals were excluded if they had known cardiovascular disease, chronic obstructive pulmonary disease, uncontrolled hypertension, musculoskeletal conditions limiting step-test performance, significant neurological or cognitive impairment, acute respiratory illness, or any other major health condition affecting the heart, lungs, muscles, or safe participation in exertional testing. Eligible participants were informed about the study purpose and procedures, and written informed consent was obtained before data collection. Ethical approval was obtained from the Institutional Review Board of the University of Management and Technology.

Data were collected using a structured assessment process that included demographic information, anthropometric measurement, physical activity assessment, and cardiovascular endurance testing. Age, sex, education level, profession, and history of COVID-19 infection were recorded before physical assessment. Body mass index was calculated as weight in kilograms divided by height in meters squared and categorized into underweight, normal weight, overweight, and obese groups according to standard BMI classification thresholds. Physical activity was assessed using the International Physical Activity Questionnaire–Short Form, which records the frequency and duration of walking, moderate-intensity activity, vigorous-intensity activity, and sitting during the previous seven days. Participants were categorized into inactive, minimally active, and fully active groups according to IPAQ scoring criteria based on reported activity volume and intensity (9).

Cardiovascular endurance was assessed using the Harvard Step Test, a field-based test of aerobic fitness and recovery response after standardized stepping exercise. Participants performed stepping activity according to the Harvard Step Test protocol, after which recovery pulse was recorded and used to classify cardiovascular endurance. The test reflects cardiovascular efficiency by evaluating the body's ability to tolerate and recover from submaximal exertion. Cardiovascular endurance was categorized as poor, below average, average, above average, or excellent according to the physical efficiency index derived from the Harvard Step Test procedure (8). To reduce measurement bias, the same assessment sequence was followed for all participants, eligibility screening was performed before exertional testing, and participants with conditions that could compromise safe or valid performance were excluded. Anthropometric and questionnaire data were checked for completeness before entry, and final analysis was conducted on complete records.

The main outcome variable was cardiovascular endurance category measured through the Harvard Step Test. The principal exposure variable was physical activity level measured through IPAQ and categorized as inactive, minimally active, or fully active. BMI category was examined as an additional explanatory variable because of its potential relationship with both physical activity and endurance. Other descriptive variables included age, sex, education level, and profession. Potential confounding by body composition was addressed by analyzing BMI category in relation to both physical activity level and cardiovascular endurance. The study did not infer causality because the cross-sectional design measured exposure and outcome variables at the same time.

Data were entered and analyzed using IBM SPSS Statistics version 23. Continuous variables, including age and BMI, were summarized as mean and standard deviation, while categorical variables, including sex, education, profession, physical activity level, BMI category, and cardiovascular endurance category, were summarized as frequencies and percentages. Associations between categorical variables were assessed using the chi-square test of independence. Specifically, cardiovascular endurance category was compared across physical activity levels and BMI categories, and BMI category was compared across physical activity levels. Statistical significance was set at $p < 0.05$. Exact p-values were reported where available, and the interpretation of findings was restricted to statistical association rather than causal effect. Data were reviewed for completeness and consistency before analysis to preserve data integrity and reproducibility.

RESULTS

A total of 179 post-COVID individuals were included in the analysis. The mean age of the participants was 24.95 ± 4.55 years, and the mean body mass index was 23.39 ± 3.41 kg/m^2. Most participants were male, 125 (69.8%), while 54 (30.2%) were female. Regarding educational status, 152 (84.9%) participants had completed graduation, 14 (7.8%) had intermediate-level education, 7 (3.9%) had postgraduate education, and 6 (3.4%) had matriculation-level education. Most participants were students, 118 (65.9%), followed by job holders, 47 (26.3%), and individuals engaged in household activities, 14 (7.8%), as shown in Table 1.

Table 1. Demographic and baseline characteristics of post-COVID participants

Variable	Category	n (%) / Mean ± SD
Total sample	—	179 (100.0)
Age, years	Mean ± SD	24.95 ± 4.55
Sex	Male	125 (69.8)
	Female	54 (30.2)
BMI, kg/m²	Mean ± SD	23.39 ± 3.41
Education	Matriculation	6 (3.4)
	Intermediate	14 (7.8)
	Graduation	152 (84.9)
	Post-graduation	7 (3.9)
Profession	Student	118 (65.9)
	Job holder	47 (26.3)
	Household	14 (7.8)

Physical activity classification showed that 34 (19.0%) participants were inactive, 91 (50.8%) were minimally active, and 54 (30.2%) were fully active. Cardiovascular endurance assessment showed that 26 (14.5%) participants had poor endurance, 56 (31.3%) had below-average endurance, 25 (14.0%) had average endurance, 62 (34.6%) had above-average endurance, and 10 (5.6%) had excellent endurance. Overall, 82 (45.8%) participants were classified in the poor or below-average endurance categories, while 72 (40.2%) were classified in the above-average or excellent endurance categories, as shown in Table 2.

Table 2. Distribution of physical activity level and cardiovascular endurance

Variable	Category	n (%)
Physical activity level	Inactive	34 (19.0)
	Minimally active	91 (50.8)
	Fully active	54 (30.2)
Cardiovascular endurance	Poor	26 (14.5)
	Below average	56 (31.3)
	Average	25 (14.0)
	Above average	62 (34.6)
	Excellent	10 (5.6)

A statistically significant association was observed between physical activity level and cardiovascular endurance, $\chi^2(8) = 113.43$, $p < 0.001$, with a large association effect size based on Cramer's V = 0.563. Among inactive participants, 20/34 (58.8%) had poor cardiovascular endurance and 13/34 (38.2%) had below-average endurance, while none had above-average or excellent endurance. In contrast, among fully active participants, no participant was classified as having poor endurance, while 26/54 (48.1%) had above-average endurance and 8/54 (14.8%) had excellent endurance. Minimally active participants showed an intermediate distribution, with 39/91 (42.9%) below average and 36/91 (39.6%) above average, indicating a graded shift toward better endurance with increasing physical activity level, as shown in Table 3.

Table 3. Association between physical activity level and cardiovascular endurance

Physical activity level	Poor n (%)	Below average n (%)	Average n (%)	Above average n (%)	Excellent n (%)	χ^2 (df)	p-value	Cramer's V
Inactive (n = 34)	20 (58.8)	13 (38.2)	1 (2.9)	0 (0.0)	0 (0.0)	113.43 (8)	<0.001	0.563
Minimally active (n = 91)	6 (6.6)	39 (42.9)	8 (8.8)	36 (39.6)	2 (2.2)			
Fully active (n = 54)	0 (0.0)	4 (7.4)	16 (29.6)	26 (48.1)	8 (14.8)			

Body mass index category was also significantly associated with cardiovascular endurance, $\chi^2(12) = 40.19$, $p < 0.001$, with a small-to-moderate association effect size based on Cramer's V = 0.274. Among obese participants, 14/48 (29.2%) had poor endurance and none had excellent endurance. In comparison, among participants with normal BMI, only 3/46 (6.5%) had poor endurance, while 15/46 (32.6%) had average endurance and 5/46 (10.9%) had excellent endurance. Overweight participants had a mixed distribution, with 29/68 (42.6%) above average but 22/68 (32.4%) below average, suggesting that BMI alone did not fully explain endurance classification. Underweight participants also showed variability, with 6/17 (35.3%) below average, 6/17 (35.3%) above average, and 3/17 (17.6%) excellent, as shown in Table 4.

Table 4. Association between BMI category and cardiovascular endurance

BMI category	Poor n (%)	Below average n (%)	Average n (%)	Above average n (%)	Excellent n (%)	χ² (df)	p-value	Cramer's V
Underweight (n = 17)	1 (5.9)	6 (35.3)	1 (5.9)	6 (35.3)	3 (17.6)	40.19 (12)	<0.001	0.274
Normal weight (n = 46)	3 (6.5)	12 (26.1)	15 (32.6)	11 (23.9)	5 (10.9)			
Overweight (n = 68)	8 (11.8)	22 (32.4)	7 (10.3)	29 (42.6)	2 (2.9)			
Obese (n = 48)	14 (29.2)	16 (33.3)	2 (4.2)	16 (33.3)	0 (0.0)			

The association between BMI category and physical activity level did not reach conventional statistical significance when recalculated from the available aggregated data, $\chi^2(6) = 11.73$, $p = 0.068$, with a small association effect size based on Cramer's V = 0.181. However, the distribution showed clinically relevant directional differences. Among inactive participants, 15/34 (44.1%) were obese and 14/34 (41.2%) were overweight, meaning that 29/34 (85.3%) inactive participants were either overweight or obese. Among fully active participants, 19/54 (35.2%) had normal BMI and 10/54 (18.5%) were obese. Minimally active participants showed the largest absolute number of overweight participants, 34/91 (37.4%), while 23/91 (25.3%) were obese, as shown in Table 5.

Table 5. Association between physical activity level and BMI category

Physical activity level	Underweight n (%)	Normal weight n (%)	Overweight n (%)	Obese n (%)	χ² (df)	p-value	Cramer's V
Inactive (n = 34)	2 (5.9)	3 (8.8)	14 (41.2)	15 (44.1)	11.73 (6)	0.068	0.181
Minimally active (n = 91)	10 (11.0)	24 (26.4)	34 (37.4)	23 (25.3)			
Fully active (n = 54)	5 (9.3)	19 (35.2)	20 (37.0)	10 (18.5)			

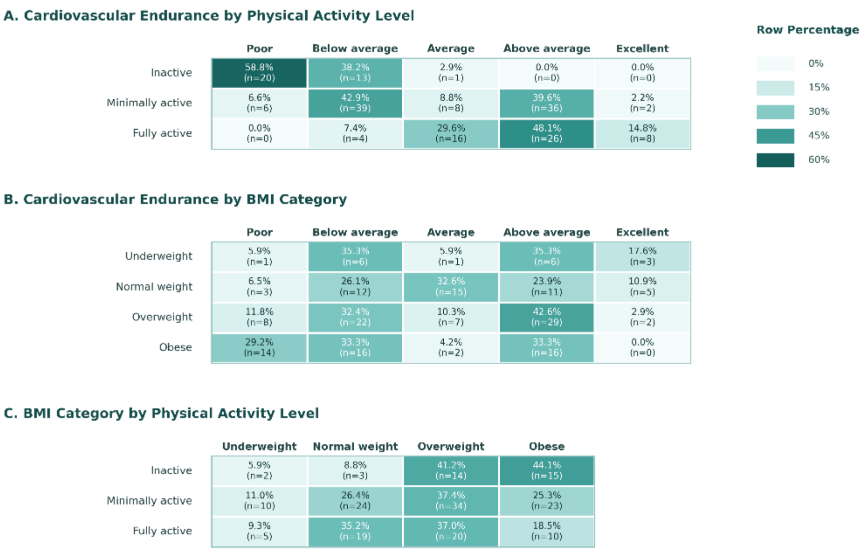

Figure 1 Pattern of Cardiovascular Endurance, Physical Activity, and BMI Among Post-COVID Individuals

The panelled visualization demonstrates a clear activity–endurance gradient among post-COVID participants: poor endurance was concentrated among inactive individuals, affecting 20/34 (58.8%), whereas fully active participants showed no poor endurance and had the highest combined proportion of above-average and excellent endurance, 34/54 (62.9%). BMI-related patterns were less linear but clinically relevant; obese participants had the highest poor-endurance proportion, 14/48 (29.2%), and no excellent endurance, while normal-weight participants had lower poor endurance, 3/46 (6.5%), and a larger average-to-excellent endurance distribution. The BMI–activity panel further shows that excess weight was concentrated among inactive participants, with 29/34 (85.3%) classified as overweight or obese, compared with 30/54 (55.6%) among fully active participants, supporting the interpretation that lower physical activity, higher BMI burden, and poorer cardiovascular endurance clustered within the post-COVID sample.

DISCUSSION

This cross-sectional study evaluated the association of physical activity level and body mass index category with cardiovascular endurance among post-COVID individuals aged 18–40 years. The principal finding was that cardiovascular endurance differed significantly across physical activity categories, with a large effect size, indicating that lower activity levels clustered strongly with poorer endurance status. Among inactive participants, 20/34 (58.8%) had poor cardiovascular endurance and 13/34 (38.2%) had below-average endurance, while no inactive participant demonstrated above-average or excellent endurance. In contrast, among fully active participants, no participant had poor endurance, 26/54 (48.1%) had above-average endurance, and 8/54 (14.8%) had excellent endurance. This gradient suggests that physical activity status is meaningfully associated with post-COVID cardiovascular endurance, although the cross-sectional design does not permit causal inference.

The observed association is biologically and clinically plausible because post-COVID symptoms such as fatigue, dyspnea, reduced exercise tolerance, musculoskeletal discomfort, and impaired functional capacity may discourage regular activity and contribute to deconditioning. Previous work has shown that persistent post-COVID symptoms are associated with poorer physical fitness and cardiopulmonary function, supporting the relevance of endurance assessment in this population (10). Similarly, studies examining long COVID have reported meaningful relationships between physical activity behavior and persistent symptoms, suggesting that reduced activity and symptom burden may reinforce each other during recovery (11). The present findings extend this evidence by showing, in a young adult local sample, that self-reported activity level was strongly associated with field-based cardiovascular endurance measured through the Harvard Step Test.

BMI category was also significantly associated with cardiovascular endurance. Obese participants had the highest proportion of poor endurance, 14/48 (29.2%), and no participant in the obese category achieved excellent endurance. In comparison, participants with normal BMI showed a lower poor-endurance proportion, 3/46 (6.5%), and a comparatively more favorable distribution across average, above-average, and excellent categories. These results indicate that BMI may be an important contextual factor when interpreting cardiovascular endurance after COVID-19. However, the pattern was not entirely linear, as overweight participants also showed a substantial proportion with above-average endurance, 29/68 (42.6%), suggesting that BMI alone does not fully determine endurance performance. This reinforces the need to interpret BMI together with physical activity behavior, functional capacity, and individual recovery profile rather than as an isolated determinant.

The relationship between BMI category and physical activity level showed a clinically meaningful distribution, although the recalculated association did not reach conventional statistical significance. Among inactive participants, 29/34 (85.3%) were overweight or obese, compared with 30/54 (55.6%) among fully active participants. This pattern suggests that excess body weight was more concentrated among inactive individuals, but the borderline statistical result indicates that the evidence should be interpreted cautiously. The lack of stronger statistical significance may reflect sample size limitations, unequal category distribution, or the complex interaction between BMI, activity behavior, post-COVID symptoms, and baseline fitness status. Therefore, these findings support the value of integrated assessment rather than single-variable interpretation.

The current findings are consistent with the broader literature emphasizing the importance of physical fitness assessment and exercise-based recovery strategies in the COVID-19 era. Cardiopulmonary exercise testing and functional fitness assessment have been highlighted as useful approaches for identifying reduced exercise capacity and guiding rehabilitation decisions during and after COVID-19 (12). Although the Harvard Step Test is less sophisticated than laboratory-based cardiopulmonary exercise testing, it offers a practical, low-cost field method for screening cardiovascular endurance in settings where advanced testing is unavailable. This is particularly relevant in university, community, and outpatient settings, where early identification of poor endurance may help guide physical activity counseling, referral, and rehabilitation planning.

The results also align with evidence suggesting that regular moderate-to-vigorous physical activity may support immune, cardiometabolic, and functional health after COVID-19 (13). In the present study, fully active participants had the most favorable endurance profile, with nearly two-thirds classified as above average or excellent. This does not prove that physical activity caused better endurance, but it indicates a strong association that is clinically meaningful. In practical terms, post-COVID individuals with low activity levels may benefit from structured screening and progressive exercise guidance, especially when inactivity is accompanied by higher BMI or poor recovery symptoms.

This study has several limitations. The cross-sectional design prevents conclusions about temporal sequence or causality, so it cannot be determined whether low physical activity contributed to poor endurance, whether poor endurance reduced activity, or whether both were influenced by residual post-COVID symptoms. The use of convenience sampling may limit generalizability, and the sample was predominantly young and student-based, which may not represent older adults or individuals with more severe post-COVID complications. Physical activity was assessed through self-report, which may introduce recall and social desirability bias. The study also did not stratify participants according to COVID-19 severity, hospitalization history, vaccination status, time since infection, or presence of persistent symptoms, all of which could influence endurance. In addition, although the Harvard Step Test is practical and feasible, it does not replace direct cardiopulmonary exercise testing for detailed physiological evaluation.

Despite these limitations, the study provides useful local evidence that physical activity level and BMI category are associated with cardiovascular endurance among post-COVID individuals. The findings support the inclusion of simple physical activity screening, BMI assessment, and field-based endurance testing in post-COVID health evaluation. Future studies should use longitudinal designs, larger and more diverse samples, objective physical activity monitoring, symptom stratification, and adjusted statistical models to clarify whether improving physical activity after COVID-19 leads to measurable gains in cardiovascular endurance and functional recovery.

CONCLUSION

This study found that physical activity level and BMI category were significantly associated with cardiovascular endurance among post-COVID individuals aged 18–40 years. Poor cardiovascular endurance was most frequent among inactive participants, whereas fully active participants showed the most favorable endurance profile, with higher proportions of above-average and excellent endurance. Obese participants demonstrated a higher proportion of poor endurance and no excellent endurance, suggesting that BMI may be an important contextual factor in post-COVID functional assessment. These findings indicate that lower physical activity, higher BMI burden, and poorer cardiovascular endurance tend to cluster in post-COVID individuals, but causal interpretation should be avoided because of the cross-sectional design. Simple screening using physical activity assessment, BMI classification, and field-based endurance testing may help identify individuals who require targeted lifestyle counseling, progressive exercise prescription, or rehabilitation referral after COVID-19.

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