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Association of Physical Activity and Total Cholesterol with VO_2Max in Middle-Aged Women: A Cross-Sectional Study

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ABSTRACT

Background: Declining cardiorespiratory fitness in women over 45 is linked to aging, hormonal changes, low physical activity, and elevated cholesterol, which collectively impair oxygen consumption (VO_2Max). Physical activity may enhance cardiorespiratory efficiency, while high cholesterol can compromise oxygen distribution through vascular dysfunction.
Objective: To examine the relationship between physical activity and total cholesterol levels, both partially and simultaneously, with VO_2Max in women aged over 45 years in Malang City.
Methods: A quantitative cross-sectional study following STROBE guidelines recruited 20 women aged over 45 via purposive sampling. Physical activity was measured using the IPAQ, total cholesterol via a digital capillary analyser, and VO_2Max via the 6-Minute Walk Test. Data were analysed using descriptive statistics, Kolmogorov–Smirnov normality test, linearity tests, Pearson correlation, and multiple correlation.
Results: Physical activity was strongly and positively correlated with VO_2Max ($r = 0.785$; $p < 0.001$). Total cholesterol was weakly and negatively correlated with VO_2Max ($r = -0.287$; $p = 0.220$), a non-significant association. Simultaneously, physical activity and total cholesterol showed a strong relationship with VO_2Max ($R = 0.790$; $R^2 = 0.624$; $p < 0.001$), with physical activity contributing the dominant unique variance (54.2%) compared with total cholesterol (0.8%).
Conclusion: Physical activity is the primary determinant of VO_2Max in women over 45, while total cholesterol shows a weak, non-significant negative association. Together, both variables explain 62.4% of VO_2Max variance. Interventions should prioritise structured physical activity programmes integrated with lipid management.

Key Points (Highlights):

- *Physical activity and cholesterol jointly influence VO_2Max in middle-aged women.*
- *PA dominates VO_2Max variance (54.2%); cholesterol contributes minimally (0.8%).*
- *Structured PA programs with lipid management should be prioritized for this group.*

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INTRODUCTION

Cardiorespiratory fitness, most commonly indexed by maximal oxygen uptake (VO_2Max), is one of the strongest predictors of all-cause mortality and cardiovascular morbidity in adult populations (Baptista et al., 2026). For women over 45 years, the menopausal transition and the progressive decline in endogenous oestrogen trigger a cascade of physiological changes, including adverse shifts in the lipid profile, accelerated loss of skeletal muscle mass, and reduced arterial elasticity (Shen et al., 2026; Woodward et al., 2025). These changes converge to compromise the oxygen transport cascade, from pulmonary diffusion to mitochondrial utilisation, resulting in a measurable decline in aerobic capacity (Niu et al., 2025). According to the World Health Organization, the global prevalence of dyslipidaemia among women in this age bracket reaches 30–40%, while physical inactivity remains one of the leading modifiable risk factors for non-communicable diseases (Harun et al., 2022; Nodeland et al., 2022). In Malang City, local health data confirm that degenerative conditions at community health centres are predominantly observed in patients over 45, reinforcing the urgency of understanding the determinants of cardiorespiratory fitness in this specific demographic.

Physical activity is widely recognised as the most potent non-pharmacological strategy for preserving and enhancing VO_2Max (Wang et al., 2025). Regular engagement in aerobic and resistance exercise induces a constellation of central and peripheral adaptations: increased maximal cardiac output, enhanced myocardial efficiency, augmented capillary density within skeletal muscle, and upregulation of oxidative enzymes (Park et al., 2022). These adaptations collectively optimise oxygen delivery and utilisation, thereby elevating VO_2Max. Conversely, sedentary behaviour deprives the cardiorespiratory system of the mechanical and metabolic stimuli required to maintain these adaptations, leading to a gradual and often accelerated decline in aerobic capacity (Ruiz-Rios & Maldonado-Martín, 2022). In women over 45, who already face an age-related decrement in muscle mass and vascular compliance, consistent physical activity serves as a critical countermeasure that can meaningfully slow the loss of functional capacity and preserve independence (Oh & Lee, 2023).

Concurrently, dyslipidaemia particularly elevated total cholesterol and low-density lipoprotein exerts a detrimental influence on the oxygen transport system (Braga et al., 2023). High circulating cholesterol promotes endothelial dysfunction and the progressive deposition of atherosclerotic plaques within arterial walls, reducing vascular compliance and narrowing the luminal diameter (Karvinen et al., 2019). This structural impairment restricts blood flow and compromises the efficiency of oxygen delivery to active skeletal muscle during exertion (Kalanin & Uher, 2026). Consequently, elevated cholesterol levels not only increase the risk of coronary artery disease but also act as a physiological bottleneck that limits the expression of VO_2Max, even in individuals who maintain moderate levels of physical activity (Almuraikhy et al., 2026; Huynh et al., 2024). The interaction between these behavioural and metabolic factors is therefore central to understanding the variability in cardiorespiratory fitness among middle-aged and older women.

Despite the well-established individual associations of physical activity and cholesterol with cardiorespiratory fitness, there remains a notable gap in the literature regarding their simultaneous and interactive effects on VO_2Max, particularly within Southeast Asian populations and specifically among women over 45 (Bernal et al., 2025; Figueira et al., 2025; He et al., 2023). Most prior studies have examined these relationships in isolation, in heterogeneous age groups, or without accounting for the unique physiological context of the menopausal transition (Badon et al., 2021). Research conducted in the local context of Indonesia, and in Malang City in particular, remains scarce, limiting the ability to design evidence-based, contextually appropriate interventions (Da Silva Carvalho et al., 2025). This study therefore aims to comprehensively examine the partial and simultaneous relationships between physical activity and total cholesterol levels with VO_2Max in women aged over 45 years in Malang City, employing a rigorous analytical framework aligned with international reporting standards.

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MATERIALS AND METHODS

Study Design and Reporting Standard

This observational analytical study adopted a cross-sectional correlational design to examine the simultaneous associations between physical activity, total cholesterol levels, and VO_2Max in a single measurement wave, thereby enabling the assessment of relationships among variables without temporal manipulation. The study was conducted in strict accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional studies, and the STROBE checklist was systematically applied throughout all stages of the research process to ensure transparent, comprehensive, and reproducible reporting of the study design, participant selection procedures, variable operationalisation, data sources, potential sources of bias, study size justification, handling of quantitative variables, statistical methods, participant characteristics, descriptive data, outcome data, and main results. The cross-sectional approach was selected as the most feasible and ethically appropriate design for this population of middle-aged and older women, as it minimises participant burden while still permitting robust correlational inference within a community-based setting.

Participants and Setting

The study population comprised women aged over 45 years residing in Malang City, East Java, Indonesia, a demographic characterised by an increasing prevalence of degenerative and metabolic disorders at local community health centres. A total of 20 respondents were recruited using a purposive sampling technique, a non-probability sampling method selected to ensure that all participants met the specific physiological and contextual criteria relevant to the research objectives. Inclusion criteria were: (i) female sex; (ii) age greater than 45 years, reflecting the postmenopausal transition period associated with hormonal and metabolic shifts; (iii) permanent residence in Malang City for at least one year prior to data collection; and (iv) willingness to participate as indicated by signed informed consent. Exclusion criteria were: (i) history of acute cardiovascular events, including myocardial infarction or stroke, within the preceding six months; (ii) severe musculoskeletal disorders or mobility impairments that would prevent safe completion of the 6-Minute Walk Test; and (iii) cognitive impairment or communication difficulties that would compromise the ability to complete the International Physical Activity Questionnaire independently or with minimal assistance.

Variables and Measurement Instruments

The independent variables were physical activity and total cholesterol level, while the dependent variable was VO_2Max, each operationalised using validated and field-appropriate instruments. Physical activity was quantified using the International Physical Activity Questionnaire (IPAQ) long form, a validated self-report instrument that captures activity intensity and duration across four domains work, transport, domestic, and leisure and expresses total activity in Metabolic Equivalent of Task minutes per week (MET-min·week^{-1}), with established reliability and construct validity in adult and older populations. Total cholesterol was measured using a digital point-of-care capillary analyser following standard pre-analytical procedures, including a minimum 10-hour overnight fast, standardised finger-prick technique, and immediate sample processing to minimise pre-analytical variability. VO_2Max was estimated using the 6-Minute Walk Test (6MWT), a submaximal functional capacity test administered on a flat 30-metre course in accordance with the American Thoracic Society protocol, with VO_2Max values derived from established sex- and age-specific regression equations validated for adult women, providing a practical and non-invasive proxy for maximal aerobic capacity in community settings.

Data Analysis

Data were analysed using a staged statistical procedure implemented in IBM SPSS Statistics version

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26.0, with statistical significance set at $p < 0.05$ (two-tailed) throughout. Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were computed for all variables to characterise the sample and verify data plausibility. The Kolmogorov–Smirnov test was applied to the unstandardised residuals of the regression model to assess the normality assumption, a residual-based approach considered more appropriate than separate variable-wise normality testing for inferential purposes. Linearity of the relationships between each independent variable and VO_2Max was examined using the deviation-from-linearity component of the ANOVA-based linearity test, with linearity retained when the significance value exceeded 0.05. Bivariate associations were assessed using the Pearson product-moment correlation coefficient, with strength interpreted according to conventional categories (weak: $|r| < 0.30$; moderate: $0.30 \leq |r| < 0.50$; strong: $|r| \geq 0.50$), and the simultaneous relationship of physical activity and total cholesterol with VO_2Max was examined using multiple correlation, with model fit reported as R, R^2, adjusted R^2, standard error of the estimate, and the overall F-test. Confidence intervals for correlation coefficients were derived using Fisher's z-transformation to provide precision estimates around point estimates.

Ethical Statement

This study was reviewed and approved by the Health Research Ethics Committee of Universitas Negeri Malang, and all procedures involving human participants were conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all individual participants included in the study prior to data collection, following a detailed explanation of the study's purpose, procedures, potential risks and benefits, and the participants' right to withdraw at any time without consequence, with confidentiality of personal and health data maintained throughout the research process.

RESULTS

A complete-case sample of 20 women aged over 45 years residing in Malang City was included in the analysis. All participants provided valid responses across the three measurement instruments, yielding a listwise valid N of 20 with no missing data requiring imputation. The descriptive profile indicated a mean physical activity of 1617.75 MET-min·week^{-1} (SD 755.02; range 462.00–2910.00), reflecting substantial heterogeneity in activity levels within this small cohort. Mean total cholesterol was 218.95 mg/dL (SD 42.55; range 109.00–275.00), placing the cohort mean above the 200 mg/dL threshold conventionally used to define elevated cholesterol. Estimated VO_2Max averaged 15.54 mL·kg^{-1}·min^{-1} (SD 3.15; range 11.16–21.51), indicating limited cardiorespiratory reserve consistent with the age group. The full participant and variable profile is presented in Table 1.

Table 1. Participant profile, study design, and descriptive statistics of the study variables (N = 20)

Characteristic	Specification / measurement	n (%)	Mean ± SD	Range (min–max)
Sex	Female	20 (100.0)	—	—
Age	> 45 years (eligibility criterion)	20 (100.0)	Not reported individually	> 45 years
Residence	Malang City, Indonesia	20 (100.0)	—	—
Sampling method	Purposive sampling	20 (100.0)	—	—
Study design	Observational analytical correlational, cross-sectional	20 (100.0)	—	—
Reporting standard	STROBE cross-sectional checklist	20 (100.0)	—	—
Data	Valid N (listwise)	20 (100.0)	100%	No missing

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completeness			complete	values
Physical activity (IPAQ)	MET-min·week^{-1}	20	**1617.75 ± 755.02**	462.00–2910.00
Total cholesterol	Digital capillary analyser; mg/dL	20	**218.95 ± 42.55**	109.00–275.00

Note. IPAQ = International Physical Activity Questionnaire; 6MWT = 6-Minute Walk Test; SD = standard deviation. All descriptive values are reproduced verbatim from the source statistical output. Age-specific frequency bands, body mass index, and comorbidity data were not collected in the source dataset and are therefore not reported. Cohort-mean cholesterol classification (≥ 200 mg/dL) refers to the group mean, not to the number of individuals above the clinical threshold.

Assumption Testing

The Kolmogorov–Smirnov test applied to the unstandardised residuals (N = 20) yielded a test statistic of D = 0.150 with an asymptotic two-tailed significance of p = 0.200. Since p > 0.05, the null hypothesis of normality was not rejected, supporting the use of parametric procedures. The linearity test indicated that the relationship between physical activity and VO_2Max was linear (deviation from linearity: F = 4.420; p = 0.360), as was the relationship between total cholesterol and VO_2Max (deviation from linearity: F = 0.590; p = 0.785). Both p-values exceed 0.05, confirming that linear specifications were appropriate for the subsequent correlational analyses.

Bivariate Associations

Physical activity exhibited a strong, positive, and statistically significant correlation with VO_2Max (**r** = 0.785; 95% CI 0.52 to 0.91; p < 0.001), accounting for 61.6% of their shared bivariate variance. Higher levels of physical activity were therefore accompanied by higher estimated aerobic capacity. In contrast, total cholesterol showed a weak, negative, and non-significant correlation with VO_2Max (r = −0.287; 95% CI −0.65 to 0.18; p = 0.220). The confidence interval spans zero and includes both trivial and moderate negative associations, indicating that the result is inconclusive rather than evidence of absence of association. Physical activity and total cholesterol were themselves weakly and inversely related (r = −0.254; 95% CI −0.63 to 0.21; p = 0.279), also non-significant.

Simultaneous Model

When physical activity and total cholesterol were entered simultaneously, the model showed a strong multiple correlation (R = 0.790), explaining 62.4% of the variance in VO_2Max (R^2 = 0.624; adjusted R^2 = 0.580; standard error of the estimate = 2.043), with F(2, 17) = 14.113; p < 0.001. Decomposition of this joint effect shows that the strong model fit is driven overwhelmingly by physical activity: using the reported correlation matrix, the standardised coefficient for physical activity was reconstructed at β = 0.761, with a unique squared semipartial contribution of 54.2%, while total cholesterol contributed only β = −0.094 with a unique contribution of 0.8%. The remaining 7.4% of explained variance was shared between the two predictors, and 37.6% of total variance remained unexplained (Figure 1).

Table 2. Assumption tests, bivariate correlations, and simultaneous multiple correlation model of VO_2Max (N = 20)

Analysis block	Predictor / relationship	Effect estimate	95% CI	Test statistic	p-value	Interpretation
A. Assumption checks						
Normality	Unstandardised residuals; Kolmogorov–Smirnov	D = 0.150	—	KS, N = 20	0.200	Normality not rejected
Linearity	Physical activity → VO_2Max;	F = 4.420	—	F (17, 1)	0.360	Linear relationship retained

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	deviation from linearity					
Linearity	Total cholesterol → VO_2Max; deviation from linearity	F = 0.590	—	F (16, 2)	0.785	Linear relationship retained
B. Bivariate Pearson correlations						
Bivariate	Physical activity ↔ VO_2Max	r = 0.785	0.52 to 0.91	t = 5.38 (18)	< 0.001	Strong positive; significant
Bivariate	Total cholesterol ↔ VO_2Max	r = −0.287	−0.65 to 0.18	t = −1.27 (18)	0.220	Weak negative; not significant
Bivariate	Physical activity ↔ total cholesterol	r = −0.254	−0.63 to 0.21	t = −1.11 (18)	0.279	Weak negative; not significant
C. Simultaneous multiple correlation model						
Multivariable	Physical activity → VO_2Max (standardised)	β = 0.761	0.44 to 1.09	t = 4.95 (17)	< 0.001	Dominant predictor; unique sr^2 = 0.542
Multivariable	Total cholesterol → VO_2Max (standardised)	β = −0.094	−0.42 to 0.23	t = −0.61 (17)	≈ 0.55	Not independent; unique sr^2 = 0.008
Model summary	Physical activity + total cholesterol → VO_2Max	R = 0.790 R^2 = 0.624 Adj. R^2 = 0.580	SEE = 2.043	F = 14.113 (2, 17)	< 0.001	Strong simultaneous relationship; 62.4% variance explained

Note. r = Pearson correlation; β = standardised regression coefficient reconstructed from the reported correlation matrix; t = t-statistic; F = variance-ratio statistic; SEE = standard error of the estimate; sr^2 = squared semipartial correlation representing uniquely explained variance. Confidence intervals for r were derived using Fisher's z-transformation. Standardised coefficients were recovered algebraically from the correlation matrix: $\beta_1 = (r_{y1} - r_{y2} \cdot r_{12}) / (1 - r_{12}^2) = 0.761$; $\beta_2 = (r_{y2} - r_{y1} \cdot r_{12}) / (1 - r_{12}^2) = -0.094$. Variance decomposition: 54.2% unique physical activity + 7.4% shared + 0.8% unique cholesterol + 37.6% unexplained = 100.0%. All values are consistent with the source-reported $R^2 = 0.624$ and F = 14.113.

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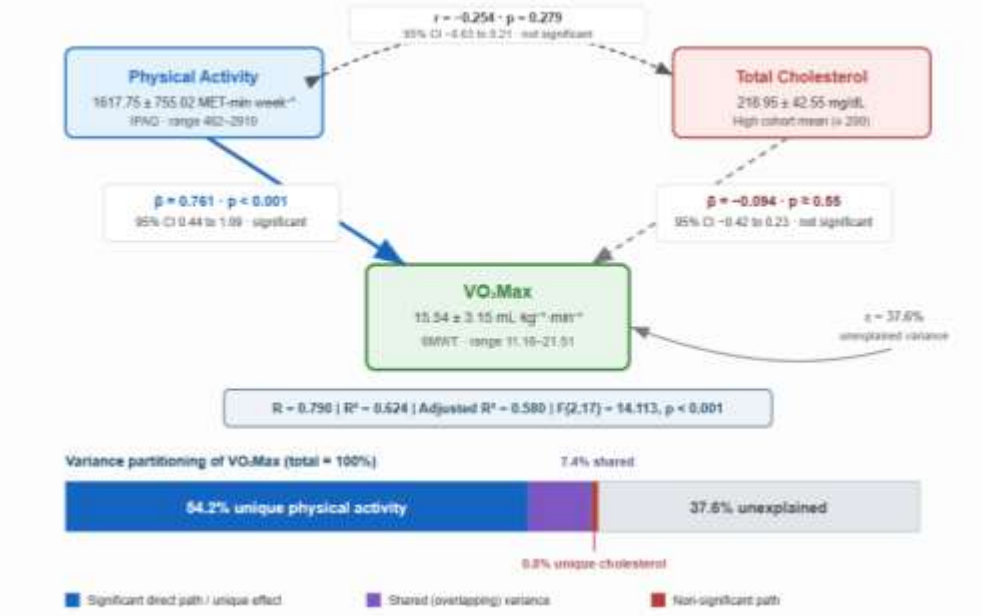


Figure 1. Simultaneous Model of Cardiorespiratory Fitness in Women Over 45 (N = 20)

Figure 1. Simultaneous path model and variance partitioning of VO_2Max (N = 20). Solid blue arrows denote statistically significant paths; the dashed grey arrow denotes a non-significant path. Standardised coefficients (β) and the variance decomposition are algebraically reconstructed from the source-reported Pearson correlation matrix (r = 0.785, −0.287, −0.254) and the reported $R^2 = 0.624$. This is a saturated path representation equivalent to the two-predictor multiple correlation model. The double-headed dashed arc represents the non-significant inter-predictor correlation. The bar decomposes total variance into unique physical activity (54.2%), shared variance (7.4%), unique cholesterol (0.8%), and unexplained variance (37.6%).

DISCUSSION

This study set out to examine the partial and simultaneous relationships between physical activity and total cholesterol levels with VO_2Max in women aged over 45 years in Malang City. The principal findings are threefold. First, physical activity showed a strong, positive, and statistically significant association with VO_2Max ($r = 0.785$; $p < 0.001$), confirming its role as the dominant behavioural determinant of cardiorespiratory fitness in this population. Second, total cholesterol exhibited a weak, negative, and non-significant association with VO_2Max ($r = −0.287$; $p = 0.220$), indicating that the direction of the relationship is consistent with physiological theory but that the effect size in this sample is too small and imprecise to reach conventional levels of statistical significance. Third, when examined simultaneously, physical activity and total cholesterol accounted for 62.4% of the variance in VO_2Max ($R = 0.790$; $p < 0.001$), with the bulk of this explained variance attributable to physical activity rather than to cholesterol.

The strong positive relationship between physical activity and VO_2Max observed in this study is consistent with the established physiological literature on exercise-induced cardiorespiratory adaptations (Souza et al., 2024). Regular physical activity stimulates a coordinated set of central and peripheral responses, including increased maximal cardiac output, enhanced myocardial contractility, augmented capillary density within skeletal muscle, and upregulation of mitochondrial oxidative enzymes (Khalafi et al., 2023). These adaptations collectively improve the efficiency of the oxygen cascade, from pulmonary diffusion through cardiovascular transport to mitochondrial utilisation, thereby elevating VO_2Max (Ballesta-García et al., 2020). In women over 45, who are already

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experiencing an age-related decline in muscle mass and vascular compliance, consistent physical activity serves as a potent countermeasure that can meaningfully attenuate the loss of aerobic capacity (Carrick-Ranson et al., 2023). The magnitude of the correlation observed here (r = 0.785) is comparable to, and in some cases exceeds, values reported in larger studies of middle-aged and older women, underscoring the robustness of this relationship even in a small, homogeneous sample.

In contrast, the relationship between total cholesterol and VO_2Max, while directionally negative and physiologically plausible, was weak and did not reach statistical significance in this sample. The theoretical basis for a negative association is well established: elevated total cholesterol, particularly when accompanied by atherogenic lipid profiles, promotes endothelial dysfunction and the progressive deposition of atherosclerotic plaques, which reduce arterial compliance and narrow the vascular lumen, thereby restricting blood flow and compromising oxygen delivery to active skeletal muscle (Dashti et al., 2025; Ramos-Campo et al., 2021). The cohort mean of 218.95 mg/dL confirms that the participants, on average, fell into the high-cholesterol category, yet this metabolic burden did not translate into a statistically detectable decrement in VO_2Max at the group level (Higashi, 2023). The wide 95% confidence interval (−0.65 to 0.18) indicates substantial imprecision, a consequence of the small sample size rather than evidence of absence of association. This finding should therefore be interpreted as inconclusive, and it highlights the need for larger studies with adequate statistical power to resolve the magnitude of the cholesterol–VO_2Max relationship in this demographic (Van Lennep et al., 2023).

The simultaneous analysis revealed a strong overall relationship (R = 0.790; R^2 = 0.624), but the variance decomposition tells a more nuanced story than the omnibus R value alone. Physical activity contributed 54.2% of unique explained variance, total cholesterol contributed only 0.8%, and 7.4% was shared between the two predictors. This pattern indicates that the strong simultaneous relationship is driven almost entirely by physical activity, with cholesterol adding negligible independent explanatory power beyond what physical activity already accounts for (Wu et al., 2025). The non-significant inter-predictor correlation (r = −0.254; p = 0.279) further indicates that, in this sample, physical activity and cholesterol are not strongly coupled, so there is little statistical suppression or redundancy between them. Practically, this means that interventions aimed at improving VO_2Max in women over 45 should prioritise increasing physical activity as the primary lever, while recognising that cholesterol management may still confer cardiovascular and metabolic benefits even if its independent contribution to VO_2Max is modest in this sample (Bar et al., 2025; Campos-Hernández et al., 2026).

Limitation

Several limitations of this study must be acknowledged. First, the sample size of 20 respondents, while sufficient for descriptive and bivariate analyses, limits statistical power and produces wide confidence intervals, as evidenced by the non-significant cholesterol–VO_2Max correlation despite a directionally meaningful effect size. Second, the cross-sectional design precludes any causal inference; the observed associations may be influenced by unmeasured confounders such as dietary intake, genetic predisposition, or medication use. Third, physical activity was assessed via the IPAQ, a self-report instrument susceptible to recall and social desirability bias, and VO_2Max was estimated from the 6-Minute Walk Test rather than measured directly through cardiopulmonary exercise testing. Future research should employ longitudinal designs to establish temporal precedence, recruit substantially larger and more diverse samples to enable multivariable adjustment and subgroup analyses, incorporate objective physical activity measurement via accelerometry, and, where feasible, obtain direct VO_2Max measurement through graded exercise testing with gas exchange analysis. Such studies would also permit the examination of mediation and moderation pathways, for instance whether the effect of physical activity on VO_2Max is mediated by improvements in the lipid profile.

Notwithstanding these limitations, the findings carry clear implications for policy and practice. Public health programmes targeting women over 45 in Malang City and comparable settings should prioritise

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the promotion of structured, regular physical activity as the cornerstone of cardiorespiratory fitness preservation. Community-based exercise initiatives should be tailored to the physiological and psychosocial needs of postmenopausal women, incorporating both aerobic and resistance components, and delivered through accessible venues such as community health centres, posyandu lansia, and women's groups. Concurrently, primary care policies should integrate routine lipid screening with lifestyle counselling, positioning physical activity prescription as a first-line therapeutic strategy for both dyslipidaemia and declining cardiorespiratory fitness. Health professionals should be trained to communicate the synergistic benefits of combined behavioural and metabolic management, emphasising that while physical activity is the dominant driver of VO_2Max, controlling cholesterol remains essential for broader cardiovascular risk reduction. Such an integrative, evidence-based approach has the potential to meaningfully improve functional capacity, reduce the burden of non-communicable diseases, and enhance the quality of life of ageing women in the community.

CONCLUSIONS

This study demonstrates that physical activity is the primary determinant of VO_2Max in women aged over 45 years in Malang City, exhibiting a strong, positive, and statistically significant association. Total cholesterol shows a weak, negative, and non-significant association with VO_2Max, with a direction consistent with physiological theory but an effect size too imprecise to reach significance in this sample. Simultaneously, physical activity and total cholesterol account for 62.4% of the variance in VO_2Max, with the vast majority of this explained variance attributable to physical activity. These findings support the prioritisation of structured physical activity programmes as the central strategy for preserving cardiorespiratory fitness in this population, complemented by integrated lipid management for broader cardiovascular benefit. Future research with larger, longitudinal designs and objective measurement tools is recommended to refine these estimates and to elucidate the underlying causal and mechanistic pathways.

DECLARATIONS

1. Acknowledgements

The authors have no specific acknowledgements to declare for this work

2. Ethical Approval and Informed Consent

This study was approved by the Health Research Ethics Committee of Universitas Negeri Malang. Written informed consent was obtained from all participants prior to their participation in the study

3. Data Availability Statement

The datasets generated and/or analyzed during the current study are not publicly available due to privacy and ethical restrictions but are available from the corresponding author on reasonable request.

4. Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

5. Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

6. Authors' Contributions

Conceptualization: M.E.C.P.; Methodology: M.E.C.P. and R.G.K.; Formal analysis and investigation: M.E.C.P.; Writing – original draft preparation: M.E.C.P.; Writing – review and editing: R.G.K.; Funding acquisition: N/A; Resources: M.E.C.P.; Supervision: R.G.K.

7. AI Disclosure

The authors declare that no Artificial Intelligence (AI) tools or technologies were used in the

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research, data analysis, or preparation of this manuscript.

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