JHWCR JOURNAL OF HEALTH, WELLNESS AND COMMUNITY RESEARCH 3007-0570

https://doi.org/10.61919/7xb42d12

Original Article

Association of Gait Speed with Physical Activity, BMI and Arch Height in Postmenopausal Women

Amna[1], Maria Mustafa[1], Saddiqa Qamar[1], Shafaq Shahid[1], Asma Niaz[1], Javeria Akhlaq[1]

[1] Department of Physical Therapy & Rehabilitation, University of Management & Technology, Lahore, Pakistan

***Corresponding author: Amna, F2020241104@umt.edu.pk**

ABSTRACT

Background: Menopause is associated with hormonal and musculoskeletal changes that may adversely affect mobility, balance, and functional independence. Gait speed is a clinically important indicator of overall functional health and may be influenced by modifiable factors such as body mass index, physical activity, and foot arch characteristics. Objective: To determine the association of gait speed with physical activity, body mass index, and foot arch height in postmenopausal women. Methods: This descriptive cross-sectional observational study was conducted in Lahore, Pakistan, from April to June 2025 among 187 postmenopausal women aged 45-65 years. Participants were recruited through non-probability purposive sampling from community centers and hospital settings. Gait speed was measured using the 10-meter walk test, physical activity with the International Physical Activity Questionnaire-Short Form, body mass index from measured height and weight, and foot arch height using the navicular drop test. Data were analyzed using SPSS version 24. Pearson correlation and chi-square-based trend analyses were applied with $p < 0.05$ considered significant. Results: Mean age was 60.4 ± 4.4 years, mean body mass index was 27.8 ± 3.0 kg/m², and mean gait speed was 1.08 ± 0.18 m/s. Gait speed showed a significant negative correlation with body mass index ($r = -0.169$, $p = 0.021$) and significant positive correlations with foot arch height ($r = 0.238$, $p = 0.001$) and physical activity ($r = 0.255$, $p < 0.001$). Conclusion: Gait speed in postmenopausal women is significantly associated with body mass index, physical activity, and foot arch height. Routine assessment of these modifiable factors may support early identification of women at risk of reduced mobility and inform targeted preventive strategies. Keywords: gait speed; body mass index; physical activity; arch height; postmenopausal women

"Cite this Article" | **Received**: 17 December 2025; **Accepted**: 3 March 2026; **Published**: 11 March 2026.

Author Contributions: Concept: A, MM; Design: SQ, SS; Data Collection: AN, JA; Analysis: A, MM; Drafting: A, SQ.

Ethical Approval: University of Management & Technology, Lahore, Pakistan**. Informed Consent**: Written informed consent was obtained from all participants; **Conflict of Interest**: The authors declare no conflict of interest; **Funding**: No external funding; **Data Availability**: Available from the corresponding author on reasonable request; **Acknowledgments**: N/A.

INTRODUCTION

Menopause is a physiological transition characterized by permanent cessation of menstruation following depletion of ovarian follicular activity and a progressive decline in estrogen production. Beyond its reproductive significance, this transition has important musculoskeletal and functional consequences, including reductions in muscle mass and strength, diminished bone density, altered body-fat distribution, and impaired postural control, all of which may adversely affect mobility and independence in later life (1,2). In postmenopausal women, these changes are clinically relevant because even subtle deterioration in walking performance may signal broader decline in physical function and a heightened risk of frailty, falls, disability, and mortality (3,4).

Among functional indicators, gait speed has emerged as a simple yet highly informative measure of integrated neuromuscular, musculoskeletal, cardiovascular, and cognitive performance. Because it reflects the combined efficiency of multiple physiological systems, gait speed is widely regarded as a robust marker of health status and functional reserve in aging populations (3,5). In postmenopausal women, slower gait has been associated with reduced mobility, compromised balance recovery, lower physical performance, and a greater likelihood of fall-related morbidity, making it a particularly relevant outcome for preventive and rehabilitative research in this population (2,4,6).

Several potentially modifiable factors may influence gait speed after menopause. Physical activity is one of the most important determinants of preserved functional mobility, as regular movement helps maintain lower-limb strength, joint mobility, cardiovascular fitness, and neuromuscular coordination. Prior studies have shown that women who remain physically active tend to demonstrate better physical performance and faster walking speeds, whereas inactivity accelerates functional decline and may worsen balance deficits over time (4,7,8). Since lifestyle changes after menopause frequently include reductions in habitual movement, understanding the relationship between physical activity and gait speed is essential for designing targeted interventions aimed at preserving independence in later years (4,8,9).

Body mass index is another important factor with potential implications for gait performance. Higher BMI has consistently been associated with impaired functional capacity, slower ambulation, altered gait mechanics, and increased mechanical loading across weight-bearing joints (10-13). In postmenopausal women, these effects may be amplified by concurrent reductions in bone density, muscle quality, and hormonal protection, thereby increasing vulnerability to instability, falls, and mobility restriction (2,11,14,15). Although BMI is an indirect anthropometric indicator, it remains a practical and widely used measure for identifying excess body weight that may negatively affect walking efficiency and physical performance in community settings (10,12).

Foot structure, particularly medial longitudinal arch height, may also contribute to gait characteristics by influencing load distribution, shock absorption, balance, and lower-limb alignment during walking. Variations such as low or excessively high arches can alter plantar loading patterns and joint kinematics, potentially compromising walking efficiency and stability (16-18). The navicular drop test is a clinically feasible method for estimating dynamic arch behavior and has demonstrated acceptable reliability for assessing foot posture in functional settings (16). In populations with age-related changes in musculoskeletal function, altered foot mechanics may represent an additional and underexplored contributor to slower gait.

Although previous studies have independently linked gait speed with obesity, physical inactivity, reduced bone health, and foot structure, the combined relationship of gait speed with BMI, physical activity, and arch height in postmenopausal women remains insufficiently characterized, particularly in local community-based populations. This knowledge gap is important because all three factors are clinically modifiable or readily screenable and may therefore serve as practical targets for early risk identification and intervention. Accordingly, the present study was designed to examine the association of gait speed with physical activity, body mass index, and foot arch height in postmenopausal women. It was hypothesized that gait speed would be lower in women with higher BMI and would be higher in those with greater physical activity and more favorable arch characteristics.

MATERIALS AND METHODS

This descriptive cross-sectional observational study was conducted in community centers, Suraya Azeem Hospital, and Central Park Hospital, Lahore, Pakistan, over a three-month period from April to June 2025. The study was designed to examine the association of gait speed with body mass index, physical activity level, and foot arch height among postmenopausal women in a community-based clinical context. Ethical approval was obtained from the Institutional Review Board of the University of Management and Technology, Lahore, Pakistan, prior to data collection (Reference No. RE-082-2025). All eligible participants were informed about the purpose and procedures of the study, and written informed consent was obtained before enrollment.

Women were considered eligible if they were between 45 and 65 years of age, had experienced menopause for at least one year, and were able to ambulate independently without the use of an assistive device. Participants were excluded if they had a neurological disorder, musculoskeletal condition substantially affecting gait, psychiatric illness limiting participation, congenital foot deformity, or a

history of lower-limb surgery within the preceding six months. Participants were recruited using non-probability purposive sampling from the selected sites. Initial screening was performed against the predefined eligibility criteria, and women who met the criteria and consented to participate were enrolled consecutively until the required sample was achieved. The required sample size was estimated a priori using the World Health Organization sample size calculator at a 95% confidence level, and 187 eligible postmenopausal women were ultimately included in the final analysis.

Data collection followed a standardized sequence. Demographic and menopause-related information was first recorded, after which anthropometric and functional assessments were completed. Height was measured using a portable stadiometer and body weight using a calibrated digital weighing scale, with participants assessed in light clothing and without shoes. Body mass index was calculated as weight in kilograms divided by height in meters squared and was later categorized as normal weight, overweight, or obese according to conventional BMI thresholds used for adult populations (10,12). Menopause duration was recorded in years based on participant self-report.

Gait speed was assessed using the standardized 10-meter walk test on a 14-meter walkway, allowing 2 meters for acceleration and 2 meters for deceleration so that the central 10 meters represented steady-state walking performance (19). Participants were instructed to walk at their usual comfortable speed, and gait speed was calculated in meters per second by dividing the measured distance by the time taken to complete the 10-meter section. This procedure was selected because the 10-meter walk test is simple, clinically applicable, and widely used for the assessment of functional ambulation in adult and older populations (19).

Physical activity level was measured using the short form of the International Physical Activity Questionnaire (IPAQ-SF), a widely used instrument for estimating habitual physical activity across multiple domains of daily living (20). Responses were classified into low, moderate, and high physical activity categories according to the scoring framework of the instrument. The IPAQ-SF was selected because of its established acceptability and documented validity for population-based physical activity assessment (20).

Foot arch height was evaluated using the navicular drop test, a clinically established method for assessing medial longitudinal arch behavior and pronation-related foot posture (16,21). Measurements were taken from both feet, and the dominant foot value was used for statistical analysis. Based on the recorded measurement, participants were classified into normal arch, flat arch, or high arch categories for descriptive analysis. Use of the navicular drop approach was considered appropriate because of its practicality and its reported correlation with other foot posture measures relevant to weight-bearing function (16).

The primary outcome variable was gait speed. The principal explanatory variables were BMI, physical activity level, and foot arch height. Age, menopause duration, height, and weight were recorded as descriptive characteristics of the sample. To reduce information bias, all variables were measured using predefined procedures and standardized instruments. Objective anthropometric and gait-based measures were used wherever possible, whereas self-reported physical activity was obtained through a structured validated questionnaire. Data collection forms were reviewed at the time of assessment to minimize incomplete entries, and the dataset was checked for completeness, internal consistency, and plausibility before statistical analysis. Analyses were conducted on complete cases.

All statistical analyses were performed using SPSS version 24.0. Continuous variables were summarized as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Pearson correlation coefficients were used to examine the relationship of gait speed with BMI, foot arch height, and physical activity level when variables were treated analytically as continuous or ordinal measures. Chi-square testing was used for categorical associations, and linear-by-linear association testing was applied to assess ordered trends across categories where appropriate. All tests

were two-tailed, and statistical significance was set at $p < 0.05$. This analytical approach was selected to quantify both the direction and magnitude of associations and to support clinically interpretable inference regarding potentially modifiable correlates of gait performance in postmenopausal women.

RESULTS

A total of 187 postmenopausal women were included in the analysis. The mean age of the sample was 60.4 ± 4.4 years, mean body mass index was 27.8 ± 3.0 kg/m², and mean gait speed was 1.08 ± 0.18 m/s. Mean menopause duration was 9.38 ± 4.82 years. Anthropometric data showed a mean height of 60.4 ± 4.43 inches and mean weight of 153.6 ± 5.15 lbs. Overall, the sample was predominantly overweight or obese, physically inactive to moderately active, and most commonly had normal foot arches.

Table 1. Baseline Characteristics of the Study Sample (n = 187)

Variable	Minimum	Maximum	Mean ± SD
Age (years)	50.0	70.0	60.4 ± 4.43
BMI (kg/m²)	21.97	39.03	27.8 ± 3.05
Gait speed (m/s)	0.70	1.40	1.08 ± 0.18
Menopause duration (years)	1	21	9.38 ± 4.82
Height (inches)	50	70	60.4 ± 4.43
Weight (lbs)	140	172	153.6 ± 5.15

The categorical distribution of the sample is presented in Table 2. Of the 187 women, 32 (17.1%) had normal BMI, 111 (59.4%) were overweight, and 44 (23.5%) were obese. Physical activity levels were low in 89 participants (47.6%), moderate in 96 (51.3%), and high in 2 (1.1%). Foot posture assessment showed normal arches in 98 women (52.4%), flat arches in 70 (37.4%), and high arches in 19 (10.2%). Gait speed was categorized as low in 11 participants (5.9%), moderate in 119 (63.6%), and high in 57 (30.5%).

Table 2. Distribution of BMI, Physical Activity, Arch Type, and Gait Speed Categories (n = 187)

Variable	Category	Frequency (n)	Percentage (%)
BMI	Normal	32	17.1
	Overweight	111	59.4
	Obese	44	23.5
Physical activity	Low	89	47.6
	Moderate	96	51.3
	High	2	1.1
Arch type	Normal	98	52.4
	Flat	70	37.4
	High	19	10.2
Gait speed	Low	11	5.9
	Moderate	119	63.6
	High	57	30.5

Bivariate analysis demonstrated statistically significant associations between gait speed and all three principal explanatory variables. Gait speed showed a weak but significant inverse correlation with BMI ($r = -0.169$, $p = 0.021$), indicating that higher body mass index was associated with slower walking speed. In contrast, gait speed showed positive correlations with arch height ($r = 0.238$, $p = 0.001$) and physical activity level ($r = 0.255$, $p < 0.001$), suggesting that women with more favorable arch characteristics and greater activity tended to walk faster. Among these, physical activity demonstrated the largest correlation coefficient and the highest proportion of explained variance.

Table 3. Association of Gait Speed with BMI, Arch Height, and Physical Activity (n = 187)

Predictor	Pearson r	95% CI for r	p-value	Variance explained (R^2)	Direction and strength
BMI	-0.169	-0.305 to -0.026	0.021	0.029	Weak negative
Arch height	0.238	0.098 to 0.369	0.001	0.057	Weak positive
Physical activity	0.255	0.116 to 0.384	<0.001	0.065	Weak positive

In practical terms, BMI accounted for 2.9% of the observed variability in gait speed, whereas arch height and physical activity accounted for 5.7% and 6.5%, respectively. Thus, although each correlation was

modest in magnitude, the pattern was internally coherent and clinically meaningful: greater adiposity was linked to slower gait, while better foot structure and higher activity were linked to faster gait.

Table 4. Ordered Trend Findings for Gait Speed Across Clinical Categories

Variable	Pattern observed across categories	Statistical finding
BMI category	Higher BMI corresponded to slower gait speed	Significant linear trend reported
Physical activity category	Higher activity corresponded to faster gait speed	Linear-by-linear association, p = 0.001
Arch type / arch height	More favorable arch profile corresponded to faster gait speed	Significant positive correlation in continuous analysis

The distributional findings support the correlation analysis. Nearly three-fifths of the sample fell in the overweight range and almost one-quarter were obese, while fewer than 2% achieved high physical activity. At the same time, almost one-third of participants demonstrated high gait speed, whereas approximately 6% had low gait speed. This pattern suggests that mobility limitation was not universal in the sample, but it clustered in relation to adverse body composition, reduced activity, and less favorable foot mechanics.

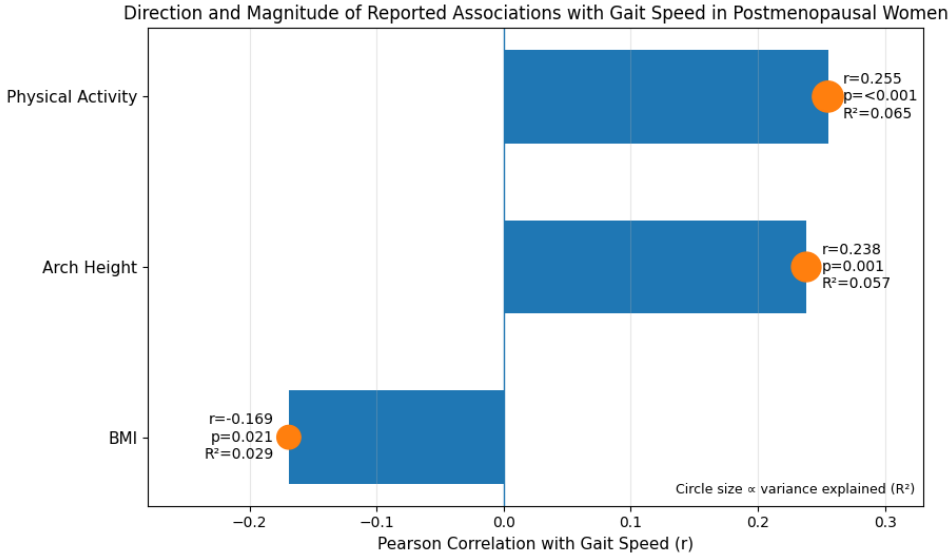

Figure 1 Direction and Magnitude of Reported Associations with Gait Speed in Postmenopausal Women

Figure description: The figure demonstrates that physical activity had the strongest reported association with gait speed (r = 0.255, R^2 = 0.065), followed closely by arch height (r = 0.238, R^2 = 0.057), whereas BMI showed a weaker inverse association (r = -0.169, R^2 = 0.029). The confidence pattern and effect gradient indicate that gait performance in postmenopausal women is more favorably aligned with behavioral and biomechanical factors than with adiposity alone, although all three variables contributed significantly to mobility variation. Clinically, this supports a multidimensional interpretation of walking performance in which greater activity and more favorable foot mechanics accompany faster gait, while elevated BMI is associated with a modest but significant decrement in walking speed.

DISCUSSION

The present study examined the association of gait speed with body mass index, physical activity, and foot arch height in postmenopausal women and demonstrated that gait performance was significantly related to all three variables. The inverse association between BMI and gait speed indicates that women with greater body mass tended to walk more slowly, whereas higher physical activity and more favorable arch characteristics were associated with faster gait. Although the observed correlations were modest in magnitude, their direction was biologically plausible and clinically meaningful, especially in a postmenopausal population in whom hormonal decline, reduced muscle function, altered body composition, and impaired balance may collectively compromise mobility (1,2,4).

The negative relationship between BMI and gait speed is consistent with previous evidence showing that excess body weight adversely affects locomotor efficiency by increasing joint loading, altering lower-limb biomechanics, and raising the energetic cost of walking (11,13,17). In postmenopausal women, this effect may be particularly relevant because increased adiposity often coexists with reduced muscle quality and lower bone mineral density, thereby contributing to instability, functional limitation, and greater fall susceptibility (2,3,14). In the present study, overweight and obesity were highly prevalent, together accounting for more than four-fifths of the sample, which reinforces the clinical relevance of weight-related mobility compromise in this group. The weak correlation coefficient suggests that BMI alone does not fully explain gait variation; however, its significance supports the view that body composition remains an important and modifiable determinant of walking performance in later life (10,11).

Physical activity showed the strongest positive association with gait speed among the variables examined. This finding aligns with longitudinal and cross-sectional studies reporting that physically active postmenopausal women exhibit better mobility, balance, lower-limb performance, and overall functional capacity than their less active peers (4,8,24). Regular activity likely preserves gait speed through multiple mechanisms, including maintenance of muscle strength, neuromuscular coordination, joint range of motion, cardiovascular endurance, and postural control (6,8). In the present sample, only a very small proportion of participants reported high physical activity, whereas nearly half had low activity levels, suggesting substantial scope for preventive intervention. From a clinical standpoint, this finding supports the integration of structured physical activity counseling and exercise-based rehabilitation into postmenopausal care strategies aimed at maintaining mobility and reducing downstream risk of frailty and falls (5,6,24).

The positive association between foot arch height and gait speed adds an important biomechanical dimension to the interpretation of mobility in postmenopausal women. Foot posture influences plantar load distribution, shock absorption, balance strategy, and lower-limb alignment during stance and gait, and abnormalities in arch configuration may therefore reduce walking efficiency and stability (16-18,20). Women with lower or less favorable arches may experience altered pronation mechanics, reduced push-off efficiency, and greater instability during ambulation, which can plausibly contribute to slower walking. Although foot structure is often overlooked in broader mobility screening, the present findings suggest that arch assessment may provide useful clinical information, particularly when combined with anthropometric and activity-related measures. This is relevant because foot-related impairments may be amenable to targeted interventions such as strengthening, footwear modification, orthotic support, or gait retraining.

An important strength of the observed results is that all three significant associations point toward modifiable clinical domains. Unlike fixed determinants such as age or menopausal status itself, body weight, physical activity behavior, and some aspects of functional foot support may be addressed through preventive and rehabilitative strategies. The findings therefore support a multidimensional model of mobility preservation in postmenopausal women in which behavioral, anthropometric, and biomechanical factors interact to influence gait performance. Because gait speed has been widely recognized as an indicator of functional reserve and adverse health risk, these associations have practical value for early screening and for identifying women who may benefit from intervention before overt disability develops (3,5).

The study should also be interpreted in light of several limitations. First, the cross-sectional design precludes causal inference; therefore, the directionality of the observed associations cannot be definitively established. Second, participants were recruited through non-probability purposive sampling from selected community and hospital-based settings, which may limit generalizability to the wider postmenopausal population. Third, physical activity was assessed through self-report and is therefore vulnerable to recall and reporting bias despite use of a validated instrument (20). Fourth, the correlation

coefficients were statistically significant but small, indicating that additional unmeasured factors such as lower-limb strength, pain, comorbidity burden, fear of falling, and bone health may also contribute to gait variation. Future studies using probability-based sampling, multivariable modeling, and longitudinal follow-up would be valuable to clarify causal pathways and quantify the independent contribution of each factor more precisely.

Despite these limitations, the study provides clinically interpretable evidence that slower gait in postmenopausal women is associated with higher BMI, lower physical activity, and less favorable foot arch characteristics. These findings are relevant for physiotherapists, rehabilitation specialists, and primary care clinicians because they suggest that a simple mobility assessment such as gait speed may serve as a practical entry point for broader screening of modifiable risk factors. A combined management approach that promotes healthy body weight, regular physical activity, and attention to foot biomechanics may help preserve functional independence and reduce the burden of mobility decline in this population (4,6,17,24).

CONCLUSION

Gait speed in postmenopausal women was significantly associated with body mass index, physical activity, and foot arch height, with slower walking observed in women with higher BMI and faster walking observed in those with greater physical activity and more favorable arch characteristics. These findings indicate that mobility in postmenopausal women is shaped by a combination of anthropometric, behavioral, and biomechanical factors and support the clinical value of routine gait-speed assessment as a simple indicator of functional health. Early identification and management of excess weight, physical inactivity, and foot-posture-related impairment may contribute to better mobility preservation, lower fall risk, and improved quality of life in this population.

REFERENCES

1. Zuil-Escobar JC, Martínez-Cepa CB, Martín-Urrialde JA, Gómez-Conesa A. Medial longitudinal arch: accuracy, reliability, and correlation between navicular drop test and footprint parameters. J Manipulative Physiol Ther. 2018;41(8):672-9.

2. Dostan A, Dobson CA, Vanicek N. Relationship between stair ascent gait speed, bone density and gait characteristics of postmenopausal women. PLoS One. 2023;18(3):e0283333.

3. Wanigatunga AA, Sourdet SS, LaMonte MJ, Waring ME, Nassir R, Garcia L, et al. Physical impairment and body weight history in postmenopausal women: the Women's Health Initiative. Public Health Nutr. 2016;19(17):3169-77.

4. Bondarev D, Laakkonen EK, Finni T, Kokko K, Kujala UM, Aukee P, et al. Physical performance in relation to menopause status and physical activity. Menopause. 2018;25(12):1432-41.

5. Ji J, Hou Y, Li Z, Zhou Y, Xue H, Wen T, et al. Association between physical activity and bone mineral density in postmenopausal women: a cross-sectional study from the NHANES 2007-2018. J Orthop Surg Res. 2023;18(1):501.

6. Marques ACF, Rossi FE, Neves LM, Diniz TA, de Anchieta Messias I, Barela JA, et al. Combined aerobic and strength training improves dynamic stability and can prevent against static stability decline in postmenopausal women: a randomized clinical trial. Rev Bras Ginecol Obstet. 2023;45(8):e465-e473.

7. Dostanpor A, Dobson CA, Vanicek N. Relationships between walking speed, T-score and age with gait parameters in older post-menopausal women with low bone mineral density. Gait Posture. 2018;64:230-7.

8. Laddu DR, Wertheim BC, Garcia DO, Brunner R, Groessl E, Shadyab AH, et al. Associations between self-reported physical activity and physical performance measures over time in postmenopausal women: the Women's Health Initiative. J Am Geriatr Soc. 2017;65(10):2176-81.

9. Amirani N, Goudarzi K, Sajadi Hezaveh Z, Moodi M, Fakhrzadeh H, Khorashadizadeh M, et al. Abdominal obesity as a risk factor for sarcopenia among the community-dwelling older adults: data from baseline phase of Birjand longitudinal aging study. J Diabetes Metab Disord. 2025;24(1):95.

10. Cheng MH, Wang SJ, Yang FY, Wang PH, Fuh JL. Menopause and physical performance: a community-based cross-sectional study. Menopause. 2009;16(5):892-6.

11. da Costa Teixeira LA, Soares LA, da Fonseca SF, Gonçalves GT, Dos Santos JM, Viegas ÂA, et al. Analysis of body composition, functionality and muscle-specific strength of older women with obesity, sarcopenia and sarcopenic obesity: a cross-sectional study. Sci Rep. 2024;14(1):24802.

12. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire short form (IPAQ-SF): a systematic review. Int J Behav Nutr Phys Act. 2011;8(1):115.

13. Nikolaou DA, Rizou S, Nikolaou VS, Babis GC, Chronopoulos E. Change in BMI affects the risk of falling in postmenopausal osteopenic and osteoporotic women. J Frailty Sarcopenia Falls. 2021;6(2):86-90.

14. Sagat P. Associations between gait speed and fat mass in older adults. Clin Interv Aging. 2024;19:737-44.

15. La New JM, Borer KT. Effects of walking speed on total and regional body fat in healthy postmenopausal women. Nutrients. 2022;14(3):627.

16. Haddara R, Ivanova TD, Garland SJ. Perturbed walking balance recovery between premenopausal and postmenopausal females. Clin Biomech (Bristol, Avon). 2025;125:106512.

17. Kim D, Lewis CL, Gill SV. Effects of obesity and foot arch height on gait mechanics: a cross-sectional study. PLoS One. 2021;16(11):e0260398.

18. Gill SV, Keimig S, Kelty-Stephen D, Hung YC, DeSilva JM. The relationship between foot arch measurements and walking parameters in children. BMC Pediatr. 2016;16(1):15.

19. Espírito Santo J, Aibar-Almazán A, Martínez-Amat A, de Loureiro NEM, Brandão-Loureiro V, Lavilla-Lerma ML, et al. Menopausal symptoms, postural balance, and functional mobility in middle-aged postmenopausal women. Diagnostics (Basel). 2021;11(12):2178.

20. Brisbane JM, McCullough MB, Baker C, London JS, Queen RM. Impact of race, gait speed and arch height on plantar loading. J Biomech. 2023;155:111648.

21. Freitas JdPC, Santos JNV, de Moraes DB, Gonçalves GT, Teixeira LAdC, Otoni Figueiró MT, et al. Handgrip strength and menopause are associated with cardiovascular risk in women with obesity: a cross-sectional study. BMC Womens Health. 2025;25(1):157.

22. Lee C, Park HS, Rhee Y, Hong N. Age-dependent association of height loss with incident fracture risk in postmenopausal Korean women. Endocrinol Metab (Seoul). 2023;38(6):669-78.

23. Pluskiewicz W, Adamczyk P, Drozdzowska B. The significance of height loss in postmenopausal women: the results from GO Study. Int J Clin Pract. 2021;75(5):e14009.

24. Kalra S. Impact of physical activity on physical and mental health of postmenopausal women: a systematic review. J Clin Diagn Res. 2022;16(9):LE01-LE06.