International Journal of Community Medicine and Public Health
Shaikh AU et al. Int J Community Med Public Health. 2026 Aug;13(8):4534-4538
https://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20262739

Original Research Article

Age of menopause and its correlation with gait parameters in 45-50 year old postmenopausal women: a cross-sectional study

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Received: 14 June 2026
Revised: 16 July 2026
Accepted: 22 July 2026

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ABSTRACT

Background: Menopause marks the permanent end of menstruation and is accompanied by declining estrogen levels, leading to changes in bone density, muscle strength, metabolism, and overall health. These changes may influence mobility. Gait, a key indicator of physical function, reflects balance, neuromuscular control, and musculoskeletal performance. While gait alterations have been reported in postmenopausal women, limited evidence exists on how the age of menopause impacts gait. Understanding this relationship may help detect early functional decline and guide physiotherapy strategies.
Methods: An analytical cross-sectional study was conducted among 30 postmenopausal women aged 45–50 years using purposive sampling. Anthropometric variables and spatiotemporal gait parameters (step length, stride length, step/stride time, and walking speed) were assessed using Kinovea software and analysed using statistical package for the social sciences (SPSS) v25.
Results: Among 30 postmenopausal women (mean age 48.6±1.8 years; menopause age 45.3±2.6 years), 13.3% were overweight and 56.6% obese. Mean gait values included walking speed 61.37±7.59 cm/s, step length 77–78 cm, and stride length 148–151 cm, with slightly shorter step/stride times than normative data. Age of menopause and body mass index (BMI) showed weak or negligible, but statistically insignificant, correlations with gait parameters ($p>0.05$).
Conclusions: Age of menopause and BMI were not associated with gait parameters, and functional mobility was largely preserved despite high overweight/obesity prevalence.

Keywords: Age of menopause, Spatiotemporal gait parameters, Body mass index

INTRODUCTION

Menopause, the permanent cessation of menstruation after 12 months without a period, is accompanied by declining estrogen levels, leading to physiological changes such as reduced bone density, loss of muscle mass and strength, metabolic alterations, weight gain, and increased central adiposity.[1-6] These changes contribute to functional decline and elevate the risk of chronic conditions, including cardiovascular disease, osteoporosis, and certain cancers, with women generally experiencing greater age-related limitations than men.[3,4,7-9]

Gait, encompassing balance, neuromuscular control, and musculoskeletal function, is a reliable indicator of mobility and overall physical function.[10-12] Postmenopausal women may demonstrate slower walking speed, altered step and stride lengths, and prolonged stance phases; however, evidence on how the age of menopause affects gait parameters is limited [2,12]

Functional limitations, including mobility impairments, can begin as early as the forties, influenced by aging and hormonal changes.[2] Gait, a reliable indicator of physical function, may be altered in postmenopausal women due to osteoporosis and musculoskeletal changes, increasing the risk of falls.[2] Evidence, including a pilot study in Poland, shows prolonged stance phases in postmenopausal women, yet the impact of menopause onset on gait remains unclear.[2,3] This study investigates the correlation between age of menopause and spatiotemporal gait parameters in women aged 45–50 years, aiming to inform early interventions and future research.

Understanding this relationship is crucial for early detection of functional decline and the design of physiotherapy interventions to preserve mobility, prevent falls, and improve quality of life in newly postmenopausal women.[3,10-14] This study investigates the correlation between age of menopause and spatiotemporal gait parameters in women aged 45–50 years.

METHODS

A cross-sectional observational study was conducted after obtaining formal ethical approval from the Scientific Review Committee at The SIA College of Health Sciences, College of Physiotherapy, Thane. The study was carried out over a period of six months, from April to October 2025. The sample size was calculated and a total of 30 postmenopausal women, aged 45–50 years, were recruited via purposive sampling from an initial screened pool of 40 candidates. Participants were included if they had experienced at least 12 months of amenorrhea and demonstrated the ability to walk independently without pain. Individuals were excluded if they presented with neurological disorders, recent lower limb fractures, musculoskeletal conditions affecting gait, or any acute low back or lower limb pain. Prior to participation, informed consent was secured in the participant's preferred language, including English, Hindi or Marathi, and a comprehensive medical history detailing gynaecological status and comorbidities such as hypertension, diabetes, and thyroid disorders was recorded.

Anthropometric measurements were standardized to ensure data precision. Height was measured to the nearest 0.1 cm using a Sknol Company stadiometer with the participant's head positioned in the Frankfurt plane, while weight was recorded to the nearest 0.1 kg on a calibrated scale. Body mass index (BMI) was subsequently calculated as weight in kilograms divided by height in meters squared (BMI=kg/m^2) in accordance with World Health Organization (WHO) guidelines.

For the gait assessment, an 11-meter hallway was prepared with 1-meter interval markings and visual guidance cones to maintain a consistent walking path. Kinematic data were captured using two synchronized cameras an iPhone 8 Plus and a Vivo Y20 positioned to provide lateral and frontal views. To facilitate digital tracking, four reflective markers were applied to the midpoint of the heel, the medial and lateral malleoli, and the 5th metatarsal head of each participant.

The experimental procedure began with a demonstration trial, followed by three barefoot, self-paced walking trials to capture natural gait patterns. After a 2-minute rest period to prevent fatigue, participants performed three 1-minute continuous walks to assess average walking speed (Figure 1).

The captured video data were then processed using Kinovea 2D motion analysis software (v2023.2.1), a validated and cost-effective tool for kinematic research. Key spatiotemporal parameters, including step length, stride length, step time, stride time, and walking speed, were extracted for both sides of the body (Figures 2 and 3).

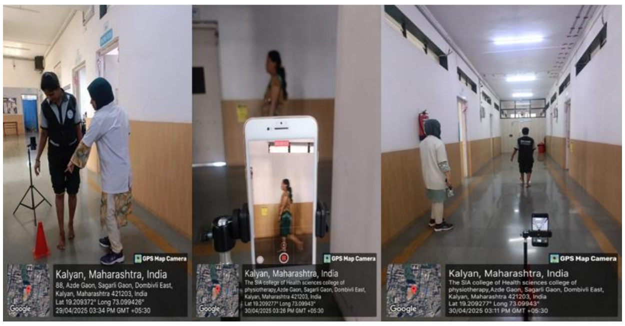

Figure 1: Recording the gait through mobiles using tripod stand.

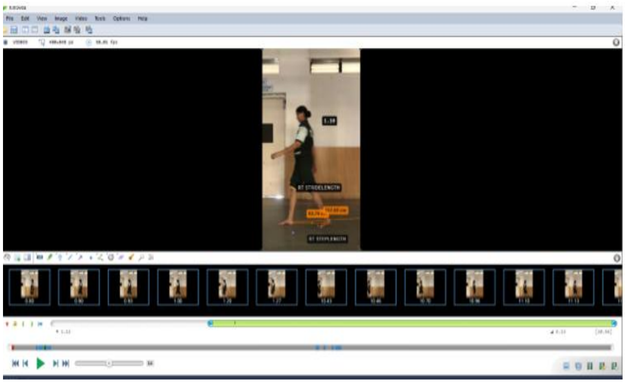

Figure 2: Analysing the gait parameters of right side, using Kinovea software.

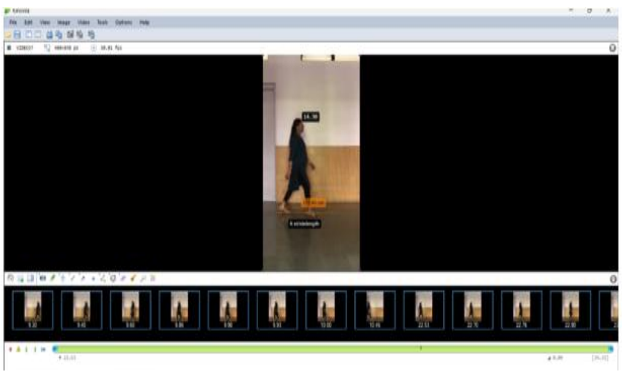

Figure 3: Analysing the gait parameters of left side using Kinovea software.

Finally, all data were documented in case record forms, coded, and tabulated in Microsoft Excel before undergoing rigorous statistical analysis using statistical package for the social sciences (SPSS) v25.

RESULTS

Normality of data was assessed using the Kolmogorov-Smirnov test. Data were entered in Microsoft Excel and analyzed with SPSS v25. Continuous variables were presented as mean±SD, categorical variables as frequency (%). Parametric or non-parametric correlation tests were applied, with significance set at $\alpha=0.05$.

Thirty postmenopausal women (mean age 48.6±1.8 years; menopause age 45.3±2.6 years) participated. Anthropometric assessment showed a mean height of 153.15±6.20 cm, weight 65.28±12.39 kg, and BMI 27.89±5.21 kg/m². Most participants were overweight or obese (43.3% obese class I, 30% obese class II, 13.3% overweight), and 60% reported no comorbidities.

As presented in Table 1, the average walking speed among participants aged 45–50 years was 61.37±7.59 cm/sec, which is lower than normative values reported for healthy middle-aged women (~70–80 cm/sec). The mean step length was 78.13±8.37 cm on the right and 76.94±9.25 cm on the left, both exceeding standard reference values (~52–55 cm). Similarly, the mean stride length was 150.72±18.55 cm (right) and 147.87±15.08 cm (left), compared to expected norms of ~110–112 cm. In contrast, mean step time was 0.51±0.03 s on the right and 0.51±0.05 s on the left, while stride time was 1.03±0.06 s (right) and 1.04±0.07 s (left), both notably shorter than age-matched normative ranges (~0.75–0.83 s for step time; ~1.15–1.20 s for stride time). Minor asymmetries were observed between right and left sides across all parameters.

Table 1: Mean and standard deviation of gait parameters.

Variables	Mean±SD	
Mean speed (m/sec)	61.37±7.59	
	Right	**Left**
Mean step length	78.13±8.37	76.94±9.25
Mean stride length	150.72±18.55	147.87±15.08
Mean step time	0.51±0.03	0.51±0.05
Mean stride time	1.03±0.06	1.04±0.07

As presented in Table 2, a very weak positive correlation ($r=0.00–0.59$; $p>0.05$) was observed with variables such as mean right step length, mean right stride length, mean left stride length, mean right step time, and mean speed, a very weak negative, correlation ($r= –0.00$ to $–0.79$; $p>0.05$) was found with mean left step time, mean right stride time, and mean left stride time. No correlation was observed between age at menopause and mean left step length ($r=0.00–0.19$; $p>0.05$). Hence no statistically significant correlations were found between age of menopause and any of the gait parameters ($p>0.05$).

Table 2: Correlation analysis between age of menopause and gait parameters.

Spatiotemporal parameters (variable 2)	Age of menopause (variable 1)	
	Pearson's correlation coefficient (r value)	**P value**
Mean step length right	0.0523	0.78372
Mean step length left	0.0087	0.963607
Mean stride length right	0.0746	0.695217
Mean stride length left	0.0347	0.855553
Mean step time right	0.0926	0.62648
Mean step time left	-0.067	0.725006
Mean stride time right	-0.0608	0.749605
Mean stride time left	-0.1165	0.539826

As shown in Table 3, a very weak negative, correlation ($r= –0.00$ to $–0.79$; $p>0.05$) was found with mean right and left step length, mean right and left stride length, as well as mean right step time and mean right stride time, an extremely weak negative, correlation ($r= –0.00$ to $–0.79$; $p>0.05$) was observed with mean left step time, mean left stride time, and mean speed. Hence, no statistically significant relationships were observed between BMI and the spatiotemporal gait parameters ($p>0.05$).

Table 3: Correlation analysis between body mass index and gait parameters.

Spatiotemporal parameters (variable 2)	Body mass index (variable 1)	
	Pearson's correlation coefficient (r value)	**P value**
Mean step length left	-0.2556	0.1728
Mean stride length right	-0.1231	0.516941
Mean stride length left	-0.2401	0.201252
Mean step time right	-0.2395	0.202414
Mean step time left	-0.0219	0.90855
Mean stride time right	-0.1394	0.462534
Mean stride time left	-0.0225	0.906055
Mean speed (m/sec)	-0.0237	0.901069

DISCUSSION

This study examined the relationship between age at natural menopause, BMI, and spatiotemporal gait parameters in 30 postmenopausal women aged 45–50 years. The mean age of menopause was 45.3±2.6 years, consistent with Indian data reporting menopause at 44–47 years — notably lower than the global average of ~51 years.[12] Sociocultural, nutritional, reproductive, and environmental factors may contribute to this earlier onset and potentially influence musculoskeletal health and gait.[3-5]

Gait analysis revealed a mean walking speed of 61.37±7.59 cm/s, slightly below global norms (~70–80 cm/s).[6] Step and stride lengths were within expected ranges with minimal asymmetry, suggesting functional mobility remains preserved in early postmenopausal women despite a high prevalence of overweight and obesity (43.3% obese class I, 30% obese class II).[7]

Correlation analyses showed very weak, non-significant associations between age of menopause and gait parameters, with minor positive trends for step length, stride length, and gait speed, and weak negative trends for step and stride time. Such trends are biologically plausible considering the role of endogenous estrogen in maintaining muscle mass, bone density, and neuromuscular function.[8,9] Similarly, BMI showed weak negative correlations with gait measures, indicating minimal influence on gait dynamics, in line with some prior research on obesity and gait.[7,10] Overall, neither menopausal age nor BMI significantly influenced gait performance in this cohort. Functional mobility appears well preserved in relatively healthy, early postmenopausal women, even with elevated BMI. Functional mobility appears to be well preserved in relatively healthy, early postmenopausal women, even in the presence of an elevated BMI. This preservation may be attributed to the relatively younger age of the participants (45–50 years), who are in the early postmenopausal phase and are less likely to have developed the cumulative effects of aging, sarcopenia, balance impairment, and functional decline that are commonly observed in older postmenopausal populations. Furthermore, the participants in the present study were community-dwelling and free from major neurological or musculoskeletal disorders that could adversely affect mobility.

Compared with several international studies that included older postmenopausal women with a wider age range (typically ≥55–65 years), the present cohort represents an earlier stage of menopause, when functional capacity is generally better preserved. Age-related reductions in gait speed, muscle strength, and physical performance are known to become more pronounced with advancing age and frailty rather than as a consequence of menopause alone (Bohannon and Studenski et al).[30,31] Therefore, the relatively preserved functional mobility observed in the present study is likely reflective of the younger age profile and healthier clinical characteristics of the participants, rather than indicating an absence of age-related changes. These findings highlight the importance of early preventive strategies during the menopausal transition to maintain mobility and delay future functional decline.[32,33]

CONCLUSION

In this sample of postmenopausal Indian women aged 45–50 years, neither age at menopause nor BMI showed significant associations with spatiotemporal gait parameters. Despite a high prevalence of overweight/ obesity, gait speed, step length, and stride symmetry were maintained, indicating maintained functional mobility in early post-menopause. Focusing on healthy weight and muscle strength can contribute to sustaining mobility and preventing future limitations.

Limitations

Key factors that may influence gait such as physical activity level, hormone replacement therapy, neuromuscular coordination, and musculoskeletal health were not assessed. Future studies should adopt larger, more diverse samples and longitudinal designs to monitor gait, body composition, muscle strength, joint health, and hormonal status over time. Such designs would allow a more comprehensive understanding of determinants affecting gait and fall risk among postmenopausal women.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Shaikh AU, Pol TT, Karajgi AK. Age of menopause and its correlation with gait parameters in 45-50 year old postmenopausal women: a cross-sectional study. Int J Community Med Public Health 2026;13:4534-8.