

Assessment of dynamic balance in postmenopausal women using the modified Star Excursion Balance Test

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DOI: <https://doi.org/10.66856/ijyppe.2026.11.3.11081>

Abstract

Background: Postmenopausal women may experience physiological changes that can influence postural stability and functional mobility. Dynamic balance is relevant to activities such as walking, reaching, and responding to perturbations. The Modified Star Excursion Balance Test (MSEBT) provides a practical assessment of dynamic postural control.

Objective: To assess dynamic balance in postmenopausal women using the Modified Star Excursion Balance Test and to describe the directional MSEBT scores.

Methodology: An observational study was conducted among 150 postmenopausal women aged 50–65 years in Navi Mumbai. Participants were selected using randomized sampling according to the stated inclusion and exclusion criteria. Dynamic balance was assessed using the MSEBT in the anterior, posteromedial, and posterolateral directions for both lower limbs. Three trials were performed and normalized reach scores were recorded. Descriptive statistics were used to summarize participant characteristics and MSEBT performance.

Results: The mean age of participants was 57.00 ± 4.13 years. The mean age at menopause was 49.94 ± 2.31 years and the mean duration since menopause was 6.98 ± 2.90 years. The overall mean MSEBT score was $73.47 \pm 6.68\%$. Mean right-limb scores were $79.76 \pm 7.15\%$ for anterior, $67.27 \pm 7.11\%$ for posteromedial, and $71.65 \pm 7.07\%$ for posterolateral reach. Corresponding left-limb scores were $80.60 \pm 6.93\%$, $67.47 \pm 6.93\%$, and $72.29 \pm 7.52\%$, respectively. Composite scores were $73.36 \pm 6.26\%$ on the right and $73.69 \pm 6.83\%$ on the left.

Conclusion: The study provides descriptive MSEBT performance values in postmenopausal women. Anterior reach showed higher mean values, while posteromedial reach showed lower mean values on both sides. These findings should be interpreted as descriptive performance values because population-specific normative or clinical cut-off values were not established in the study.

Keywords: Postmenopausal women, Dynamic balance, Modified Star Excursion Balance Test, MSEBT, Postural control, Physiotherapy

Introduction

Menopause represents a major biological milestone marked by the permanent end of menstruation and accompanied by hormonal, musculoskeletal, and neuromotor alterations that affect physical performance and postural stability.^[1, 11] The changes in body composition, declines in muscle strength, and disruptions in neuromuscular function factors that collectively heighten the likelihood of falls and fractures in post-menopausal women.^[11, 3]

Falls are a significant health issue within this group. A systematic review including more than 42,000 post-menopausal women found that advancing age, increased BMI, lower physical activity levels, prior fractures, and multiple chronic conditions were key predictors of fall risk.^[11] Additionally, diminished body mass density has been associated with greater postural sway, indicating that bone deterioration plays a role in compromised balance.^[8]

Beyond musculoskeletal contributors, the severity of menopausal symptoms also affects balance, linked with reduced postural stability as shown by increased stabilogram length, centre-of-pressure velocity, and anteroposterior displacement even after controlling for age and body measurements.^[1]

Dynamic balance defined as the capacity to maintain stability during movement is essential for functional mobility. Routine activities such as walking, reaching,

obstacle negotiation, and responding to sudden disturbances rely heavily on dynamic stability, yet research focusing specifically on dynamic balance in post-menopausal women is still scarce.^[3, 6, 9] Existing evidence shows that post-menopausal women perform notably worse on dynamic mobility tests compared with pre-menopausal women, indicating a functional decline related to menopausal changes.^[4]

Research examining dynamic balance and movement control also highlights that aging and musculoskeletal changes diminish dynamic stability, underscoring the importance of functional assessment in older female populations.^[10, 2]

Considering the combined effects of bone mineral density, muscular strength, body composition, menopausal symptoms, and aging on balance.^[3, 7] evaluating dynamic balance with a validated instrument such as the mSEBT may offer meaningful insights into fall risk among post-menopausal women.

The Star Excursion Balance Test (SEBT) and its modified version (mSEBT) are reliable tools for assessing dynamic postural control. The mSEBT uses three directions anterior, posteromedial, and posterolateral offering a faster yet effective method for evaluating balance and neuromuscular control in both clinical and athletic settings.^[5, 12, 13] It shows strong reliability (ICC: 0.90–0.95) and is effective for

detecting subtle balance issues with minimal time and effort.
[14, 15]

Methodology

Study design: Observational study.

Sampling method: Randomized sampling.

Sample size: 150 participants.

Study setting: Navi Mumbai.

Participants: Postmenopausal women aged 50–65 years.

Inclusion criteria included women aged 50–65 years, community-dwelling women, participants described in the study protocol as being in early postmenopause stage +1c according to STRAW criteria, and post-hysterectomy participants. Exclusion criteria included lower-limb injuries, recent surgeries, neurological conditions, and use of assistive devices.

Ethical approval was obtained from the Institutional Ethics Committee of TMV's Lokmanya Tilak College of Physiotherapy. The purpose and procedure were explained to participants and written informed consent was obtained. Participant information was recorded confidentially.

The Modified Star Excursion Balance Test was used to assess dynamic balance. The test involved single-limb stance while reaching in the anterior, posteromedial, and posterolateral directions. Three trials were performed for each direction and the recorded reach values were used for analysis. Directional reach values were normalized to limb length and expressed as percentages. Right- and left-limb composite scores were also obtained.

Statistical analysis

Data were entered into Microsoft Excel and summarized using descriptive statistics. Frequency and percentage were used to describe categorical participant characteristics, including age group, age at menopause, and years since menopause. Mean and standard deviation were used to summarize MSEBT directional scores, right- and left-limb composite scores, and the overall MSEBT score. The analysis was descriptive and was intended to characterize MSEBT performance in the study population.

Data analysis and results

The data collected from 150 postmenopausal women were entered into Microsoft Excel and analysed using descriptive and inferential statistics. Frequency and percentage were used to describe the demographic characteristics of the participants, including age, age at menopause, and years since menopause. Mean and standard deviation were calculated for the MSEBT reach scores in the anterior, posteromedial, and posterolateral directions for both the right and left lower limbs. Mean and standard deviation were also calculated for the right and left MSEBT composite scores and the overall MSEBT score.

Table 1: Age distribution of participants (n=150)

Age groups	No. Of participants (%) (n=150)
50-54 YEARS	48 (32.0%)
55-59 YEARS	57 (38.0%)
60-64 YEARS	42 (28.0%)
65 YEARS	3 (2.0%)

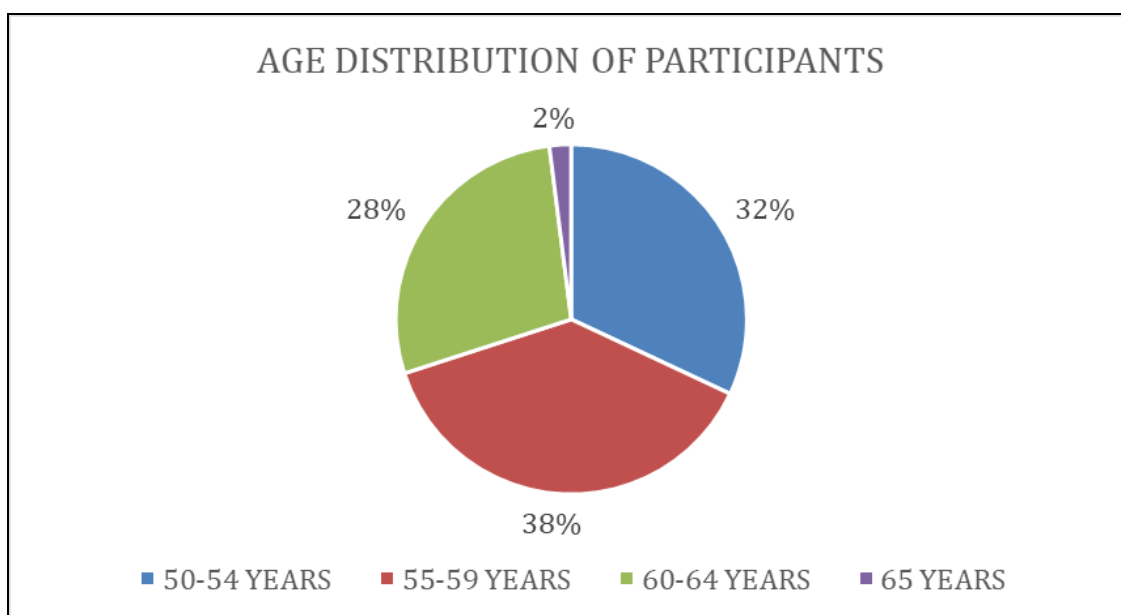


Fig 1: Age distribution of participants (n=150)

Interpretation

The distribution of participants according to age showed that the majority of participants, 57 (38.0%), belonged to the 55–59 years age group. This was followed by 48 (32.0%) participants in the 50–54 years age group and 42 (28.0%) participants in the 60–64 years age group. Only 3 (2.0%) participants were aged 65 years.

The mean age of the participants was 57.00 ± 4.13 years.

Table 2: Age at menopause of participants (n=150)

Age at Menopause	No. of participants (%) (n=150)
43-45 YEARS	5 (3.3%)
46-48 YEARS	35 (23.3%)
49-51 YEARS	65 (43.3%)
52-55 YEARS	45 (30.0%)

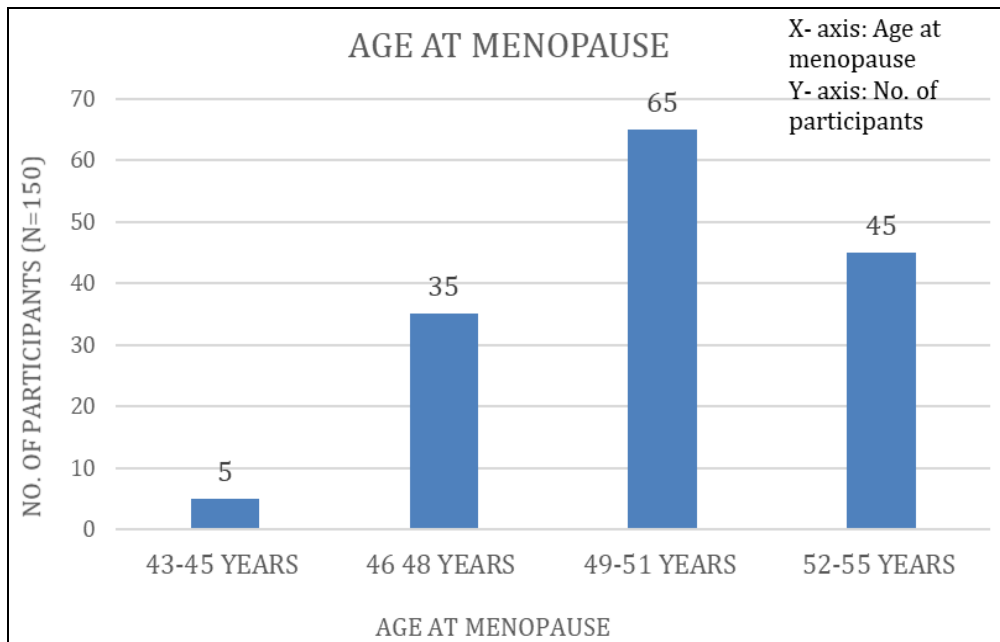


Fig 2: Age at menopause of participants (n=150)

Interpretation

The distribution according to age at menopause showed that the majority of participants, 65 (43.3%), attained menopause between 49–51 years of age. This was followed by 45 (30.0%) participants who attained menopause between 52–55 years, 35 (23.3%) between 46–48 years, and 5 (3.3%) between 43–45 years.

The mean age at menopause was 49.94 ± 2.31 years.

Table 3: Years since menopause

Years since meopause	No. of participants (%) (n=150)
3-5 YEARS	60 (40.0%)
6-8 YEARS	47 (31.3%)
9-11 YEARS	32 (21.3%)
12-15 YEARS	11 (7.3%)

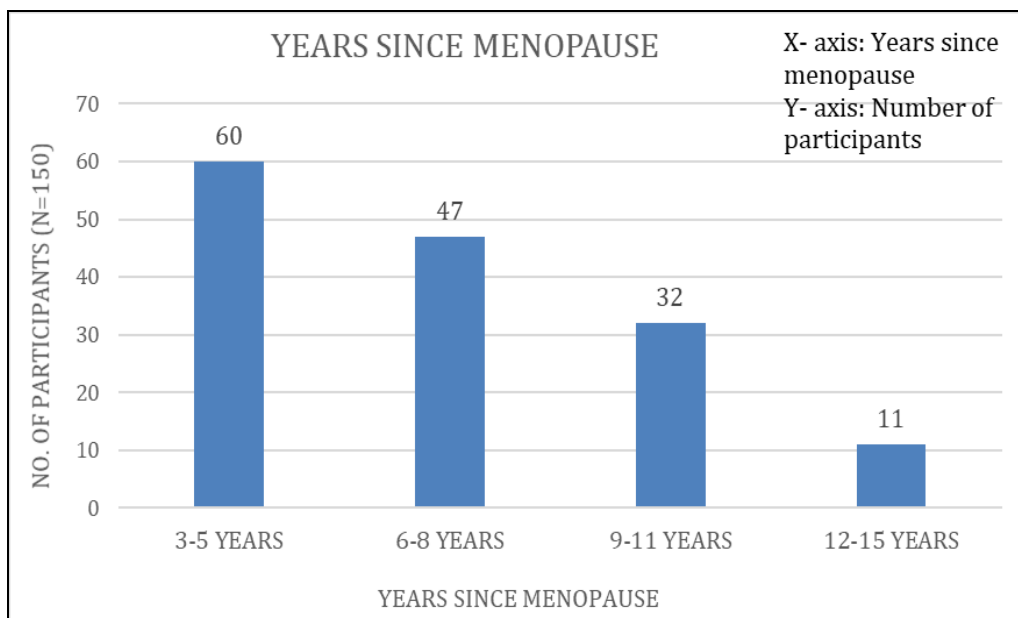


Fig 3: Years since menopause

Interpretation

The distribution according to years since menopause showed that the majority of participants, 60 (40.0%), had been postmenopausal for 3–5 years. This was followed by 47 (31.3%) participants with 6–8 years since menopause, 32 (21.3%) participants with 9–11 years, and 11 (7.3%) participants with 12–15 years since menopause.

The mean duration since menopause was 6.98 ± 2.90 years.

Table 4: Mean (MSEBT) reach score for right leg

Msebt direction	Mean score (%)
Anterior	79.76%
Posteromedial	67.27%
Posterolateral	71.65%

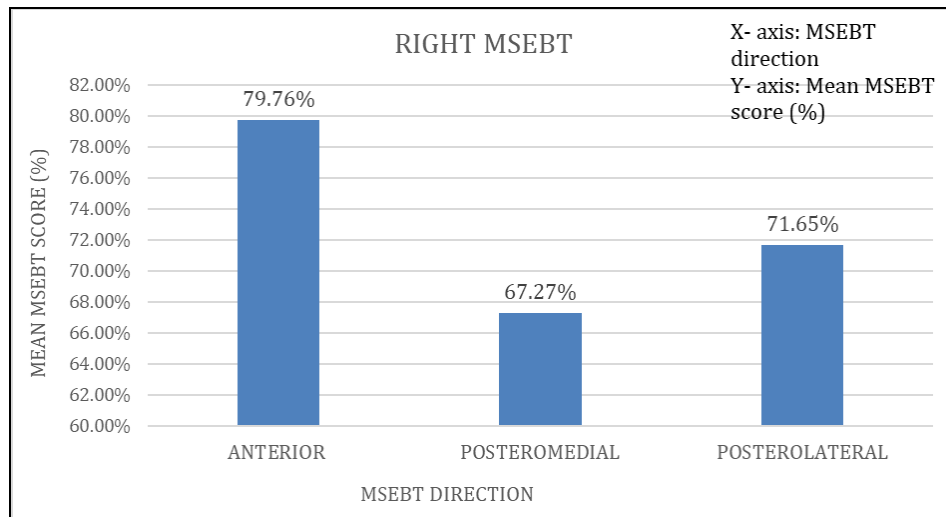


Fig 4: Mean (MSEBT) Reach score for right leg

Interpretation

The mean MSEBT reach score for the right lower limb was highest in the anterior direction ($79.76 \pm 7.15\%$), followed by the posterolateral direction ($71.65 \pm 7.07\%$). The lowest mean reach score was observed in the posteromedial direction ($67.27 \pm 7.11\%$).

Table 5: MEAN (MSEBT) reach score for left leg

Msebt direction	Mean score (%)
Anterior	80.60%
Posteromedial	67.47%
Posterolateral	72.29%

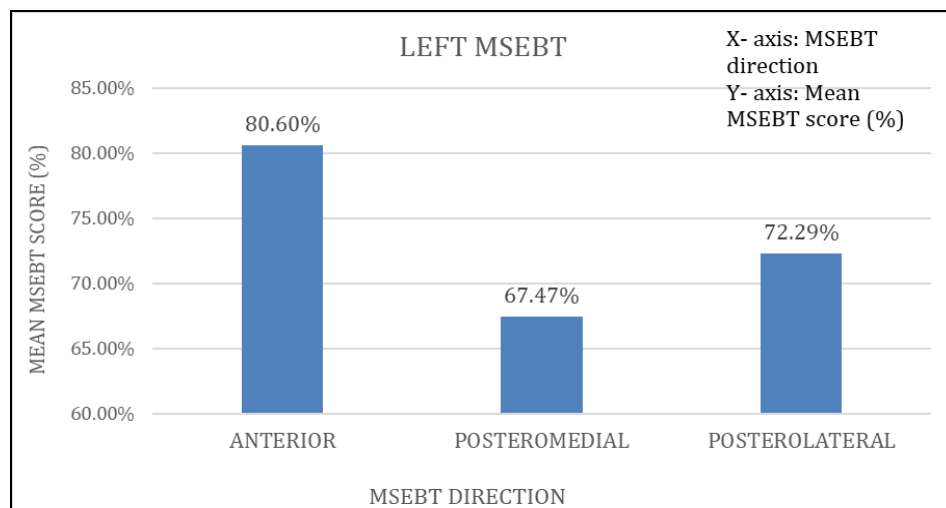


Fig 5: Mean (MSEBT) Reach score for left leg

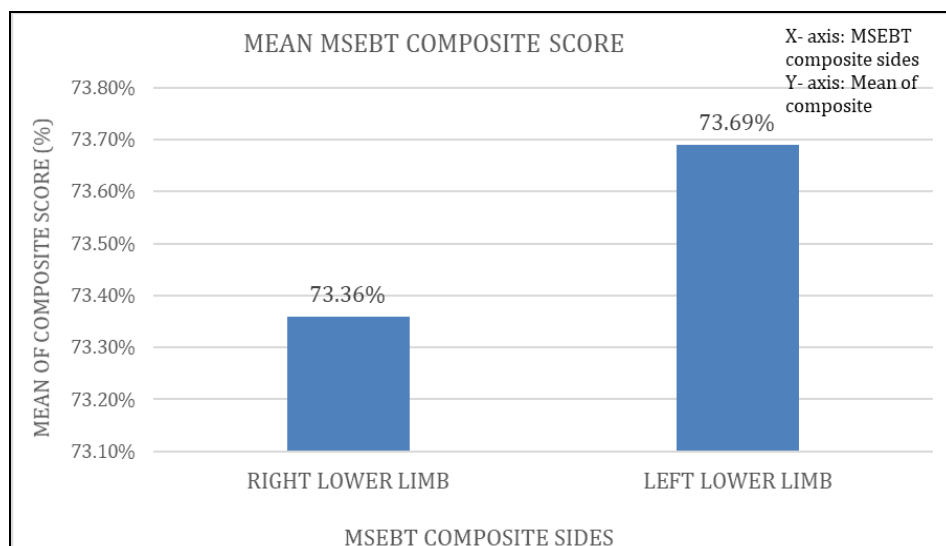


Fig 6: Mean msebt composite score of right and left lower limbs

Interpretation

The mean MSEBT reach score for the left lower limb was highest in the anterior direction ($80.60 \pm 6.93\%$), followed by the posterolateral direction ($72.29 \pm 7.52\%$). The lowest mean reach score was observed in the posteromedial direction ($67.47 \pm 6.93\%$).

Table 6: Mean msebt composite score of right and left lower limbs

Msebt composite score	Mean score (%)
Right lower limb	73.36%
Left lower limb	73.69%

Interpretation

The mean MSEBT composite score of the right lower limb was $73.36 \pm 6.26\%$, whereas the mean composite score of the left lower limb was $73.69 \pm 6.83\%$. The left lower limb showed a slightly higher mean composite score than the right lower limb.

Table 7: Descriptive statistics of msebt scores

MSEBT variable	Mean (%)	SD
Right anterior	79.76	7.15
Right posteromedial	67.27	7.11
Right posterolateral	71.65	7.07
Right composite	73.36	6.26
Left anterior	80.60	6.93
Left posteromedial	67.47	6.93
Left posterolateral	72.29	7.52
Left composite	73.69	6.83
Overall MSEBT score	73.47	6.68

Interpretation

The overall MSEBT score among the participants was $73.47 \pm 6.68\%$. Among the individual reach directions, the highest mean score was observed in the left anterior direction ($80.60 \pm 6.93\%$), while the lowest mean score was observed in the right posteromedial direction ($67.27 \pm 7.11\%$).

The overall findings demonstrate variation in reach performance across the three MSEBT directions in both lower limbs.

Discussion

The present study assessed dynamic balance in 150 postmenopausal women aged 50–65 years using the Modified Star Excursion Balance Test (MSEBT). The mean age of the participants was 57.00 ± 4.13 years, with the largest proportion belonging to the 55–59 years age group. The mean age at menopause was 49.94 ± 2.31 years, while the mean duration since menopause was 6.98 ± 2.90 years. These findings provide a descriptive profile of dynamic balance in community-dwelling postmenopausal women within the selected age range.

The overall mean MSEBT score in the present study was $73.47 \pm 6.68\%$. Among the individual directions, the highest mean score was observed in the left anterior direction ($80.60 \pm 6.93\%$), whereas the lowest score was observed in the right posteromedial direction ($67.27 \pm 7.11\%$). A similar pattern was observed on both sides, with anterior reach showing higher values and posteromedial reach showing lower values. This variation indicates that dynamic balance

performance differs according to the direction of reach rather than remaining uniform across all movement planes.

The MSEBT requires the participant to maintain single-leg support while reaching the opposite limb in different directions. Successful performance therefore depends on the ability to control the centre of mass, maintain postural stability, and coordinate movements of the trunk and lower limb. The relatively lower posteromedial scores observed in the present study may reflect the greater postural-control demands involved in this direction, as it requires controlled weight shifting and adequate lower-limb and trunk coordination while maintaining the supporting limb position.

The findings are consistent with the observations of Segal *et al.*, who reported age-related reductions in dynamic balance performance when assessed using the simplified Star Excursion Balance Test. Their findings also indicated that posterior reach directions may be more challenging compared with anterior reaching.^[2] This provides a possible explanation for the lower posteromedial values observed in the present study. However, the results should be interpreted as descriptive findings, as the present study did not compare the participants with a younger or premenopausal group. 18 Menopause-related changes may also provide relevant context when considering postural balance. Espírito Santo *et al.* reported that greater severity of menopausal symptoms was associated with poorer postural balance in postmenopausal women.^[1] Although menopausal symptoms were not assessed in the present study, this previous evidence suggests that physiological changes occurring during the postmenopausal period may be relevant to balance performance. The present study, however, cannot establish a direct relationship between menopausal characteristics and MSEBT performance because these variables were not analysed for association.

Previous research has also described differences in balance between premenopausal and postmenopausal women. Khangare *et al.* reported poorer dynamic balance in postmenopausal women when compared with premenopausal women.^[4] This supports the relevance of assessing dynamic balance during the postmenopausal period. In the present study, however, the findings are limited to the selected postmenopausal population and therefore should not be interpreted as evidence of decline compared with premenopausal women.

The right and left limb results in the present study were relatively similar, although the left side showed slightly higher mean values in all three reach directions. The composite score was $73.36 \pm 6.26\%$ on the right side and $73.69 \pm 6.83\%$ on the left side. These small differences describe the performance pattern of the participants but should not be interpreted as clinically meaningful side-to-side differences without further analysis. The findings therefore suggest generally comparable dynamic balance performance between the two limbs within this sample.

The reliability of the MSEBT is another important consideration when interpreting the findings. Onofrei *et al.* reported good to excellent within-session reliability of the modified Star Excursion Balance Test, supporting its use for assessing dynamic balance performance.^[5] This strengthens the methodological basis for using the MSEBT as a

functional assessment tool. However, much of the available reliability evidence has been obtained from healthy or athletic populations, highlighting the need for further research specifically involving postmenopausal women. 19 Postural balance in postmenopausal women is influenced by multiple physical and functional factors. Cangussu *et al.* examined postural balance in postmenopausal women in relation to bone health, demonstrating the relevance of balance assessment in this population. [8] Similarly, the literature indicates that balance should be considered as a multifactorial function rather than being attributed to a single factor. Therefore, the MSEBT findings in the present study represent dynamic balance performance at the time of assessment and should not be used alone to identify an individual's risk of falling.

Iolascon *et al.* highlighted that fall risk among postmenopausal women is multifactorial and may involve factors such as balance, muscle strength, previous falls, visual factors, medications, and other health-related conditions. [3] In this context, the MSEBT can be considered as one component of functional assessment rather than a direct measure of fall risk. Its ability to challenge dynamic postural control makes it useful for identifying movement and balance performance that may require further physiotherapy assessment.

Overall, the present study provides descriptive information regarding dynamic balance in community-dwelling postmenopausal women aged 50–65 years. The overall mean MSEBT score was $73.47 \pm 6.68\%$, with anterior reach demonstrating higher mean values and posteromedial reach demonstrating lower values on both sides. These findings highlight the directional nature of dynamic balance performance in this population. From a physiotherapy perspective, the MSEBT may be incorporated as part of functional screening to assess dynamic postural control and to identify areas that may benefit from further assessment or preventive intervention.

It is important to note that the present study did not establish population-specific normative values or clinical cut-off scores for postmenopausal women. Therefore, the observed percentages should be interpreted as descriptive performance values rather than being classified as normal or abnormal. Further studies involving larger and more diverse populations, along with variables such as physical activity, lower-limb strength, fear of falling, previous falls, menopausal symptoms, and training or functional status, may provide a more comprehensive understanding of dynamic balance in postmenopausal women.

Limitations

- The study included postmenopausal women aged 50–65 years; therefore, the findings may not be applicable to younger or older postmenopausal women.
- The study assessed dynamic balance but did not evaluate actual fall incidence or prospective fall risk.
- Factors that may influence balance, such as physical activity level, muscle strength, fear of falling, and severity of menopausal symptoms, were not specifically evaluated.
- The study did not include pre-menopausal women or assess balance before and after menopause; therefore, it

could not determine whether menopause itself affects dynamic balance.

- The study was descriptive in nature, so causal relationships and population-specific normative or clinical cut-off values could not be established.

Conclusion

The present study concluded that the MSEBT is a practical tool for assessing dynamic balance in postmenopausal women. Among 150 participants, the overall mean MSEBT score was $73.47 \pm 6.68\%$, with the highest performance in the anterior and lowest in the posteromedial direction. Composite scores were $73.36 \pm 6.26\%$ for the right and $73.69 \pm 6.83\%$ for the left lower limb, showing slightly better left-limb performance. Overall, the findings demonstrate directional and limb-wise variations in dynamic balance. The scores represent descriptive performance values, as no normative or clinical cut-off values were established.

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