

[Sports Physical Therapy]

Dynamic Balance Differences as Measured by the Star Excursion Balance Test Between Adult-aged and Middle-aged Women

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Background: Middle-aged women have less postural control than younger women. The Star Excursion Balance Test is a functional and inexpensive postural control measurement tool that is sensitive to age-related changes in balance.

Hypothesis: The middle-aged females will experience lower excursion scores compared with the younger women.

Methodology: Fifty-three healthy, recreationally active women were divided into 2 groups: adult-aged (n = 29; age range, 23-39 years) and middle-aged (n = 24; age range, 40-54 years). Each participant performed 3 reaches for 3 trials (anteromedial, medial, posteromedial) in a randomized order. The 3 reach trials were converted to a normalized value (percentage of participant's height) and assessed as an overall mean for the 1-way analysis of variance. Intraclass correlation coefficients and 95% confidence intervals were calculated.

Results: No differences were found for body mass index and height; however, age was different between groups ($P < 0.01$). Intraclass correlation coefficient^{2,3} values for the 3 directions ranged from 0.72 to 0.97. The adult-aged women were able to reach farther in all 3 directions when tested with the Star Excursion Balance Test (6.8-7.6 cm, $P < 0.05$).

Conclusion: Lower postural control scores based on the Star Excursion Balance Test were found for the older women. The younger women were able to reach approximately 7 cm farther during the anterior, anteromedial, and posteromedial excursions.

Keywords: postural control; dynamic balance; women; Star Excursion Balance Test

Postural control decreases with age.^{9,26,28,43} The greatest decrease in balance in 60- to 70-year-old women occurs with eyes closed during a single-limb stance.³² Computerized dynamic posturography was used in elderly individuals to show that they were less stable and that they exerted more hip strategy during a dynamic balance test compared with middle-aged and younger adults.³⁰ Age-related effects on balance have been found at 40 years of age.³¹ The most significant decline in medial-lateral balance occurs in women between 40 and 60 years of age.³⁴ Before the age of 50 years, women begin to experience decreased quadriceps and hip strength as well as reduced somatosensory function.³¹ Dynamic balance tests have been developed to predict fall risk primarily in the elderly.^{3,37,42,46} There are less common dynamic tests for the older adult: rapid step test,³³ alternate step test,⁷ lateral rhythmic step,¹⁹ and side step.¹¹ Balance assessment

should be reliable, valid, and easy while identifying those at risk for falls.

The Star Excursion Balance Test (SEBT), a dynamic single-limb balance test, has been used in athletic^{6,10,35,36,38,45} and recreationally active college-aged populations.[†] Studies have shown dynamic balance decreases with age.^{5,21,44}

Since women appear to exhibit a decline in dynamic balance in their mid-40s, a fall prevention program may be beneficial. To help identify those at risk, the aim of this study was to determine if dynamic balance as measured by the SEBT is affected by age. The hypothesis was that an increase in age would lower excursion scores, indicating poorer dynamic balance.

[†]References 8, 13-16, 18, 20, 22-24, 27, 39, 40.

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METHODS

Dynamic Postural Control Testing

A convenience sample of 56 women between the ages of 23 and 54 years was recruited for the study using flyers distributed throughout the university and surrounding community. Inclusion criteria included healthy, recreationally active women without formal balance training. These women participated in recreational activities 3 to 5 times a week for at least 30 minutes per day. The exclusion criteria were musculoskeletal, cardiovascular, vestibular, visual, or neurologic disorder (multiple sclerosis, vertigo, or dizziness).

The study sample was divided into 2 groups: adult women (range, 23-39 years; mean, 30.4 years) and middle-aged women (range, 40-54 years; mean, 46.6 years). The university institutional review board approved the study protocol, and written informed consent was obtained from all individuals before participation.

Protocol

The SEBT is a dynamic postural control test that requires balance on 1 leg with maximum reach of the opposite limb.¹² The SEBT has been found to have high interrater reliability, ranging from intraclass correlation coefficient (ICC) values of 0.67 to 0.96, and high intrarater reliability, 0.81 to 0.93.^{23,27} A verbal and visual demonstration of the SEBT was provided to each participant by the investigator. There are 8 directions for the stance leg; only 3 directions were assessed in this study. Eight directions are redundant, so excursions were limited to anteromedial, medial, and posteromedial (Figure 1).²² Participants warmed up using a stationary bike for 5 minutes at a self-selected pace. Following the warm-up, each participant was asked to stand on her dominant limb in the center of the Combo grid (Engineering Fitness International, Inc, San Diego, California). Four practice trials for each of the 3 excursions were performed.⁴⁰ Following a rest break, participants completed 3 trials in randomized order with a 10-second break between trials and 20 seconds between directions. The trial was completed when the participant returned to the starting position by placing the reaching leg within 5 in. (12.7 cm) of the stance leg. The trial was repeated if she lost balance, lost foot contact, or was unable to return the reaching foot to the starting position. Reach distance was normalized to the participant's leg length.¹³

Statistical Analysis

Descriptive statistics, analyses of variance, and ICCs with 95% confidence intervals were calculated using SPSS 18.0 (IBM Corporation, Somers, NY). Descriptive statistics were reported as means \pm standard deviations for all participants. One-way analyses of variance were used to determine differences for age, height, and body mass index. The 3 trials for each of the 3 excursions (anteromedial, medial, and posteromedial) were converted to a mean for each direction, and the overall mean was used for analysis. A 1-way analysis of variance

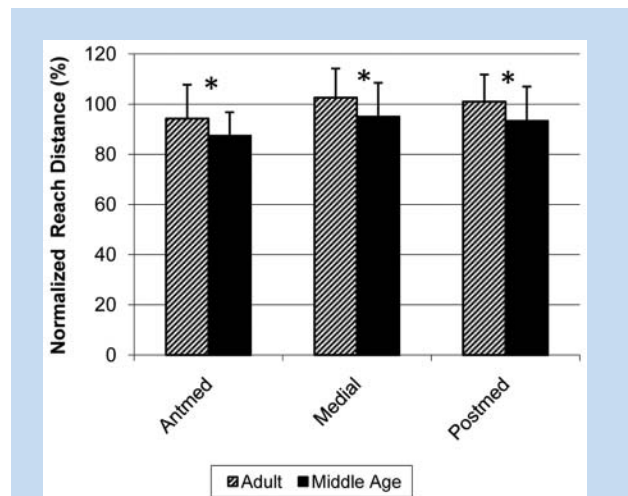


Figure 1. Normalized reach distance (reach divided by leg length \times 100) between adult women ($n = 29$, mean age = 30.4 years) and middle-aged women ($n = 24$, mean age = 46.6 years). * $P < 0.05$ (between groups).

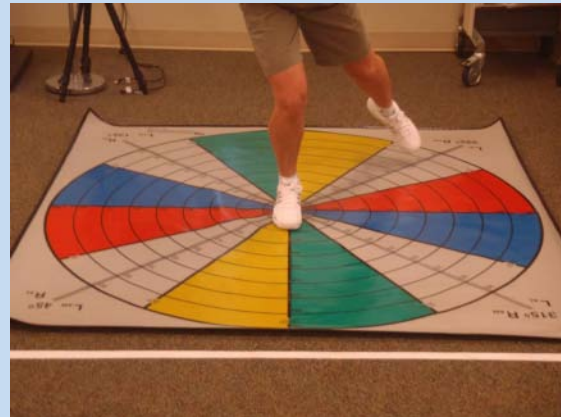


Figure 2. The posteromedial reach of the Star Excursion Balance Test. The participant stands on the dominant limb and reaches as far as possible with the nondominant limb.

was performed on the 3 excursions to determine age-related differences. The ICCs and 95% confidence intervals were calculated using the 2-way random model. The ICC_{2,3} model using the "average measures" output from SPSS was used to calculate the reliability across 3 repetitions for each direction. The significance level was set a priori at $P < 0.05$.

RESULTS

There was a statistical difference for only age between the 2 groups ($P < 0.01$) (Table 1). The reliability analysis across the 3 repetitions for each direction resulted in ICC_{2,3} values ranging

Table 1. Description of adult and middle-aged women.

Variable	Adult ^a	Middle-Aged ^b
Age, y	30.4 ± 6.73	46.6 ± 3.95
Height, m	1.7 ± 0.07	1.7 ± 0.10
Body mass index, kg/m ²	24.7 ± 5.54	25.1 ± 4.43
Anteromedial ^c	89, 99	83, 91
Medial ^c	98, 106	90, 101
Posteromedial ^c	97, 105	88, 99

^aAdult women, 23 to 39 years; n = 32.

^bMiddle-aged women, 40 to 54 years; n = 24.

^cConfidence interval, 95%.

from 0.72 to 0.97, with the standard error of measurement value between 1.7 and 2.7 cm (Table 2). The data suggest moderately high to high reliability across all directions between the 2 groups.

The adult group was able to reach significantly farther in the anteromedial direction (94.2 ± 13.5 cm vs 87.4 ± 9.4 cm; *F* = 4.41, *P* = 0.04), posteromedial direction (101.02 ± 10.8 cm vs 93.4 ± 13.7 cm; *F* = 5.15, *P* = 0.03), and medial direction (102.6 ± 11.6 cm vs 95.4 ± 13.5 cm; *F* = 4.35, *P* = 0.04) (Figure 1).

DISCUSSION

The study shows that with an increase in age, dynamic balance declines in healthy women. The adult-aged women reached approximately 7 cm farther than the middle-aged group for each of the 3 excursions (anteromedial, medial, and posteromedial). There is a negative relationship between the SEBT and age after 60 years, and 48% of the excursion variance could be explained by age.⁴⁴ Differences were found between young and middle-aged participants. Age-related declines in standing balance have been reported in healthy older adults.^{4,41,47}

The SEBT has been used to predict lower extremity injury risk in high school basketball^{6,36} and soccer,^{6,10,45} ACL injuries,²¹ and chronic ankle instability^{18,22,24,35} to assess deficits in dynamic balance control.^{1,2,6,14,18,24,35,38} The SEBT has also been used in healthy, recreationally active individuals over the age of 30 years.^{5,21,44} Women over 40 years have greater instability and decreased joint position sense, thus justifying the screening of women for balance deficits before the age of 60 years to minimize fall risks.²⁵

It is unclear whether the shorter excursions among the middle-aged women are clinically significant. College-aged students were able to reach approximately 10 cm farther than the women tested in this study,²⁹ while other studies reported shorter reach distances in all 3 directions in college-aged individuals.^{13,40} The studies are difficult to compare because of the variability in methodology and participant demographics.

Table 2. Interrater repeatability for adult and middle-aged women among 3 excursions.^a

Excursion	ICC _{2,3} (95% CI)	SEM
Anteromedial		
Adult	0.97 (0.94-0.98)	2.50
Middle-aged	0.94 (0.89-0.97)	1.91
Medial		
Adult	0.95 (0.91-0.97)	2.16
Middle-aged	0.72 (0.53-0.85)	2.75
Posteromedial		
Adult	0.95 (0.90-0.97)	2.00
Middle-aged	0.96 (0.92-0.98)	2.80

^aICC, intraclass correlation coefficient; CI, confidence interval; SEM, standard error of measurement.

The smaller excursion in the middle-aged group may be the result of decreased lower extremity strength or range of motion.^{39,45} Poor balance has been found in men with hip and trunk stiffness.¹⁷ Hip and knee flexion can account for 62% to 89% of variance in the anteromedial, medial, and posteromedial directions for college-aged individuals.³⁹

Four weeks of neuromuscular training—including range of motion, strength and balance training, and functional exercises—had a beneficial effect on SEBT performance in individuals with chronic ankle instability.¹⁸ Eight weeks of neuromuscular training was beneficial among high school soccer players.¹⁰ Balance is maintained by multiple systems (vestibular, visual, and somatosensory) that must act on the musculoskeletal system to produce postural changes. We postulated that if one of these systems was limited—namely, vision—then excursion scores would decrease particularly among the middle-aged group (ie, participants' visual field is limited when they perform the SEBT in posterior-related directions, because to complete the movement, they must move their limb backward and are thus unable to see the rays that they are asked to follow).

A significant limitation to our study is the lack of range of motion and strength data. This study also did not assess trunk and lower extremity flexibility. We also do not know how joint angle, muscle, or kinetic patterns are affected by age using the SEBT.

CONCLUSION

Dynamic balance measured by excursion distance using the SEBT appears to decrease with age from adulthood to middle age among women. Postural control assessment of this population may justify proactive measures to minimize fall risk.

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