Kinematic Analysis of Selected Reach Directions of the Star Excursion Balance Test Compared With the Y-Balance Test

Karl Fullam, Brian Caulfield, Garrett F. Coughlan, and Eamonn Delahunt

Context: The Star Excursion Balance Test (SEBT) and the Y-Balance Test (YBT) have 3 common reach directions: anterior (ANT), posteromedial (PM), and posterolateral (PL). Previous research has indicated that reach-distance performance on the ANT reach direction of the SEBT differs from that on the YBT. Kinematic patterns associated with the ANT reach direction of the SEBT and YBT need to be investigated to fully understand this difference, along with the PM and PL reach directions, to deduce any kinematic discrepancies between the 2 balance tests. Objective: To compare and contrast the kinematic patterns associated with test performance on the reach directions common to the SEBT and YBT. Design: Controlled laboratory study. Setting: University laboratory. Participants: 15 healthy male (age 23.33 ± 2.02 y, height 1.77 ± 0.04 m, body mass 80.00 ± 9.03 kg) and 14 healthy female (age 21.14 ± 1.66 y, height 1.63 ± 0.06 m, body mass 59.58 ± 7.61 kg) volunteers. Intervention: Each participant performed 3 trials of the ANT, PM, and PL reach directions of the SEBT and YBT on their dominant leg. Main Outcome Measures: Sagittal-plane lower-limb kinematic profiles were recorded using a 3-D motion-analysis system. Reach distances were also recorded for each reach direction. Results: A significant main effect (P < .05) was observed for test condition with participants reaching farther on the ANT reach direction of the SEBT compared with the YBT. While reaching in the ANT direction participants were characterized by a more flexed position of the hip joint at the point of maximum reach on the YBT (27.94° ± 13.84°) compared with the SEBT (20.37° ± 18.64°). Conclusions: Based on these observed results, the authors conclude that test performance on the SEBT and YBT differ in terms of dynamic neuromuscular demands, as evidenced by differences in reach distances achieved in the ANT reach direction and associated test kinematic profile.

Keywords: postural stability, lower-limb injury, kinematics

It is well established in the published literature that decreased static and dynamic postural stability are risk factors for lower-limb injury. In a prospective study, McGuine et al demonstrated that female basketball players characterized by higher postural-sway-velocity scores than their peers incurred nearly 7 times as many ankle sprains. Plisky et al measured dynamic-postural-stability performance of high school basketball players using selected directions of the Star Excursion Balance Test (SEBT). Logistic-regression models indicated that players with an anterior right/left reach distance difference greater than 4 cm were 2.5 times more likely to sustain a lower-extremity injury. Furthermore, female athletes with a composite reach distance less than 94% of their limb length were 6.5 times more likely to have a lower-extremity injury. In a more recent prospective study involving elite Australian football players, Hrysomallis et al indicated that players with an increased mediolateral center-of-pressure excursion incurred at least twice as many ankle-ligament injuries as those with average or good postural stability.

Postural-stability testing is an integral component of clinical practice. Recent evidence suggests that traditional laboratory measures of postural stability including static single-leg stance on instrumented force plates may not be sensitive enough to detect postural-stability deficits associated with lower-limb injury. Furthermore, Hrysomallis indicated that postural-stability performance in static positions cannot be extrapolated to dynamic-postural-stability performance, concluding that it is not advisable to infer dynamic-postural-stability proficiency based on static-postural-stability performance. Thus, the benefit of using instrumented force-plate measures of static postural stability may be limited, which is furthermore confounded by the limited accessibility of clinicians to such measurement techniques.

The SEBT is an established outcome measure of dynamic postural stability that assesses a combination...
of range of motion, flexibility, neuromuscular control, and strength. Performance on the SEBT requires an individual to move from a position of bilateral stance to a position of single-leg stance whereby the non-test limb is used to reach maximally making a light touch along 1 of 8 designated lines on the ground and then return to a position of bilateral stance. The primary outcome measure is how far subjects can reach along each designated line without compromising their postural stability. The SEBT has been shown to be a reliable measure of dynamic postural stability, with test-retest intraclass correlations ranging from 0.89 to 0.93 and coefficients of variation ranging from 3.0% to 4.6%, thus indicating good measurement stability. It has previously been used as a discriminative tool for identifying dynamic-postural-stability deficits in individuals with chronic ankle instability, whereby decreased reach distance in certain directions correctly predicted group membership in 80% of subjects with chronic ankle instability and 73.3% of healthy subjects. Furthermore, the SEBT has recently been used to differentiate dynamic-postural-stability performance in anterior cruciate ligament (ACL) deficient and ACL-reconstructed athletes.

A recent systematic review outlined specific recommendations for the use of the SEBT in clinical and research environments. However, there are a number of limitations to the test when it is conducted in its entirety, as 48 reaches are required for full test completion (3 reaches each in 8 directions performed bilaterally), thus rendering performance of the test protocol time-consuming in clinical practice. Based on this time constraint, Hertel et al subsequently showed that the anterior (ANT), posteromedial (PM), and posterolateral (PL) reach directions capture the least redundant information and can be used to simplify the test’s performance and administration. Furthermore, a recent systematic review recommends that the ANT, PM, and PL reach distances be used for clinical research. To improve the efficiency of administration of the ANT, PM, and PL reach directions of the SEBT in clinical and research environments, a commercial product called the Y Balance Test (YBT) has been developed. While both tests are commonly used clinical measures that are based on the same paradigm (ie, dynamic balance is an essential element of musculoskeletal assessment), the performance on each test involves different equipment. Performance of the ANT, PM, and PL reach directions of the SEBT can be easily quantified using tape measures applied to a solid support surface. In contrast, performance of the ANT, PM, and PL reach directions of the YBT requires the subject to slide a reach indicator along a calibrated pipe while standing on a raised support surface. The theory behind the use of the sliding reach indicator relates to the potential limitation of the touch-down aspect of the SEBT, whereby the actual amount of pressure applied through the non-test limb at the point of maximal is difficult to control.

As a modified version of the ANT, PM, and PL reach directions of the SEBT, the YBT should produce similar results in the reach distances achieved. However, a recent study indicated that this is not the case. It was reported that participants reached farther in the ANT reach direction of the SEBT than the ANT reach direction of the YBT. This study evaluated reach distance only and did not investigate the kinematic patterns associated with test performance. The differing results in reach distance achieved on the ANT reach direction may be explained by differences in the kinematic pattern and warrant further investigation.

Thus, the aim of the current study was to compare the reach distances achieved on the ANT, PM, and PL reach directions of the SEBT and YBT and to then investigate the kinematic pattern associated with test performance on these reach directions if a significant difference was observed in the reach distance achieved.

Methods

Participants

Ethical approval was obtained from the university’s Human Research Ethics Committee. Fifteen healthy male participants (age 23.33 ± 2.02 y, height 1.77 ± 0.04 m, body mass 80.00 ± 9.03 kg, body-mass index 25.47 ± 2.20 kg/m²) and 14 healthy female participants (age 21.14 ± 1.66 y, height 1.63 ± 0.06 m, body mass 59.58 ± 7.61 kg, body-mass index 22.57 ± 3.06 kg/m²) from the local university population volunteered to participate. Inclusion criteria for the study required participants to be age 18 to 30 years with no history of lower-limb injury in the past 3 months and no history of neurological or balance disorder or lower-limb fracture. Before formal testing each participant read an information leaflet, signed an informed-consent form, and was given an outline of the test procedures and familiarized with the testing apparatus by the lead investigator.

SEBT/YBT Protocol

The protocol used for the completion of the SEBT/YBT is similar to that previously described. Participants reported to the laboratory in shorts and T-shirt for a single test session. Each participant’s anthropometric measurements were then taken. The participant’s height, weight, pelvic width (anterosuperior iliac spine to anterosuperior iliac spine), and pelvic depth (anterosuperior iliac spine to posterosuperior iliac spine) were measured. Limb length (anterosuperior iliac spine to the center of the ipsilateral medial malleolus), thigh length (greater trochanter to lateral knee joint line), shank length (lateral knee-joint line to medial joint line), knee width (lateral joint line to medial joint line), and ankle width (lateral malleolus to medial malleolus) were all measured in supine lying. Participants were then randomized to perform either the SEBT or YBT first. The SEBT reach directions were evaluated by affixing 3 tape measures to the laboratory floor, 1 oriented anteriorly (ANT) to the apex and the other 2 aligned at 135° to this in the PM and PL directions (Figure 1).
Performance on the YBT was evaluated using a commercially available device (Y Balance Test, Move 2 Perform, Evansville, IN; Figure 2). Participants reached with the nondominant leg, and test direction was randomized at each test session. All testing was conducted barefoot to eliminate additional balance support and stability from shoes. As in the YBT, the anterior border of the participants’ feet was placed at the convergence of the reach-direction lines at the second toe. The test was demonstrated by a member of the research team before the participant completed 4 practice trials in each direction on the dominant leg. Completing practice trials has previously been reported to decrease the learning effect without hindering an individual’s ability to perform the test.\textsuperscript{13} After the completion of the test trials, each participant was given a 2-minute rest period and then conducted 3 test trials in each direction. A trial was classified as invalid if the participant removed the hands from the hips, did not return to the start position, applied sufficient weight through the reach foot so as to gain an increase in reach distance (SEBT), placed the reach foot on the ground either side of the line or tube, raised or moved the stance foot during the test, or kicked the plate with the reach foot to gain more distance (YBT). If an invalid trial occurred, the participant repeated the trial and data for the invalid trial were discarded. Reach distances were measured from the start point to the point of maximum reach and observed and noted by the investigator on the SEBT. The point of maximum reach on the YBT was where the plate rested when the subject had returned to the start position after carrying out the reach, which was also noted after each reach by the investigator. Reach distances on both tests were normalized to limb length by calculating the maximized reach distance (%MAXD) using the formula (Reach distance/limb length) \times 100 = \% MAXD.\textsuperscript{13}

**Kinematic Analysis**

Kinematic-data were acquired at 200 Hz using 3 CODA cx1 units (Charnwood Dynamics Ltd, Leicestershire, UK). All participants were tested in similar conditions, with the CODA cx1 units placed in the same position in the laboratory for both the YBT and SEBT tests. The CODA markers and marker wands were then applied to the body as outlined by Monaghan et al.\textsuperscript{14,15} Application of the markers and marker wands was carried out by the same investigator for all participants, with the specific marker and wand setup being detailed in previous research.\textsuperscript{16–18} The participants were then positioned in a neutral stance position for 10 seconds. This trial was used to align the participant with the laboratory coordinate system and to function as a reference position for subsequent kinematic analysis.

Kinematic data were calculated by comparing the angular orientations of the coordinate systems of adjacent limb segments using the angular coupling set “Euler angles” to represent clinical rotations in 3
dimensions. Marker positions within a Cartesian frame are processed into rotation angles using vector algebra and trigonometry (CODA cx1 User Guide, Charnwood Dynamics Ltd, Leicestershire, UK). Joint angular displacements were calculated for the hip, knee, and ankle joints in the sagittal plane. Kinematic data were analyzed using CODA software, with the following axis convention: y-axis = sagittal-plane motion. Kinematic data at the point of maximum reach for each SEBT and YBT trial were extracted, with the average of the 3 trials for each participant for each direction and each kinematic variable being used for analysis. Group profiles for the SEBT and YBT were then calculated for sagittal-plane angular displacement of the participants’ dominant leg. The rationale for undertaking analysis of sagittal-plane angles only relates to previously published work of Robinson and Gribble,13 who indicated that the combination of hip-joint and knee-joint flexion accounts for 78% of the variance in reach distance achieved on the ANT reach direction of the SEBT.

Statistics

Reach Distance. A 1-way multivariate analysis of variance (MANOVA) was conducted to explore the impact of test condition on performance of the ANT, PM, and PL reach directions of the SEBT and YBT. The categorical independent variable was test condition (ie, SEBT vs YBT). The continuous dependent variables were reach distance in the ANT, PM, and PL reach directions of the SEBT and YBT. When a significant effect was observed on the multivariate tests, the results of the between-subjects effects (ie, SEBT vs YBT) were investigated using a Bonferroni adjustment (P < .017) in accordance with the recommendations of Tabachnick and Fidell.19

Kinematics. Paired-samples t tests were conducted to evaluate the effect of test condition (ie, SEBT vs YBT) on sagittal-plane hip-, knee-, and ankle-joint angular displacement at the point of maximum reach for the ANT reach direction. (Based on analysis of the reach-distance results it was decided that kinematic analysis would only be undertaken on the ANT reach direction.)

Level of Agreement Between the Measures. Pearson correlations and Bland and Altman assessments for agreement were used to compare performance on the ANT, PM, and PL reach directions of the SEBT and YBT.

Correlation Between Reach Distance and Kinematics. Pearson correlations were calculated to examine the relationship between sagittal-plane hip-, knee-, and ankle-joint angular displacement and performance on the ANT reach direction of the SEBT and YBT.

Results

Reach Distance

Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance matrices, and multicollinearity, with no serious violations noted. When the dependent variables were considered as a whole there was a statistically significant difference between performance on the SEBT and YBT, $F_{3.54} = 10.53$, $P < .01$, Wilks’s Lambda = 0.63, partial eta squared = .36. When the results of the dependent variables were considered separately, the only difference to reach statistical significance, using a Bonferroni-adjusted alpha level of .017, was the ANT reach direction, $F_{1.56} = 31.26$, $P < .017$, partial eta squared = .36. An inspection of the mean scores indicated that participants reached farther on the ANT reach direction of the SEBT (67.05% ± 4.97%MAXD) compared with the ANT reach direction of the YBT (59.74% ± 4.85%MAXD). These results are displayed in Table 1. No significant differences were observed for the PM and PL reach directions on the SEBT and YBT ($P > .05$). Furthermore, the individual results of each participant were examined to determine if all subjects achieved a greater reach distance on the ANT direction of the SEBT than on the YBT. Results of this analysis indicated that 28 of the 29 participants achieved a greater reach distance on the SEBT than on the YBT (Figure 3).

Kinematics

There was a statistically significant difference in sagittal-plane hip-joint angular displacement at the point of maximum reach between the ANT reach direction of the SEBT (20.37° ± 18.63°) and the ANT reach direction of the YBT (28.32° ± 13.19°). The mean difference between test conditions was 7.95°, with a 95% confidence interval ranging from −15.60 to −0.30. The eta-squared statistic (.15) indicated a large effect size. No statistically significant difference was observed between the sagittal-plane

| Table 1 Reach-Distance Results, % Maximized Reach Distance, N = 29 |
|-----------------|-----------------|-----------------|-----------------|
|                 | Anterior        | Posterolateral  | Posteromedial   |
| SEBT            | 67.05 ± 4.97    | 99.71 ± 8.67    | 106.14 ± 7.94   |
| YBT             | 59.74 ± 4.85*   | 99.53 ± 9.81    | 102.87 ± 9.24   |

Abbreviations: SEBT, Star Excursion Balance Test; YBT, Y-Balance Test.

*Significantly different from SEBT.
knee-joint (mean difference between test conditions was 5.61°, with a 95% CI ranging from –11.76 to 0.52) and ankle-joint (mean difference between test conditions was 1.63°, with a 95% CI ranging from –4.49 to 1.22) angular displacements at the point of maximum reach between the ANT reach direction of the SEBT and the ANT reach direction of the YBT \((P > .05)\). The sagittal-plane angular displacement of the hip, knee, and ankle can be observed in Table 2.

**Level of Agreement Between the Measures**

The Bland-Altman test results are shown in Table 3. The Bland-Altman analysis showed that the mean difference between the ANT reach distance on the SEBT and YBT was 7.31%, with a 95% limit of agreement ranging from –0.35% to 14.97%, thus indicating that the reach distance on the ANT reach direction of the SEBT was on average greater than the ANT reach direction of the YBT. The Bland-Altman analysis showed that the mean difference between the PL reach distance on the SEBT and YBT was 0.17%, with a 95% limit of agreement ranging from –11.19% to 11.53%. The Bland-Altman analysis showed that the mean difference between the PM reach distance on the SEBT and that on the YBT was 3.26%, with a 95% limit of agreement ranging from –4.16% to 10.68%.

The relationship between reach distance achieved on the ANT, PM, and PL reach directions of the SEBT and YBT was investigated using Pearson product–moment correlation coefficients. There was a statistically significant correlation between reach distance achieved in the ANT \((r = .68, n = 29, P < .01)\), PM \((r = .91, n = 29, P < .01)\), and PL \((r = .80, n = 29, P < .01)\) reach directions of the SEBT and YBT.

**Figure 3** — Anterior (ANT) reach direction (% maximized reach distance [MAXD]). Abbreviations: SEBT, Star Excursion Balance Test; YBT, Y-Balance Test.

The relationship between reach distance achieved on the ANT, PM, and PL reach directions of the SEBT and YBT was investigated using Pearson product–moment correlation coefficients. There was a statistically significant correlation between reach distance achieved in the ANT \((r = .68, n = 29, P < .01)\), PM \((r = .91, n = 29, P < .01)\), and PL \((r = .80, n = 29, P < .01)\) reach directions of the SEBT and YBT.

**Correlation Between Reach Distance and Kinematics**

The relationship between reach distance achieved on the ANT reach direction of the SEBT and YBT and corresponding sagittal-plane angular displacement at the hip, knee, and ankle joints is presented in Table 4. No statistically significant relationships between sagittal-plane angular displacement at the hip, knee, and ankle joints and reach distance achieved on the ANT reach direction of the SEBT and YBT were observed. Of note, however, was that there was a negative correlation \((r = –.06, r^2 = 0.36, n = 29, P > .01)\) between hip-joint flexion angle and reach distance achieved on the ANT reach direction of the SEBT, while a positive correlation \((r = .43, r^2 = 18.49, n = 29, P > .01)\) between hip-joint flexion angle and reach distance achieved on the ANT reach direction of the YBT was observed (Table 4).
The primary aim of the current study was to compare the reach distances achieved on the ANT, PM, and PL reach directions of the SEBT and YBT and to then investigate the kinematic pattern associated with test performance on these reach directions if a significant difference was observed in the reach distance achieved. The associated hypothesis was that the kinematic patterns associated with test performance on the SEBT and YBT would differ and may account for differences in test reach-distance performance. The main finding of this investigation was that the reach distance achieved on ANT reach direction and associated sagittal-plane angular displacement at the hip joint differed significantly between the SEBT and YBT. These findings have implications for the interpretation of the SEBT and YBT in a healthy population and provide a rationale for differences in reach-distance performance observed between the 2 tests.

A recent study found that participants achieved a greater reach distance on the ANT reach direction of the SEBT compared with the YBT, with the authors hypothesizing that these differences may be due to disparities in postural-control strategies when undertaking the tests.12

The results of the current study concur with the findings of Coughlan et al,12 whereby it was observed that participants achieved a reach distance of 67.05% ± 4.97% MAXD on the SEBT compared with 59.74% ± 4.85% MAXD on the YBT. In addition to the differences in reach distance achieved on the ANT reach direction, it was also observed that participants were characterized by a less flexed position of the hip joint at the point of maximum reach during performance of the ANT reach direction, it was also observed that participants were characterized by a less flexed position of the hip joint at the point of maximum reach during performance of the ANT reach direction of the SEBT compared with the YBT (20.37° ± 18.63°) compared with the YBT (27.94° ± 13.84°). In an effort to further elucidate the influence of sagittal-plane hip-joint angular displacement on reach distance achieved in the ANT reach direction, Pearson correlations were calculated to examine the relationship between sagittal-plane hip-joint angular displacement and performance on the ANT reach direction of the SEBT and YBT. Results of this analysis revealed that there was a negative correlation between reach distance on the ANT reach direction of the SEBT and hip-joint sagittal-plane angular displacement, whereas there was a positive correlation between reach distance on the ANT reach direction of the YBT and hip-joint sagittal-plane angular displacement. Consequently, for the ANT reach direction of the SEBT, reach distance achieved is inversely proportional to the degree of hip-joint flexion (ie, as hip-joint-flexion angle increases, reach distance achieved decreases). The opposite applies to performance on the ANT reach direction of the YBT, whereby reach distance achieved is directly proportional to the degree of hip-joint flexion.

The results of the Pearson correlations would suggest that the increased hip-joint flexion at the point of maximum reach while performing the ANT reach direction of the YBT partly contributes to the observed decreased reach distance compared with the ANT reach direction of the SEBT. At the beginning of the ANT reach direction of the SEBT, the individual’s reach leg commences the initial movement.
along the ground and hip flexion on the stance leg is minimal (Figure 4). However, hip-joint flexion is immediately required while performing the ANT reach direction of the YBT, as the individual must initiate movement of the reach indicator, which is primarily achieved by flexing the stance leg’s hip and knee joints (Figure 5). The individual also requires greater amounts of hip flexion to maintain contact with the YBT reach indicator throughout the completion of the excursion in this reach direction, owing to the position of the support surface, and subsequently may not reach as far compared with the SEBT. In addition, as part of the SEBT protocol, the individual may only place a slight downward pressure through the reach foot at the end of the reach excursion and would therefore be inclined to limit trunk and hip flexion on the stance leg to prevent losing stability at the point of maximum excursion. A study by Farrohki et al. supports this observation, whereby subjects performing a lunge with trunk extension were characterized by less hip-joint flexion (79.7° ± 11.5°) than with a lunge performed with trunk flexion (107.9° ± 9.7°). Thus, it is likely that a change in the position of participants’ center of mass as a consequence of trunk position is likely to influence their hip-joint kinematics. Although we did not measure trunk position, we hypothesize that the observed decreased hip-joint flexion while performing the ANT reach direction of the SEBT may result in less anterior displacement of participants’ center of mass, which may allow them to achieve a greater reach distance, with the position of their center of mass essentially acting as a counterbalance to their reaching leg.

Gribble et al. contest that hip- and knee-joint sagittal-plane angular displacement appear to provide important contributions to performance on selected reach directions of the SEBT. In the current study, participants exhibited greater knee-joint sagittal-plane angular displacement at the point of maximum reach in the ANT direction in the YBT (59.59° ± 13.05°) than with the SEBT (53.97° ± 15.54°), although this finding was not significant. Despite subjects’ not reaching as far in the YBT, it appears that the test requires greater levels of dynamic hip- and knee-joint-flexion range of motion than the SEBT. These findings may influence the selection of an appropriate postural-stability test in the clinical assessment and/or rehabilitation of pathological populations. For example, in the early stages of rehabilitation from knee surgery, the therapist may wish to limit the amount of lower-limb mobility and focus on regaining neuromuscular stability in smaller ranges. Therefore, using the YBT may place the participant at risk and consequently the use of the SEBT may be more favorable. The increased hip-joint flexion at the point of maximum reach on the ANT reach direction of the YBT when compared with the SEBT will result in a smaller knee-flexion moment, due to the position of the center of mass relative to the knee-joint center. Consequently, during performance of the ANT reach direction of the YBT a decreased quadriceps-derived extension moment will be necessitated to control knee-joint position. This is particularly relevant after knee-joint surgery, when quadriceps weakness and
inhibition are a common clinical finding. Alternatively, for patients demonstrating deficits in lower-limb mobility, the integration of the YBT as a rehabilitation exercise may be more prudent.

Even though the reliability of the SEBT and YBT has been established, we contest that it is up to clinicians to decide which test to use with their athletes. The results of the current study cannot clarify which test is preferential, but the current study does offer the scientific community some reasons as to why differences in reach distance in the ANT reach direction are observed between performances on the SEBT and YBT. The results of the current study suggest that the extrapolation of test results from the ANT reach direction of the SEBT to the anterior reach direction of the YBT and vice versa is not advisable. This is highlighted by the Bland-Altman analysis, which showed that the mean difference between the ANT reach distance on the SEBT and YBT was 7.31%, with a 95% limit of agreement ranging from −0.35% to 14.97%, indicating that the reach distance on the ANT reach direction of the SEBT was on average greater than the ANT reach direction of the YBT. The mean differences between the PM and PL reach directions on the SEBT and YBT were 0.17% and 3.26%, respectively. These results are further compounded by the Pearson product–moment correlations between reach distances achieved on the ANT, PM, and PL reach directions of the SEBT and YBT, which were .68, .91, and .80 respectively.

There is a number of limitations to this investigation. The existence of differences between men and women in a variety of dynamic and functional measures related to physical performance is well established. Differences in reach-distance performance have been reported between genders when they are not normalized by height and limb length. Although we accounted for this, differences have also been found in kinematic patterns, with women having a greater hip-flexion range (29.10° ± 4.24°) than men (11.43° ± 4.24°) in the ANT reach direction, which the authors proposed may be due to better activation of vasti muscles in women. Future studies should potentially evaluate a single gender to better activate of vasti muscles in women. Future studies should examine kinematic patterns associated with these reach directions.

Conclusion

The results of the current study indicate that there are differences in reach-distance performance on the ANT reach direction of the SEBT and YBT, as well as hip-joint sagittal-plane angular displacement at the point of maximum reach. Thus, the extrapolation of test results in the ANT reach direction from the SEBT to YBT and vice versa is not possible. We conclude that the tests should not be used interchangeably and that clinicians should decide to use 1 or the other as an assessment and/or rehabilitation tool.

References


