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The Development and Reliability of an Updated Dance-Specific Star Excursion Balance Test (dsSEBT) Protocol

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The Development and Reliability of an Updated Dance-Specific Star Excursion Balance Test (dsSEBT) Protocol

Abstract (Word Count: 279)

While the previous research has made crucial developments in a dance-specific version of the SEBT, current modifications to the SEBT have not conclusively produced a valid dance-specific dynamic balance test. The aim of this paper was to utilize the most practical dance-specific variations from previous research and incorporate them into a reliable test to be considered for future screenings for dancers. Twenty- one female dancers voluntarily took part in the research (age: 20.86 ± 3.68 years). This protocol consists of three stages, each increasing in difficulty; stage one: dsSEBT Average Tempo, stage two: dsSEBT Block , and stage three: a combination of stage one and stage two, the dsSEBT Average Tempo on Block. Reach distance (% of limb length), error scores, and average time to complete each stage were recorded. A stage completion criteria was developed to move from one stage to the next wherein certain reach distance and error score standards needed to be met. Between previous research using the same participants and the current study, each reach direction exhibits a statistically significant correlation ($p < .05$) with good to excellent ICC values ranging from .750-.918, suggesting that test-retest reliability is high. Overall, 90.48% of participants succeeded in passing stage one, 19.05% of total participants passed stage two, and only 4.76% of the twenty-one participants passed all three stages with statistically significant differences detected for reach distance and incomplete trials between stages ($P < .05$). This data suggests that the test is challenging enough to show dancers weaknesses and push the limits of their balance capabilities. With a clear increase in difficulty from stage to stage, the test adds layers of demanding tasks designed to test the dancer proprioceptively.

Word Count

3,989

Key Points

1. Between previous research using the same participants and the current study, each reach direction exhibits a statistically significant correlation ($p < .05$) with good to excellent ICC values ranging from .750-.918, suggesting that test-retest reliability is high.
2. With a clear increase in difficulty from stage to stage, the test adds layers of demanding tasks designed to test the dancer proprioceptively.
3. Overall, only 4.76% of the twenty-one participants passed all three stages with statistically significant differences detected for reach distance and incomplete trials between stages ($P < .05$).

Introduction

Balancing dynamically necessitates greater demands on range of motion, strength, and proprioception since it involves some degree of anticipated movement around the base of support.[1,2] Proprioception in dancers can be tested and challenged using unstable surfaces, such as foam pads or blocks, or disturbing sensory input via closing the eyes.[3,4] Practice of high-skilled activities involving tasks that challenge proprioception improves overall performance and balance control.[3,5] To increasingly challenge the specialized receptors of the body, exercises that lead to enhancing dancers' proprioception have been recommended to reduce the risk of injury which may be associated with decreased stability in the changing and challenging conditions dancers find themselves in constantly.[3] Generally, studies indicate that dancers and other highly trained individuals exhibit better balance control than the general population, suggesting that postural reflexes can be trained to perform at a higher level of performance.[4,7,15-17]

An ideal balance test will involve taking risks while still pushing the dancer within a margin of safety.[18] Research suggests that dance training leads to greater static and dynamic balance capabilities because it enhances overall sensorimotor control.[19,20] It is advised that dancers undergo a series of balance assessments where more difficult and unstable conditions can be introduced to develop their neuromotor skills.[5,7,23,24] As preliminary balance screens, the Star Excursion Balance Test (SEBT) has been used with dancers, but has not been considered specific enough to be an injury screening tool.[18,24-27] Proprioception and balance are important areas of the dancer's fitness profile which should be routinely screened to detect any deficits and track any injuries that may occur through the dancer's training.[28] A research study conducted on basketball players using the SEBT reported that women with scores of less than 94% their limb length for composite reach average were 6.5 times more likely to experience a lower extremity injury than women who achieved over 94% of their limb length.[39]

The specificity principle is crucial for testing and screening in addition to training. To accurately evaluate the proficiency of a particular skill, testing should be related to the fundamentals of the specified activities, emulating movements, intensities, duration, and pace.[29] Some steps taken thus far with regards to a dance-specific SEBT have been adding a platform to stand upon to challenge the dancers' stability,[30,31] adding an element of speed and/or tempo,[24,30,32] cognitive interference,[30] changing the order sequence,[24,32] and altering foot positioning.[31] While the previous studies made crucial steps towards dance-specific alterations and difficulty of the SEBT, all researchers have concluded that current modifications to the SEBT have not conclusively produced a valid dance-specific test.[18,24,30-32]

The aim of this paper was to utilize the most realistically dance-specific variations from previous research[24,30-33] and incorporate them into a relatively reliable and valid test to be considered for future screenings for dancers as well as examine the difficulty of the test to dancers.

Methods

From two UK-based undergraduate dance programmes, twenty-one female ballet and contemporary dancers volunteered and consented to participate in this study as a continuation of previous research.[31,32] Ethical approval by the Trinity Laban Research Ethics Committee was gained prior to data collection. Emails and posters were used to recruit participants along with in-class presentations. A participant characteristics form was sent to interested individuals to determine eligibility along with an information sheet.

Participation inclusion criteria included being over 18, experience in ballet and contemporary/modern dance, and at least three years of dance training. Exclusion criteria included if they had any disorders that may affect their vestibular system, any lower extremity injury in the six months prior to data collection, complaints of dizziness due to respiratory or ear infections, or a history of cerebral concussions. At any stage, the participants had the right to withdraw. Power analysis calculations concluded that 21 participants would be needed for this research assuming a power level of 80% with an alpha level of 5%; therefore, regression analysis was appropriate for this sample size. See Table 1 for participant characteristics.

Table 1 Participant Characteristics

Age (yrs) (mean± SD)	Stature (cm) (mean± SD)	Mass (kg) (mean± SD)	Body Mass Index (BMI) (mean± SD)	Leg Length (cm) (mean± SD)	Dance Experience (yrs)

					(mean± SD)
20.86± 3.68	163.45± 6.65	61.63± 11.45	23.72± 3.57	85.23± 5.07	13.42± 5.73

Prior to data collection, limb length was measured bilaterally using a standard measuring tape (cm) with the participant lying supine from the anterior superior iliac spine to the middle of the medial malleolus.[2,6,15,34] Medical PAR-Q and relevant consent forms were also completed.

Procedures

The same initial procedures were used as outlined in Beckman and Brouner's[31,32] research with regards to set up of the SEBT grid, warm-up, instructions, and SEBT reach vocabulary. Standard order was followed with regards to the eight reach directions, starting with the front and moving clockwise with the left stance leg and counter-clockwise with the right stance leg. This protocol consists of three stages, each increasing in difficulty. Stage one is the dance-specific SEBT (dsSEBT) Average Tempo,[32] stage two was the dsSEBT Block,[31] and stage three was a combination of stage one and stage two, the dsSEBT Average Tempo on Block, to provide more of a challenge to the dancer to keep tempo while on a block. The stages progress in level of challenge and instability as suggested by previous research to challenge dancers and test their neuromuscular system and neuromotor strategies.[7] See Table 2 for Protocol Details.

Table 2 Protocol Details

Variation Name	Recommended Criteria
dsSEBT Average Tempo (72bpm)	- Shoes off - Keep navel facing forward - Refrain from axial rotation (turning) - Testing order of spokes will begin with the front spoke moving clockwise for the left standing foot and counterclockwise for the right standing foot - Minimal stance foot movement is allowed, no heel raises - Flexing and extending of the knee is permitted - Participants must complete test on all spokes before standing fully on gesture limb again - Arms in second position (running roughly parallel to the ground and rounded slightly) - Head is to remain still, gaze fixed on a target [1,22,28,29]
mSEBT Foam (6cm Foam Block)[19]	- Shoes off - Keep navel facing forward - Refrain from axial rotation (turning) - Testing order of spokes will begin with the front spoke moving clockwise for the left standing foot and anticlockwise for the right standing foot - Minimal stance foot movement is allowed, no heel raises - Hands on hips for all trials - Flexing and extending of knee is permitted - Participants must complete reach on all spokes before standing fully on gesture limb again - [19]

To closely mimic a realistic screening setting, only reach distance and error scores were measured to determine dynamic balance ability. The reach indicators were placed at 60% of leg length initially as this was found in previous research to be the best position to begin with.[32] This was done so the reach indicator was not so far away the dancer would need to search to find it, but not too close the dancer needed to bend their gesture leg too much to begin the reach.

Stage Completion Criteria

To move from one stage to the next, certain reach distance and error score criteria needed to be met. For reach distance, participants needed to initially reach at least 75% of their leg length averaged across all spokes to continue to stage two. From stage two to three, participants needed to reach at least 95% of the leg length achieved in stage one. This was to ensure there was no statistically significant difference between stages and that the more difficult stage wasn't jeopardizing their ability to reach maximally. Stage three had the same criteria for reach distance as stage two for the same reasons. Error scores used the same rating system as previous research[31] with an added one-point deduction for being off-tempo for more than two spokes.[18] See Table 3 for an updated Error Score Rating System.

Table 3 Error Score Rating System

Severity	Error	Error Characteristics
Level 1	Hands Move	Hands are removed from hips or hands move below hips or above head as relevant.[21,27,29]
	Torso Twist	Top half of torso moves in line with hips *en bloc* rather than segmented.[27]
	Loss of Focus	Gaze moves off of focus spot in front.[4]
	Off Tempo	Off tempo for more than two spokes[18]

Level 2	Near Fall	Toe touches the ground not at full extension of the reach as strategy to regain balance.[19,27]
	Skipped Spoke	A spoke is completely skipped.[27]
	Standing Foot Shift	The standing foot shifts from its original position.[27]
Level 3	Full Fall	Full weight into reaching leg, widening the base of support.[19,27,30]

When participants reached an error score of three or above, they were asked to stop and redo that trial as recommended by previous research.[6,33] When a trial was stopped, it was considered incomplete. If there were three incomplete trials on any leg or the reach distance criteria was not met, the participant would not move forward to the next stage and their average reach distance and error scores from the last completed stage would be used to determine their dynamic balance capabilities. To calculate the limb length percentages quickly, an excel spreadsheet was designed to automatically make the necessary calculations in real time as data was inputted. See Table 4 for stage completion criteria.

Table 4 Stage Completion Criteria

Stage Number	Variation	Criteria to Move to Next Stage

1	dsSEBT Average Tempo[32]	- Reach at least 75% of limb length averaged across all spokes - No more than 3 incomplete trials on either leg
2	dsSEBT Block[31]	- Reach at least 95% of score achieved in stage one averaged across all spokes - No more than 3 incomplete trials on either leg
3	dsSEBT Average Tempo on Block	- Reach at least 95% of score achieved in stage one averaged across all spokes - No more than 3 incomplete trials on either leg

Data Collection

Reach distance and error scores were recorded in accordance with Beckman & Brouner's methods as described above.[31] Average time (minutes) to complete each stage was also looked at to see how long the test takes realistically.

Statistical Analysis

Data was again analyzed using SPSS and the alpha levels were initially set to $p < .05$ for all tests. Reach Distance data was normalized and represented as a percentage of leg length reached. Means were calculated for the three trials on each leg in each stage for reach distances(%), error scores, and number of incomplete trials. Means and SDs were reported for normally distributed data and medians alongside SDs were reported for non-normally distributed data.

Stage Completion

Descriptive statistics were used to get the average time (minutes) to completion of each stage of the test. Additionally, the number of participants who successfully completed each stage was recorded.

Test-Retest Variability

Intraclass correlation coefficients (ICC) were assessed for test-retest variability of individual reach distances for the dsSEBT average tempo stage with previous research which was recorded three months prior to this study.[32] To establish random error scores, standard error of measurement (SEM)[35] and smallest detectable difference (SDD)[36] were calculated from the ICCs. ICC values were interpreted as: poor = < .40, fair = .40-.70, good = .70-.90, and excellent = > .90 in accordance with previous research.[37] SEM was calculated using the formula SD(pooled) * ($\sqrt{(1-\text{ICC})}$)[35] and SDD was calculated by utilizing the formula 1.96 * ($\sqrt{2}$) * SEM.[36] Results for the Shapiro-Wilkinson test were insignificant for reach distance; therefore, the data was considered to be normally distributed.

Validity

Three correlations were run between the original (o)SEBT values from previous research using the same participants[32] and all three stages performed in this study to see the interaction between completed reach distances and test for validity. For the correlations, all spoke scores were averaged to get an overall composite score for each stage as done in the oSEBT and previous research[33,38,39] Data was found to be normally distributed for reach distance data sets, therefore the Pearson's R was utilized for the three correlations.

Learning Effect

Since the dsSEBT average tempo was standardized across participants as the first stage to be completed after two practice trials,[31,32] a repeated measures (RM) ANOVA was run to assess the learning effects across the first three trials. All spoke scores were averaged to get an overall value for each trial. Data was found to be normally distributed for all data sets; therefore, a RM ANOVA was found to be appropriate. Mauchley's Test of Sphericity was not statistically significant; therefore, the sphericity assumption had been met.

Between Stages

Three Repeated Measures Mixed Methods tests were performed to test significant differences in reach distance, error scores, and number of incomplete trials across the three stages of the test. For these statistical tests, all spoke scores were averaged to get an overall composite reach score for each stage for each participant who attempted the stage. These tests were run again with only the individuals who attempted all three stages. Data was found to be normally distributed for the reach distance and error score data sets; however, the data was not normally distributed for the incomplete trials data set. Due to this, a Repeated Measures Mixed Methods test was performed for the reach distance and error score data sets and a non-parametric Repeated Measures Mixed Methods test was performed for the incomplete trial data. When comparing the data between the stages for the four participants that attempted all three stages, a Friedman test was used for the error score and incomplete trials data set as they were found to be not normally distributed. For the reach distance data set, a RM ANOVA was performed due to the data having normal distribution. For reach distance between the four participants, Mauchley's Test of Sphericity was insignificant, which meant the sphericity assumption had been met.

Results

Stage Completion

The average time to complete each stage was 7.11 (*SD* = 0.78) minutes for each stage. See Table 5 for how many participants completed each stage.

Table 5 Completion of Stages as Represented by Number of Participants, and Percentage of Participants Completed

Stage	Participants Attempted (No.)	Participants Passed (No.)	Participants Passed (% of attempted participants)	Participants Passed (% of overall participants)
dsSEBT Avg. Tempo	21	19	90.48%	90.48%
dsSEBT Block	19	4	21.05%	19.05%
dsSEBT Avg. Tempo on Block	4	1	25.00%	04.76%

Test-Retest Variability

Between Beckman & Brouner's research using the same participants[32] & the current study, each reach direction exhibits a statistically significant correlation ($p < .05$) with good to excellent ICC values ranging from .750-.918 (See Table 6).

Table 6 Test-Retest Variability of Reach Distance (% of limb length) for the dsSEBT Average Tempo Stage with previous research,[32] SEMs, SDDs, and ICCs

Direction	dsSEBT Avg. Tempo Previous Research[32] (mean ± SD)	dsSEBT Avg. Tempo Current Study (mean ± SD)	SEM (%)	SDD (%)	ICC
Front	78.89± 5.04	80.48± 3.92	1.90	5.25	.821**
Open Front	80.91± 4.57	81.54± 3.45	1.96	5.42	.762**
Open Side	81.01± 4.98	82.02± 4.44	1.99	5.51	.822**
Open Back	84.41± 5.64	85.69± 5.47	1.59	4.41	.918**
Back	88.53± 7.79	90.72± 6.61	3.60	9.98	.750*
Crossed Back	85.34± 5.86	87.11± 6.51	2.38	6.60	.852**
Crossed Side	77.36± 6.18	78.82± 6.38	2.80	7.77	.801**
Crossed Front	74.81± 5.08	76.41± 4.06	1.95	5.40	.818**

*= statistically significant correlation ($p < .05$)

** = statistically significant correlation ($p < .001$)

Validity

Statistically significant strong correlations were found between the oSEBT results and stages one and two of the protocol. There was also a strong statistically insignificant correlation between the oSEBT and stage three of this protocol (See Table 7).

Table 7 Correlations of the Composite Reach Distance (% of limb length) for Each Stage of the dsSEBT with the Participant's Values from the oSEBT

Stage	Participants Attempted (No.)	oSEBT (mean ± SD)	dsSEBT (mean ± SD)	Correlation (r)
dsSEBT Avg. Tempo	21	84.606± 5.92	82.85± 4.39	.837**
dsSEBT Block	19	85.11± 6.07	77.66± 4.91	.783**
dsSEBT Avg. Tempo on Block	4	90.56± 2.21	80.03± 3.51	.904

* = statistically significant correlation ($p < .05$)

** = statistically significant correlation ($p < .001$)

Learning Effect

There was no statistically significant difference between trials for the dsSEBT Avg. Tempo using the reach indicators, $F(2,38) = 1.75$, $p = .190$.

Between Stages

A statistically significant difference was found between stages, $F(2,15.54) = 41.75$, $p < .001$. Post hoc analyses uncovered that reach distances for stage one were significantly greater than stage two and three. There was no statistically significant difference in reach distance achieved between stage two and three.

No statistically significant difference was found between stages with regards to error, $F(2,5.94) = 4.13$, $p = .075$. A statistically significant difference was found in number of incomplete trials between stages, $F(2,13.23) = 11.69$, $p < .05$. The post hoc revealed that the second stage resulted in significantly more incomplete trials than the first and third stages.

For the participants who attempted all the stages, there was a statistically significant difference was found between stages, $F(2, 6) = 87.43$, $p < .001$. Post hoc analysis revealed once again that the first stage has significantly greater reach values than the third stage.

As with the error score data overall, there was no statistically significant difference found between stages for the participants who attempted all three stages, $X^2(2) = 0.133$, $p = .936$. There was also no statistically significant difference found with these participants between stages when looking at incomplete trials, $X^2(2) = 6.00$, $p = .050$ (See Table 8).

Table 8 Dynamic Balance Performance Per Stage as Shown by the Core Variables, Averaged Across All Spokes

Stage	Reach Distance (% of limb length) (mean ± SD)	Error Scores (rating system) (mean ± SD)	Incomplete Trials (rating system) (median ± SD)
	Overall		

dsSEBT Avg. Tempo	82.85± 4.39	1.12± 0.62	0.50± 0.44[b]
dsSEBT Block	77.64± 4.88[a]	1.57± 0.91	1.00± 1.13
dsSEBT Avg. Tempo on Block	80.03± 3.51[a]	1.01± 0.61	0.00± 0.25[b]
Only Participants Who Attempted All Three Stages			
dsSEBT Avg. Tempo	84.56± 3.90	0.67± 0.17	0.25± 0.48
dsSEBT Block	81.62± 3.26	0.84± 0.30	0.50± 0.25
dsSEBT Avg. Tempo on Block	80.03± 3.51[a]	1.01± 0.61	0.00± 0.00

[a] statistically significant difference from dsSEBT Avg. Tempo ($p < .05$)

[b] statistically significant difference from dsSEBT Block ($p < .05$)

Discussion

Test-Retest Variability

Test-retest reliability scores were high for the dsSEBT Average Tempo Stage with the inclusion of reach indicators between this study and previous studies[32] as ICC's ranged from .75-.92. This is in accordance with previous research with ICC values ranging from .78-.96[34,39-41] Attempts made to control the testing environment along with the standardized protocol across the two test attempts proved to be effective in producing relatively high ICC values.

To establish random error scores, SEMs and SDDs were calculated.[34-37] SEM values give researchers and clinicians reference data to recognize the range in which an individual's true score may lie.[34,35] The current study's normalized SEM values range from 1.59-3.60% which suggests an individual's true score would lie within this range. This range is in line with previous research wherein SEM values ranged from 1.20-4.68%.[34,41-44] SDD values give a minimal amount of difference that would be needed for change to be statistically significant between two independently obtained performance scores.[34,36,41] With the SDD values averaging 6.29%, this suggests a true change would only be seen if an individual's composite score improved or decreased by 6.29% between SEBT tests. This value is also in line with previous research where SDD values ranged from 3.25-11.75% depending on the spoke.[34,42-45]

Some variability is to be expected between studies due to the assumption that human movement changes day to day, even though the participants were the same.[9] Having measurement error values is important to indicate whether the dancer's balance training programme is meeting its aims, or potentially whether a dancer's balance capabilities have significantly reduced because of injury. Without these values, it is not known whether change in performance is due to measurement errors or as a result of interventions or injury.[34,41]

Validity

Since no dynamic functional test is considered a gold standard, it proves difficult to clearly establish validity of the SEBT and its variations.[40] When comparing reach distance results from the three stages of the final test, all stages had strong correlations to the oSEBT values from the same participants[32] with the r value ranging from .783-.904. The third stage, which had an r value of .904, was the only stage to be found technically statistically insignificant according to the SPSS software (p = .096). This is most likely due to the sample size of the third stage only having four participants meaning the p value is impacted in such a way that significance is harder to achieve. The final testing protocol is regarded as having internal validity for stages one and two. However, to properly assess validity, a greater sample size would need to be present.

Learning Effect

In some previous studies, participants were given no practice trials before recording their maximal reach values.[24,30] This was said to be a more ‘dance-specific’ way of testing by arguing that dancers rarely receive time to adequately warm up before class and performance.[30] However, this was considered a limitation as most screening tests recommend some sort of familiarization with the test before recorded executions.[34] Additionally, while a movement may be new in class or rehearsal, often dancers receive time to go over the movement specifics before performance or class evaluations so the movement is familiar mentally and physically. A protocol such as this study and previous research[31,32] consisting of two practice trials is halfway between Batson's[30] no practice trial recommendation for dancers and Munro and Herrington's[34] four practice trial recommendation for future research. Considering there were no statistically significant differences found between trials in the first stage tested, this may suggest a protocol of two practice trials would be sufficient for the dance population as there was no statistically significant learning effect.

Three trials were recorded for increased measurement reliability even though previous dance-specific modifications of the SEBT have only required the participant to complete one successful trial.[24,27,30] Only executing and recording one trial would make the test faster overall and reflect other single leg balance tests.[46-48] However, with familiarization of the test, the test focusses more on balance over specific technique performance and initial accuracy. By having the dancer demonstrate they are able to successfully complete three trials, there is greater overall reliability. The researcher may gain a fuller picture of the dancer and their capabilities and there is less of a risk that their successful or unsuccessful completion of the test was by chance.[1,49]

Stage Difficulty and Completion

Each stage of the test took an average of 7 minutes to complete including instruction time, three trials per leg, and any retrials that needed to be completed. Therefore, the total test would take just over 20 minutes for a dancer to complete all three stages successfully.

The error score rating system is effective in recording errors based on severity. In previous research, any error would warrant a redo of the trial.[6,26,33] However, allowing small errors such as arms and gaze moving lend themselves to the dynamic focus of the test as the dancer is forced to respond to internal and external disturbances made while completing all eight spokes. The severity level assigned to each error was determined by how much that error interfered in aiding the dancer to complete the test. One glance down may be out of habit; however, multiple glances at spoke locations undermines the dance-specific criteria and consistency is lost across trials and participants.

Out of the 21 participants, the majority (90.48%) completed stage one, 19.05% successfully completed stage two, and only 1 participant (4.76%) completed the entire test successfully. In stage one, the two participants who did not pass were unsuccessful as they had too many errors which resulted in over three incomplete trials. In the second stage, 53.33% of the participants who did not pass, did not pass due to their reach distances alone not meeting 95% of their achieved score in stage one. 20% did not pass stage two due to incomplete trials, and 26.66% did not successfully complete stage two due to a combination of insufficient reach distances as well as incomplete trials. All participants who did not complete the third stage were unsuccessful due to their insufficient reach distance values when compared to stage one.

The percentages are in line with the data shown comparing the stages as it was revealed the second and third stages had a significantly reduced reach distance overall when compared to stage one. Additionally, it was shown that stage two had greater incomplete trials when compared to stage one and three. This is as to be expected as Batson[30] remarks on the same observation when she introduced the mSEBT foam condition to her participants. Her research states overall errors increased and seven out of her twenty-nine participants (24.14%) could not complete the mSEBT foam trial due to incomplete trials. In this study, 46.66% of the participants did not complete the block stage, achieving the goal of disrupting dancers' sense of proprioception by altering the standing surface.[30]

For the four participants who reached the final stage, their biggest downfall was their inability to reach maximally once the tempo was added. However, no more errors were made with the tempo added in stage three when compared to when there was no tempo in stage two. This may be where the speed-accuracy trade off comes into play; as the tempo added a speed to keep up with, the dancers constricted their maximal reach to not make more errors.[17] Given that one participant successfully completed all three stages, there is indication that overcoming the speed-accuracy trade-off is possible. While adding a tempo in the third stage requires even greater effort to successfully complete the overall test, this makes stage three a sufficient final challenge to the test dynamic balance ability of dancers.

Limitations and Suggestions for Future Research

While this study is the first of its kind to go through stages of modification with an aim of creating a more dance-specific SEBT, the present study is not without limitations. One of the main limitations of this study is that values of significance, ICCs, SEMs, and SDDs were calculated from data that was recorded from a relatively small sample of healthy subjects. How these values may reflect on dancers who have previously had injuries and are undergoing rehabilitation is unclear.[41] It is uncertain if this specific protocol will be able to detect functional deficits between injured and uninjured dancers. However, this protocol may be used with healthy dancers to detect deficits in performance and have the potential to predict future potential injury risk. Due to Batson's[30] findings with deficits detected by using the mSEBT foam condition in injured dancers, it is right to assume that the dsSEBT block stage may be able to provide similar outcomes.

Future research would benefit from using the dsSEBT to examine dancers in a variety of environments and scenarios. These environments to examine include but are not limited to: injured vs. non-injured dancers,[18,30,34] the effects of taping and bracing of the ankle and knee,[2] dance-specific fatigue,[2,6,16] different levels of dancer experience,[2,7,13,20,21,28] and dancers who are undergoing rehabilitation.[41]

Conclusion and Implications

While previous SEBT protocols have commonly been used with dancers,[9,26,46-48] the dsSEBT focusses on more dance-specific balance needs where tempo and proprioception are more intentionally targeted and will therefore be able have more sensitivity in detecting areas of weakness. If proprioceptive deficits go undetected, this can predispose the dancer to injury, increase the risk of re-injury, or even setback rehabilitation.[28] This data suggests the test is challenging enough to show dancers weaknesses and push the limits of their balance capabilities. As a battery for training balance, the individual stages themselves may also prove useful as exercises increasing in difficulty to be used by clinicians in remedial programs, personal trainers in balance-focused sessions, and dance teachers as a way to train base-level balance technique.[18]

The dsSEBT has been found to be cost effective in comparison to commonly used dynamic balance tests,[9,33,39] sensitive, reliable, and simple to administer to dancers. The seemingly high internal validity and test-retest reliability scores along with the low measurement error scores suggests the dsSEBT is appropriate for use by clinicians and researchers. Having a test that is consistent in recording and reporting results can lead to the development of preventative training and treatment programs. The dsSEBT allows for more objective measurements of reach distance and error scores, with the inclusion of reach indicators and a three-tiered error rating system and can therefore yield powerful quantitative results.

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N/A

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Tables

Table 1 Participant Characteristics

Age (yrs) (mean± SD)	Stature (cm) (mean± SD)	Mass (kg) (mean± SD)	Body Mass Index (BMI) (mean± SD)	Leg Length (cm) (mean± SD)	Dance Experience (yrs) (mean± SD)
20.86± 3.68	163.45± 6.65	61.63± 11.45	23.72± 3.57	85.23± 5.07	13.42± 5.73

Table 2 Protocol Details

Variation Name	Recommended Criteria
dsSEBT Average Tempo (72bpm)	- Shoes off - Keep navel facing forward - Refrain from axial rotation (turning) - Testing order of spokes will begin with the front spoke moving clockwise for the left standing foot and counterclockwise for the right standing foot - Minimal stance foot movement is allowed, no heel raises - Flexing and extending of the knee is permitted - Participants must complete test on all spokes before standing fully on gesture limb again - Arms in second position (running roughly parallel to the ground and rounded slightly) - Head is to remain still, gaze fixed on a target [1,22,28,29]
mSEBT Foam (6cm Foam Block)[19]	- Shoes off - Keep navel facing forward - Refrain from axial rotation (turning) - Testing order of spokes will begin with the front spoke moving clockwise for the left standing foot and anticlockwise for the right standing foot - Minimal stance foot movement is allowed, no heel raises - Hands on hips for all trials - Flexing and extending of knee is permitted - Participants must complete reach on all spokes before standing fully on gesture limb again - [19]

Table 3 Error Score Rating System

Severity	Error	Error Characteristics
Level 1	Hands Move	Hands are removed from hips or hands move below hips or above head as relevant.[21,27,29]
	Torso Twist	Top half of torso moves in line with hips *en bloc* rather than segmented.[27]
	Loss of Focus	Gaze moves off of focus spot in front.[4]
	Off Tempo	Off tempo for more than two spokes[18]
Level 2	Near Fall	Toe touches the ground not at full extension of the reach as strategy to regain balance.[19,27]
	Skipped Spoke	A spoke is completely skipped.[27]
	Standing Foot Shift	The standing foot shifts from its original position.[27]
Level 3	Full Fall	Full weight into reaching leg, widening the base of support.[19,27,30]

Table 4 Stage Completion Criteria

Stage Number	Variation	Criteria to Move to Next Stage
1	dsSEBT Average Tempo[32]	- Reach at least 75% of limb length averaged across all spokes

		- No more than 3 incomplete trials on either leg
2	dsSEBT Block[31]	- Reach at least 95% of score achieved in stage one averaged across all spokes - No more than 3 incomplete trials on either leg
3	dsSEBT Average Tempo on Block	- Reach at least 95% of score achieved in stage one averaged across all spokes - No more than 3 incomplete trials on either leg

Table 5 Completion of Stages as Represented by Number of Participants, and Percentage of Participants Completed

Stage	Participants Attempted (No.)	Participants Passed (No.)	Participants Passed (% of attempted participants)	Participants Passed (% of overall participants)
dsSEBT Avg. Tempo	21	19	90.48%	90.48%
dsSEBT Block	19	4	21.05%	19.05%

dsSEBT Avg. Tempo on Block	4	1	25.00%	04.76%

Table 6 Test-Retest Variability of Reach Distance (% of limb length) for the dsSEBT Average Tempo Stage with previous research,[32] SEMs, SDDs, and ICCs

Direction	dsSEBT Avg. Tempo Previous Research[32] (mean ± SD)	dsSEBT Avg. Tempo Current Study (mean ± SD)	SEM (%)	SDD (%)	ICC
Front	78.89± 5.04	80.48± 3.92	1.90	5.25	.821**
Open Front	80.91± 4.57	81.54± 3.45	1.96	5.42	.762**
Open Side	81.01± 4.98	82.02± 4.44	1.99	5.51	.822**
Open Back	84.41± 5.64	85.69± 5.47	1.59	4.41	.918**
Back	88.53± 7.79	90.72± 6.61	3.60	9.98	.750*
Crossed Back	85.34± 5.86	87.11± 6.51	2.38	6.60	.852**
Crossed Side	77.36± 6.18	78.82± 6.38	2.80	7.77	.801**
Crossed Front	74.81± 5.08	76.41± 4.06	1.95	5.40	.818**

*= statistically significant correlation ($p < .05$)

** = statistically significant correlation ($p < .001$)

Table 7 Correlations of the Composite Reach Distance (% of limb length) for Each Stage of the dsSEBT with the Participant's Values from the oSEBT

Stage	Participants Attempted (No.)	oSEBT (mean ± SD)	dsSEBT (mean ± SD)	Correlation (r)
dsSEBT Avg. Tempo	21	84.606± 5.92	82.85± 4.39	.837**
dsSEBT Block	19	85.11± 6.07	77.66± 4.91	.783**
dsSEBT Avg. Tempo on Block	4	90.56± 2.21	80.03± 3.51	.904

Table 8 Dynamic Balance Performance Per Stage as Shown by the Core Variables, Averaged Across All Spokes

Stage	Reach Distance (% of limb length) (mean ± SD)	Error Scores (rating system) (mean ± SD)	Incomplete Trials (rating system) (median ± SD)
Overall			
dsSEBT Avg. Tempo	82.85± 4.39	1.12± 0.62	0.50± 0.44[b]
dsSEBT Block	77.64± 4.88[a]	1.57± 0.91	1.00± 1.13
dsSEBT Avg. Tempo on Block	80.03± 3.51[a]	1.01± 0.61	0.00± 0.25[b]
Only Participants Who Attempted All Three Stages			

dsSEBT Avg. Tempo	84.56± 3.90	0.67± 0.17	0.25± 0.48
dsSEBT Block	81.62± 3.26	0.84± 0.30	0.50± 0.25
dsSEBT Avg. Tempo on Block	80.03± 3.51[a]	1.01± 0.61	0.00± 0.00

[a] statistically significant difference from dsSEBT Avg. Tempo ($p < .05$)

[b] statistically significant difference from dsSEBT Block ($p < .05$)