## Abstract

**Objectives:** To determine the association between the Functional Movement Screen (FMS), Star Excursion Balance Test (SEBT) and the Beighton Score (BS) in dancers with implications for performance and injury.

**Methods:** Forty-seven female university dancers (age: 20.36 ± 0.70 years, height: 160.51 ± 5.75 cm; mass: 55.55 ± 4.78 kg) completed the FMS and the anterior, posteromedial and posterolateral reach components of the SEBT and had their hypermobility assessed via the BS.

**Results:** A fair significant correlation was demonstrated between FMS composite and total BS. (r = 0.37, p = 0.01). For individual elements of the screening tools there was 24 significant correlations between the FMS and the BS, 11 significant correlations between the FMS and SEBT and 4 significant correlations between the SEBT and BS. The FMS and the BS correlations highlighted the importance of the deep squat in functional movement and the relationship between FMS mobility elements and the BS.

**Conclusion:** The significant correlation between the FMS and the BS may suggest that they capture similar information. The active straight leg raise and shoulder mobility provide valuable information.

**Keywords:** Beighton Score, shoulder mobility, active straight leg raise, correlation

## Introduction

Dancers are required to manage an often demanding physical workload and maintain performance while avoiding injury. Injury rates in dancers have been reported to range from 0.57 to 5.6 injuries per 1000 hours dancing and most injuries occur in the lower limb with overuse and foot and ankle injuries most prevalent.[1-4] Musculoskeletal screening tools have been used to identify individuals at risk of injury and to predict performance and although their use has predominantly been in sporting activities [5-10] a number of studies have investigated their use in dance [4, 11-14]. As musculoskeletal screening in dance develops the use of these screening tools is increasing. Three tools which have been shown to have good to excellent inter and intra-rater reliability [15-20] are the Functional Movement Screen (FMS) [21,22], Star Excursion Balance Test (SEBT) [23] and the Beighton score (BS) [24] and can be used to identify movement patterns, balance deficits, dynamic stability and joint range of motion that may potentially relate to injury and performance.

The FMS measures movement patterns which require integration between stability and mobility elements while moving through a proximal to distal sequence [21,22] and is composed of seven elements namely the deep squat (DS), hurdle step (HS), in-line lunge (ILL), shoulder mobility (SM), active straight leg raise (ASLR), trunk stability push-up (TSPU) and rotatory stability (RS). The movements are scored from 0 to 3 to produce a FMS composite score. The SEBT challenges dynamic postural control and requires strength, proprioception and flexibility [25] and the original version [23] was composed of 8 movement directions (anterior, medial, lateral, posterior, anterolateral, anteromedial, posterolateral and posteromedial) spaced 45° apart however an observation of redundancy on these movements resulted in the recommendation of the use of a modified version composed of anterior, posterolateral and posteromedial directions [26]. The BS [24] measures joint hypermobility and the capability of a joint to move passively and/or actively, beyond normal limits along physiological axes [27] which assesses five joints that provide a potential score of 9 with scores of ≥4 classified as hypermobile [28] however values of 5 and 6 have been utilised [29].

The relationship between FMS, SEBT and modified SEBT have been investigated in team sports athletes [30,31] however the interaction of the FMS, SEBT and BS in dancers has not been investigated previously. Enhanced understanding of any potential interaction between these screening tools and the contribution of each tool and its associated components to the screening process could potentially influence dancer's health and well-being. The primary aim of this study was to determine the association between FMS, SEBT and the BS in dancers with implications for performance and injury. The secondary aim was to report FMS, SEBT and BS values in relation to previous dance research.

## Methods

### Study design and participants

This was a cohort study design and included forty-seven female university dancers (age: 20.36 ± 0.70 years, height: 160.51 ± 5.75 cm; mass: 55.55 ± 4.78 kg; Ethnicity: 42 white Caucasians, 2 Hispanic and 3 black Caribbean enrolled on an undergraduate dance programme volunteered to participate in this study. Inclusion criteria specified that participants were injury free in the 30 days prior to testing and were 18 years of age or older and attending a minimum of four dance classes of 2 hours on a weekly basis. Participants completed a medical screening questionnaire prior to participating in the study and those who had heart disease and/or were pregnancy or had been diagnosed with either Ehlers-Danlos, Marfan Syndrome or osteogenesis imperfecta were excluded. Participation was voluntary, and participants were informed of potential risks and provided written consent prior to testing. The University Research Ethics Committee provided ethical approval prior which adhered to the Declaration of Helsinki guidelines.

### Procedures

Subject's height was measured using a stadiometer (Leicester Height Measure, Child Growth Foundation, Leicester, UK) and body mass was recorded using digital scales (Salter 9028, Kent, UK). Limb dominance was determined for the upper limb by asking which hand participants wrote with and for the lower limb by asking them to state which was their preferred leg to kick a ball [32]. The order of testing of the FMS, SEBT and BS and its individual components was randomised via computer generated randomisation. All tests were performed on the same day with 1 hour between the three screening tools to reduce any potential fatigue effects. The lead researcher performed all screening and was an experienced musculoskeletal physiotherapist with 16 years experience who was trained in the use of the FMS, SEBT and BS and had used these screening tools extensively in their practice. Intra-rater reliability was calculated using inter-class correlations coefficients ($ICC_{3,1}$) [33] and involved measuring the FMS, SEBT and BS of all components using 8 participants (8 females) on 2 separate occasions, 24 hours apart. These participants were not part of the investigated population. The following scores were obtained which demonstrated excellent reliability: FMS composite score (0.94), SEBT composite score (0.91) and total BS (0.99).

**FMS**

The FMS comprises seven movement assessments: DS, HS, ILL, SM, ASLR, TSPU and RS [21,22]. Movement was scored from 0 to 3 based on the following criteria with a maximum total score of 21. 0: Participants experiences pain during movement. 1: Subject fails to complete functional movement. 2: Subject performs compensatory movement. 3: Subject performs test to perfection. Clearing tests were performed for SM, TSPU and RS [21] to ensure participants were safe to complete these tests and the movements were demonstrated to the participants by the researcher and verbal instruction provided and supported with FMS images [21,22] to ensure understanding of the movement required. Participants performed each movement three times with a 5 second rest between each movement and the maximal score of these movements was recorded. For the 5 movements that assess bilateral movement the lowest score from the two sides was used to determine FMS composite score [21,22].

**SEBT**

The original SEBT involves a total of 48 reaches in 8 directions [23] however it has been recommended that anterior, posterolateral, and posteromedial directions are used for clinical research [34] and these three directions capture the least redundant information [35]. This shortened version [35] was utilised and prior to the participants performing the test the movements were demonstrated by the lead researcher. Subject's leg length (cm) was measured from the anterior superior iliac spine to the distal end of the medial malleolus using a standard tape measure with the participants supine on a plinth. Participants stood on both feet with the midpoint of their stance foot over the intersection mark of the grid centre and were told to keep their hands on their hips, head facing forward at all times and their stance foot flat on the floor and to reach as far as possible in the three directions. Participants were not allowed to slide their foot along the floor or maintain their final reach position. Participants who lost balance by failing to maintain their hands on hips, return their reach leg to the starting position or removed their stance leg from the standing position repeated the trial [34]. The distance reached was normalised to limb length by the following calculation: excursion distance ÷ limb length x 100 = Percentage maximised reach distance [34]. SEBT percentage composite scores was calculated by the sum of the three distances for non-dominant and dominant limb respectively divided by 3 and multiplied by 100 [36]. The performance of the SEBT has been found to stabilise by the 4th practice trial[17] and therefore reach distance was recorded on the 5$^{th}$ trial. A 10 second rest period was used between each practice trial followed by a 1 minute rest period before the 5$^{th}$ trial.

## Joint Hypermobility

The BS [24] was used to measure joint hypermobility which classifies joint hypermobilty as a score of ≥ 4. The researcher performed all measurements by measuring range of motion of the 5th metacarpophalangeal joints (1 point each joint), thumbs (1 point each joint), elbows (1 point each joint), knees (1 point each joint) and lumbar spine (1 point) providing a maximum score of 9. A goniometer (Vivomed, UK) was used to measure all joints except the lumbar spine for which joint hypermobility was classified as yes/no based on the participants ability to put the palms of their hands flat on the floor. All tests were performed as described by Juul-Kristensen et al [20].

## Statistical analysis

FMS composite score, SEBT composite score and the total BS and the individual elements of these screening tools were analysed using a Pearsons correlation coefficient (*r)*. Correlation coefficients were interpreted as 0.00 to 0.25 (little or no correlation), 0.25 to 0.50 (fair correlation), 0.50 to 0.75 (moderate to good correlation) and >0.75 (good to excellent correlation) [37]. Mean scores were calculated for FMS, SEBT and the BS and the individual components. All data are reported as mean ± standard deviation unless otherwise stated. Statistical analysis was performed using SPSS version 23 software (IBM Inc.) and significance was accepted at the $P < 0.05$ level.

## Results

Table 1 reports *r* for the FMS and anterior, posterolateral and posteromedial components of the SEBT with P values denoted in parentheses. Significant correlations existed for non-dominant HS and non-dominant anterior reach ($r = 0.29$, $p = 0.049$), non-dominant SM and non-dominant anterior reach (r = 0.41, p = 0.004), non-dominant SM and dominant anterior reach (r = 0.36, p = 0.01), non-dominant ASLR and non-dominant anterior reach (r = 0.32, p = 0.02) and dominant anterior reach (r = 0.42, p = 0.003). Dominant ASLR and dominant anterior reach (r = 0.36, p = 0.01), non-dominant RS/dominant RS and SEBT composite (r = -0.33, p = 0.02), non-dominant RS/dominant RS and non-dominant posterior-lateral reach (r = -0.34, p = 0.02), FMS composite score and dominant anterior reach (r = 0.29, p = 0.045). All significant values demonstrated a fair correlation.

**Insert table 1 here**

Table 2 reports *r* for the FMS and the BS with P values denoted in parentheses. Significant correlations existed for DS and non-dominant 5$^{th}$ metacarpophalangeal joint (r = 0.42, p = 0.003), non-dominant thumb (r = 0.47, p = 0.001) and dominant thumb (r = 0.44, P = 0.002). Non-dominant SM and dominant 5$^{th}$ metacarpophalangeal joint (r = 0.37, p = 0.01), non-dominant thumb (r = 0.47, p = 0.001), dominant thumb (r = 0.34, p = 0.02), non-dominant elbow (r = 0.30, p = 0.04) and total BS (r = 0.51, p = 0.001). Dominant SM and non-dominant thumb (r = 0.30, p = 0.04) dominant thumb (r = 0.37, p = 0.01) and total BS (r = 0.35, p = 0.02). Non-dominant ASLR and non-dominant 5$^{th}$ metacarpophalangeal joint (r = 0.44, p = 0.002), non- dominant thumb (r = 0.47, p = 0.001), dominant thumb (r = 0.39, p = 0.006) and total BS (r = 0.36, p = 0.012). Dominant ALSR and non-dominant 5$^{th}$ metacarpophalangeal joint (r = 0.33, p = 0.02), non-dominant thumb (r = 0.38, p = 0.008), dominant thumb (r = 0.32, p = 0.03) and total BS (r = 0.29, p = 0.047). TSPU and non-dominant 5$^{th}$ metacarpophalangeal joint (r = -0.33, p = 0.03). FMS composite was related to dominant 5$^{th}$ metacarpophalangeal (r = 0.37, p = 0.01), non-dominant thumb (r = 0.57, p = 0.001), dominant thumb (r = 0.55, p = 0.001). All significant findings demonstrated a fair correlation except for FMS composite and non-dominant and dominant thumb which demonstrated a moderate to good correlation.

*Insert table 2 here*

Table 3 reports *r* for the SEBT and the BS with P values denoted in parentheses. Tables 1, 2 and 3 demonstrate a fair correlation demonstrated between the FMS composite score and the total BS (r = 0.37, p = 0.01) and little or no correlation between FMS composite and SEBT composite score (r = 0.23, p = 0.12) and the SEBT composite score and the BS (r = 0.16, p = 0.29). Significant correlations existed between non-dominant anterior reach and total BS (r = 0.33, p = 0.02), dominant anterior reach and non-dominant thumb (r = 0.36, p = 0.01) and total BS (r = 0.30, p = 0.04) and non-dominant posteromedial reach and dominant thumb (r = 0.37, p = 0.02).

*Insert table 3 here*

Table 4 reports the screening scores for FMS, SEBT and BS (Mean ± SD). FMS composite score was 16.87 ± 1.39, SEBT composite score was 409.94 ± 69.38cm and total BS was 4.87 ± 2.01.

*Insert table 4 here*

**Discussion**

**FMS composite, SEBT composite and total BS scores**

The primary aim of this study was to determine the relationship between FMS, SEBT and the BS. Analysis of FMS composite, SEBT composite and total BS provided contrasting findings with a fair significant correlation demonstrated between FMS and the BS ($r = 0.37$, $p = 0.01$) and little or no correlation between FMS and SEBT composite ($r = 0.23$, $p = 0.12$) and SEBT composite and the BS ($r = 0.16$, $p = 0.29$). The FMS and the total BS may potentially capture similar information and may highlight the importance of joint mobility in the performance of functional movement. SM and the ASLR measure mobility and although not directly measured via the BS it is possible that individuals with joint hypermobility in these 9 joints may have increased shoulder and hip range of motion. SM measures bilateral and reciprocal shoulder range of motion via combination of internal rotation/adduction of one shoulder and external rotation/abduction of another while maintaining scapula mobility and thoracic spine extension [38]. Dancers have been reported to have good spinal mobility with positive lumbar flexion as identified by the BS recognised as a performance adaptation [39] and several dance movements in contemporary and ballet dancing require good shoulder mobility, stability and strength particularly when partner lifting is required. The ASLR is a measure of hamstring and gastrocnemius/soleus flexibility and hip/knee range of motion and therefore the high prevalence in this study of positive BS for lumbar flexion (42 dancers, 89.4%) which is also a measure of hamstring flexibility is likely to contribute to ASLR performance. Screening tools as unitary constructs are not good predictors of performance [10,40] and may explain the poor correlation of composite scores between FMS and SEBT and the SEBT and the BS. The constructs assessed for dynamic balance by the FMS may not relate to those captured by the SEBT and the BS may not relate directly to these dynamic balance demands. The FMS requires muscle strength, flexibility, range of motion, coordination, balance and proprioception to be performed in a more complex manner than the SEBT and its range of motion requirements is more functional than the BS.

**FMS and SEBT**

The non-dominant HS and non-dominant anterior reach demonstrated a significant fair correlation which may relate to the movement pattern of the HS being similar to the anterior reach of the SEBT with both movements requiring the maintenance of single leg balance with contralateral lower limb anterior reach. In contrast previous research in team sports [30,31] reported little to no correlation and no statistical significance for these movements. Lockie et al [30] used predominantly males who may demonstrate different movement biomechanics. Furthermore, dancers are used to performing lower limb gesturing movements which point the targeting toe in space while maintain balance on the stance leg [41] which mimics dance performance. Females with greater hip flexor, extensor, and abductor strength have greater anterior and posterolateral reach [42] and although strength was not directly measured directly this may partially support our finding for the HS and anterior reach which requires appropriate muscle integration on these movements. A HS score of 2 may suggest minor limitations in ankle dorsiflexion and hip flexion in the step leg while a score of 1 may relate to stance leg instability [21]. The observed relationship between non-dominant HS and anterior reach may provide an area for performance intervention and for an integrated approach the range of motion, strength, proprioception and neuromuscular control of these joints should be investigated in addition to screening tools. The HS represents one the primary foot positions adopted in weight bearing and therefore changes in their execution may lead to injury. The HS challenges the individual in a narrow base of support via step and stride movements and requires mobility and stability to be utilised concurrently and any performance deficits may represent a reduction in postural control [21].

ASLR and SM have a mobility bias and represent two of the two most fundamental patterns of the FMS[21] and fair correlations existed between non-dominant SM and non-dominant and dominant anterior reach, non-dominant ASLR and non-dominant/dominant anterior reach. The relationship between non-dominant SM and anterior reach is difficult to explain as the shoulder joint remains in a stationery position during the SEBT due the placement of hands on the hips however it may relate to the mobility aspect of both movements as good shoulder mobility may also be reflected by good lower limb mobility. The observed fair correlation and significant relationship between non-dominant SM and non-dominant ASLR ($r = 0.34$, $p = 0.02$) may support this hypothesis. Previous research reported that military personnel that performed better on the Y balance test demonstrated superior performance on the ILL and SM.[43] Our finding of a relationship between FMS composite score and greater anterior reach is in accordance with previous findings [43]. The relationship between non-dominant ASLR/dominant ASLR and anterior reach may suggest that ASLR range of motion contributes to anterior reach performance. Both movements require the ability to disassociate the lower extremity from the trunk while maintaining core stability and actively extending the moving leg. The lack of a relationship between dominant ASLR and non-dominant anterior reach may relate to leg dominance. The SM and ASLR were the only elements that demonstrated a significantly positive relationship which supports the notion that the SEBT is a measure of dynamic postural control and mobility. Dancers may identify mobility as an area for personal development with a focus on SM and ASLR range development to improve SEBT performance.

For RS significant fair correlations existed for non-dominant RS/dominant RS and dominant posterior-lateral reach and non-dominant RS/dominant RS and SEBT composite score. RS tests cores stability and the ability to coordinate movement and had the lowest mean score of FMS elements. Although a negative correlation existed between RS and composite SEBT further analysis of the RS data reveals that 46 (98%) dancers scored 2 on this test This difficulty in achieving a maximum score has been reported previously in physically active individuals [44]. RS requires trunk stability in sagittal and transverse planes while performing asymmetrical upper and lower limb movement [22]. Any potential training intervention must consider that this movement is difficult to perform and that any improvements in core stability may not be obvious via the FMS scoring system. Previously, Harshbarger et al [31] reported a fair and significant correlation between RS and anterior and posteromedial reach which was in contrast to our findings. However, this study used only the dominant leg as the stance leg during the SEBT and in contrast our study reported 5 significant findings for the non-dominant leg and this coupled with the contrasting populations may explain potential differences. A lack of consideration of non-dominant leg limits comparison with bilateral FMS movements as for example that the left HS is a combination of right single leg balance and step and reach with the left leg [31] Future studies could replicate our methodology by investigating both dominant and non-dominant legs as both sport and dance require both legs to act as the stance leg.

**FMS and BS**

There was a fair significant correlation between the DS and non-dominant 5$^{th}$ metacarpophalangeal joint, non-dominant thumb and dominant thumb. The DS is recognised as the most complex of the FMS movements and requires a higher degree of neuromuscular control [45] and involves the integration of a number of joints and muscles for effective movement. Low performers in the squat make gross movement errors [46] and asymmetry may result in inappropriate muscle recruitment or weight transference. The 5th metacarpophalangeal joints and thumbs are required to support the dowel during the DS however their movement is minimal and therefore although not directly measured it is possible that as part of the kinetic chain which requires the integration of joint movement [47] these joints may allow increased wrist range of motion which could potentially assist the DS by allowing greater upper limb and wrist control. Muscle weakness and/or limited mobility in the lower extremities reduce DS performance [48] Increased DS depth is associated with increased hip, knee and ankle range of movement [49] and ankle dorsiflexion is greater in those who scored 3 on the FMS in comparison to those who scored 1 [46] Further differences were reported in knee and hip joint range of motion between FMS scores [46] which supports the notion of measuring range of motion to enhance the understanding of the relationship between the FMS and the BS.

There was a fair correlation between the non-dominant SM and dominant 5th metacarpophalangeal joint, non-dominant thumb, dominant thumb, non-dominant elbow and total BS. The number of significant findings for SM and the three upper limb elements of the BS supports the notion that hypermobility in these joints may relate to enhanced shoulder mobility and function and may highlight range of motion interaction within the kinetic chain. There was a fair correlation between non-dominant ASLR and dominant 5th metacarpophalangeal joint, non-dominant thumb, dominant thumb which may be a reflection of general joint hypermobility as individuals with hypermobile thumbs and fingers may have increased mobility at the hip as determined by the ASLR which is predominantly a mobility test. There was a fair correlation between non-dominant ASLR and total BS. The finding that the total BS was related with the 4 mobility tests of the FMS confirms the strong mobility element of these movements. The negative correlation between TSPU and non-dominant 5th metacarpophalangeal joint is difficult to explain as the 5th metacarpophalangeal joint makes limited contribution to the push up movement. FMS composite score was related to dominant 5th metacarpophalangeal joint, non-dominant thumb, dominant thumb and the relationship between FMS composite and non-dominant and dominant thumb demonstrated a moderate to good correlation. The positive correlations present at the fingers and thumbs may provide an indication of general joint hypermobility.

**SEBT and BS**

There was a fair significant correlation between non-dominant anterior reach and total BS, dominant anterior reach and non-dominant thumb and total BS, non-dominant posteromedial reach and non-dominant thumb. The findings for total BS and anterior reach components may reflect that hypermobility in a number of joints is beneficial for reaching tasks such as the SEBT which require functional stability and neuromuscular control. There is no obvious relationship between the movement patterns of non-dominant posteromedial reach and non-dominant thumb hypermobility and therefore any potential relationship may be viewed in terms of general hypermobility. Although no significant findings existed for knee hypermobility previous research has reported higher passive knee range of motions in individuals with hypermobility syndrome in comparison to healthy controls [50] and it is likely that this would aid performance on reaching tasks. The SEBT involves the dancer moving over a fixed based of support in a predominantly anterior posterior plane which requires a compromise between forward propulsion of the body and the maintenance of lateral stability [51] and requires lower extremity strength [52] and ankle, knee and hip range of motion [53] and therefore joint hypermobility is likely to be an asset for performance of this task. Whether hypermobility is advantageous for dancers has been the focus of some debate with the suggestion that it is a performance asset [54] however some studies have also suggested that it is associated with increased injury risk [4,55] Aesthetic demands may influence the selection of hypermobile dancers for dance schools however as the progression through elite levels continues it may be associated with higher injury risk [55]. Within ballet an increased injury risk comes from the level of muscular effort required by hypermobile dancers to maintain stability [56]. Previously a moderate to good correlation between lower limb hypermobility and balance has been reported in dancers with hypermobile dancers having better balance on the SEBT [42]. However, caution must be applied with reference to these findings as only 3 dancers had lower limb hypermobility.

Dancers exhibit improved control in limb gesturing in comparison to non-dancers[57] and training effects have been observed between elite and non-elite dancer's alignment with less variability in their alignment of elite dancers when transferring from right legged balance to a step and returning to left legged balance [58]. Faster neuromuscular responses and more consistent muscle activation [59] have been observed in ballet dancers in comparison to controls. Dancers may demonstrate more distinct and variable kinematic strategies which facilitate performance of the SEBT [60] and include a variety of different strategies for the same reach direction including movement of the torso *en bloc* versus segmenting [41] and therefore some strategies may have demonstrated reduced movement quality but allowed dancers to obtain their maximum score. SEBT scores for dominant and non-dominant limbs were similar which may highlight a dance training adaptation of dance training. Previous research has suggested that a reduced reach distance in one limb is a potential injury risk factor in both limbs reach distance [61] however whether this is applicable to dancers requires investigation.

Dance genre may influence any potential intervention to improve performance or reduce injury risk. Contemporary dancers tend to use more upper and whole body movements than ballet [42] which puts potentially more emphasis on lower limb movements [62] furthermore some genres such as breaking require increased weight bearing via the upper limb as does partner lifting in ballet. The findings of screening can be used in conjunction with the specific performance demands to develop appropriate training programmes. Our findings could be used to potentially create a battery of movements that provide the most relevant information for the screening of dancers which could make screening more productive in terms of time and information obtained. For example, elements of the FMS such as the ASLR and SM may provide more valuable information than the BS on joint hypermobility/mobility and how movements are integrated and the movements of the SEBT might potentially not be demanding enough to test dancers dynamic postural control and mobility. The current study utilised university dancers who mostly performed contemporary dance and ballet and therefore this should be considered in any practical application of our findings.

**FMS, SEBT and BS**

The secondary aim of this study was to report FMS, SEBT and BS in relation to previous findings. The mean composite FMS score 16.87 was similar to the 16.83 previously reported [63] and higher than the mean FMS composite score reported across three year groups of 13, 14 and 15 in a professional ballet company [64]. Few studies report FMS composite score in dancers with some reporting components of the FMS but not all elements [12,13] and their use of injured dancers prevents meaningful comparison.

All SEBT directions were within the range of 3.31% of each other with dominant posteromedial demonstrating the greatest reach and are similar to previous reported findings in university dancers [14]. Comparison of mean SEBT reach scores are restricted by variations in the methodology utilised. Ambegaonkar et al [42] did not report values as dominant and non-dominant leg with values of right anterior 70.1%, left anterior 69.9%, right posteromedial 96.7%, left posteromedial 97.1%, right posterolateral 95.6% and left posterolateral reach 94.7% reported of all  which are higher than our values with the exception of anterior reach. The mean BS of 4.87 and was greater than the mean BS of 4.36 [54] and 3.80 [4] previously reported but and less than the 5.29 [67] and 6.2 [68] reported in female dancers however it is important to consider that the level of dancer may impact on findings.

Future research may wish to analyse the BS with specific degree values of joint hypermobility and include a variety of joints. This may be of value at the ankle joint where dorsiflexion has been reported to influence SEBT scores [69] The BS measures predominantly upper limb components however as lower limb injuries are most prevalent in dancers [1-4,70] measurement of lower limb joint range of motion at a number of joints such as the ankle, knee and hip joint is required. Consideration of a number of joints throughout the body may improve the understanding of the kinetic chain as an alteration in movement pattern at one aspect may produce compensatory dysfunction at other kinetic chain locations [71].

**Limitations**

It is acknowledged that some limitations exist within the study. The results of the study are limited to the populations investigated and our findings are only applicable to female dancers. Females have been reported to demonstrate significantly greater joint laxity than males post puberty [72] and joint hypermobility is more prevalent in Asians and Africans followed by white Caucasians [73] and the majority of the dancers in this study were white Caucasian (n = 43, 92%).

## Conclusions

The strongest relationship was demonstrated between FMS and the BS with 24 significant correlations, the FMS and SEBT had 11 significant correlations and the SEBT and BS had 4 significant correlations. A significant correlation existed between the FMS and the BS which may suggest that they capture similar information. The ASLR and SM were found to correlate with 5 SEBT movements and highlights the need for dynamic postural control and mobility during the SEBT. The FMS and the BS correlations highlighted the importance of the DS in movement and the relationship between FMS mobility elements and the BS which demonstrated 16 significant correlations. The correlations between the SEBT and the FMS suggested some performance benefits for anterior reach those individuals with joint hypermobility. Our findings suggest that consideration of individual elements of the FMS, SEBT and the BS are likely to provide more clinically relevant information than composite score. Clinicians should consider that the FMS and BS have the greatest correlation when deciding upon a screening programme with dancers and it the measurement of ASLR and SM appear to provide clinically relevant information.

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## Disclosure statement

The authors report no conflict of interest.

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