

1 **Original Research**

2 **Lower extremity hypermobility, but not core**  
3 **muscle endurance influences balance in female collegiate dancers**

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27 **Abstract**

28 **Background:** Dance is a physically demanding activity, with almost 70% of all injuries in  
29 dancers occurring in the lower extremity (LE). Prior researchers report that muscle function (e.g.  
30 muscle endurance) and anatomical factors (e.g. hypermobility) affect physical performance (e.g.  
31 balance) and can subsequently influence LE injury risk. Specifically, lesser core muscle  
32 endurance, balance deficits, and greater hypermobility are related to increased LE injury risk.  
33 However, the potentials interrelationships among these factors in dancers remain unclear.

34 **Purpose:** The purposes of this study were to examine the relationships among core muscle  
35 endurance, balance, and LE hypermobility and determine the relative contributions of core  
36 muscle endurance and LE hypermobility as predictors of balance in female collegiate dancers.

37 **Study Design:** Cross-sectional

38 **Methods:** Core muscle endurance was evaluated using the combined average anterior, left, and  
39 right lateral plank test time scores(s). LE hypermobility was measured using the LE-specific  
40 Beighton hypermobility measure, defining hypermobility if both legs had greater than 10° knee  
41 hyperextension. Balance was measured via the composite anterior, posterolateral, and  
42 posteromedial Star Excursion Balance Test (SEBT) reach distances (normalized to leg length) in  
43 15 female healthy collegiate dancers (18.3±0.5yrs, 165.5±6.9cm, 63.7±12.1kg). Point-biserial-  
44 correlation-coefficients examined relationships and a linear regression examined whether core  
45 endurance and hypermobility predicted balance ( $p \leq .05$ ).

46 **Results:** LE hypermobility (Yes;  $n=3$ , No;  $n=12$ ) and balance (87.2±8.3% leg length) were  
47 positively correlated  $r(14)=.67$ , ( $p=.01$ ). However, core endurance (103.9±50.6 s) and balance  
48 were not correlated  $r(14)=.32$ , ( $p=.26$ ). LE hypermobility status predicted 36.9% of the variance  
49 in balance scores ( $p=.01$ ).

50 **Conclusion:** LE hypermobility, but not core muscle endurance may be related to balance in  
51 female collegiate dancers. While LE hypermobility status influenced balance in the female  
52 collegiate dancers, how this LE hypermobility status affects their longitudinal injury risk as their  
53 careers progress needs further study. Overall, the current findings suggest that rather than using  
54 isolated core endurance-centric training, clinicians may encourage dancers to use training  
55 programs that incorporate multiple muscles - in order to improve their balance, and possibly  
56 reduce their LE injury risk.

57 **Level of Evidence:** 2b

58 **Key Words:** Beighton Score, lower body, plank tests, Star Excursion Balance Test

59

## 60 **Introduction**

61 Dancing is a physically challenging activity.<sup>1,2</sup> Dancers reportedly have a 90% lifetime  
62 injury incidence rate,<sup>3</sup> with around 70% of all dance-related injuries occurring in the lower  
63 extremity (LE).<sup>4-6</sup> Prior researchers have noted that neuromuscular (e.g. muscle endurance),  
64 anatomical (e.g. hypermobility) factors can influence motor performance (e.g. balance ability)  
65 and subsequently influence LE injury risk.<sup>7-12</sup>

66 The core musculature is important for stabilizing the LE during movement,<sup>13,14</sup> and can  
67 influence LE injury risk.<sup>15</sup> The muscles that collectively comprise the core include the  
68 transversus abdominis/internal obliques, rectus abdominus, external obliques, multifidus, and  
69 erector spinae muscles.<sup>13,16</sup> Researchers<sup>12,16</sup> have examined the effects of trunk and core-specific  
70 factors including proprioception on LE injury risk using logistic regression modeling. These  
71 researchers found that these factors were able to predict ligamentous knee injury (91%  
72 sensitivity, 68% specificity), and were able to predict knee injury risk with 84% accuracy, knee  
73 ligament injury risk with 89% accuracy, and anterior cruciate ligament injury risk with 91%  
74 accuracy in female athletes. As the terms core and trunk are often used interchangeably in the  
75 literature, for the current study the authors operationalized core endurance as the time that  
76 participants could maintain plank positions as previously.<sup>17,18</sup> Generally, higher scores on core  
77 musculature tests indicate better LE control during activity and may decrease LE injury  
78 risk.<sup>12,15,16</sup>

79 Balance and neuromuscular stability deficits also increase LE injury risk.<sup>7,9,11,19</sup> As  
80 postural stability and balance are often used interchangeably, for this study the authors  
81 operationalized balance as the ability to maintain postural stability while standing on one leg and  
82 performing a reach with the other leg as described when performing the Star Excursion Balance

83 Test (SEBT).<sup>20</sup> Poor SEBT performance can predict increased LE injury risk, with prior  
84 researchers<sup>11</sup> reporting that female athletes with lower (< 94% Leg Length, LL) reach distances  
85 are 6.5 times more likely to sustain a LE injury than female athletes with higher (> 94% LL)  
86 reach distances.<sup>11</sup> Generally, previous researchers note that individuals with worse balance have  
87 a greater LE injury risk than those with better balance,<sup>11</sup> and that improved balance decreases LE  
88 injury risk.<sup>7,8,11</sup>

89 Increased hypermobility can alter proprioception & balance,<sup>21,22</sup> and is related to  
90 increased LE injury risk.<sup>10</sup> In a systematic review and meta-analyses of generalized joint  
91 hypermobility and LE joint injury risk during sport, Pacey et al. reported that participants with  
92 generalized joint hypermobility had an increased risk of knee joint injury.<sup>10</sup> Although dancers  
93 often are reported to be hypermobile,<sup>21,23</sup> relatively little literature has examined if this  
94 hypermobility is an asset or liability.<sup>21,23</sup> Some researchers<sup>24</sup> have noted that when injured,  
95 female dancers with joint hypermobility syndrome had to stop dancing for longer periods of time  
96 than those without joint hypermobility syndrome. However, others<sup>25</sup> have not found any  
97 differences in injury rates between hypermobile and non-hypermobile dancers.

98 In general, greater core muscle endurance and better balance is related to decreased LE  
99 injury risk, while greater hypermobility is related to increased LE injury risk. Dancers are a  
100 group of physically active individuals who commonly suffer LE injury. Still limited literature  
101 exists examining the potential interrelationships relationships among core endurance,  
102 hypermobility, and balance in dancers. As the current authors wanted to examine how muscular  
103 and anatomical factors affect performance, we chose core muscle endurance and LE  
104 hypermobility as the predictor variables and balance as the predicted outcome measure for the  
105 study. Thus, the purposes of this study were to examine the relationships among core muscle

106 endurance, balance, and LE hypermobility, and determine the relative contributions of core  
107 muscle endurance and LE hypermobility as predictors of balance in female collegiate dancers.

## 108 **Methods**

### 109 *Participants and Informed Consent*

110 Fifteen healthy female collegiate modern dancers ( $18.3 \pm 0.5$  years,  $165.5 \pm 6.9$  cm,  $63.7$   
111  $\pm 12.1$  kg, dance experience =  $12.5 \pm 4.6$  years) participated in the study. All participants were  
112 volunteer dance majors and recruited from the same dance class at the university. While most  
113 dancers reported some prior injury in the past, at the time of testing they were injury free and did  
114 not have report any pain or issues that would affect their ability to perform the study tests. The  
115 local Institutional Review Board approved all testing procedures and all participants provided  
116 informed consent. The authors used a cross-sectional study design. All tests were performed in a  
117 single session. The same examiners measured the same task for all participants.

### 118 *Balance*

119 Balance was measured via the Star Excursion Balance Test (SEBT) – and specifically –  
120 the Y-balance components of the test using previously published methods.<sup>18</sup> The test required  
121 participants to first assume a single-leg stance, and then maximally reach along marked lines  
122 using the other leg while keeping the stance leg stable at the center of a grid, and then return the  
123 reach leg back to the center without losing balance.<sup>20,26</sup> For this study, participants performed  
124 reaches in three reach directions: (a) anterior (b) posterolateral, and (c) posteromedial (Figure 1a,  
125 1b, and 1c) in that order. The same investigator taught all participants to perform the test using  
126 both verbal instruction and demonstration, and participants were allowed three practice trials in  
127 each direction before actual test performance.<sup>18</sup> Participants first performed right leg and then  
128 left leg reaches, three times each. Participants took a 15-second rest interval between each trial in

129 the same direction and on the same leg, and a one-minute rest interval when changing feet and  
130 among different directions.<sup>18</sup> So an exemplar trial order and rest period interval was as follows:  
131 right leg anterior trial one – 15-second rest interval – right leg anterior trial two – 15-second rest  
132 interval – right leg anterior trial three – 1-minute rest interval (switching directions); then right  
133 leg posteromedial trial one – 15-second rest interval – right leg posteromedial trial two, and so  
134 on until all they completed all reaches in all directions.<sup>18</sup> A trial was not counted and asked the  
135 participant to repeat it if: (a) the participant was unable to maintain single leg stance, (b) the heel  
136 of the participants' stance foot did not remain in contact with the floor, (c) the participants'  
137 weight shifted onto the reach foot, or (d) the participant did not maintain start and return  
138 positions each for one second. The reach distances for the three trials in each direction were  
139 averaged and normalized to % leg length (LL). LL was measured from the anterior superior iliac  
140 spine to the medial malleolus.<sup>11,27,28</sup> SEBT scores were combined across all directions bilaterally  
141 and this composite score was used for analyses.<sup>18</sup>

#### 142 *Core Endurance*

143 Core endurance was measured using plank tests in three positions: anterior (Figure 2a),  
144 right (Figure 2b) and left (Figure 2c) lateral using procedures described in prior literature.<sup>17,18</sup>  
145 Participants first performed a single practice trial for a few seconds to confirm that they were  
146 able to successfully attain the test position. Then participants performed one recorded test trial.  
147 The maximum time (seconds, s) that the participants were able to hold and maintain the correct  
148 test position was recorded. The same examiner visually determined the end of all tests.

149 For the anterior plank test, participants assumed a push-up posture in the down position:  
150 legs together, lower leg in contact with a mat with ankles plantar-flexed, back straight, hands

151 shoulder width apart, head up. Time recording was stopped when any segment of the  
152 participants' body did not remain parallel to the floor as described in prior literature.<sup>17</sup>

153 To perform the left lateral plank test, participants placed their feet one on top of the other,  
154 their right arm perpendicular to the floor, with the elbow resting on the mat and the left arm  
155 across the chest with the left hand on the right shoulder. Participants used a similar position for  
156 the right lateral musculature plank test, with the left arm perpendicular to the floor. The time  
157 point when the participants could not maintain a straight line between the trunk or lower body  
158 (thigh or shank) segments on visual observation was recorded by the investigator.<sup>18</sup> The average  
159 score of three tests was used for analyses.

#### 160 *Hypermobility*

161 The 2 lower extremity-specific items on the previously published Beighton  
162 Hypermobility tests (knee hyperextension  $>10^\circ$  goniometry) were used to classify participants as  
163 LE hypermobile or not for this study.<sup>23,29</sup> Specifically, participants were operationally defined as  
164 not LE hypermobile if one or neither knee hyperextended greater than  $10^\circ$  and LE hypermobile if  
165 both their knees hyperextended greater than  $10^\circ$ . The same investigator determined LE  
166 hypermobility for all participants.

#### 167 **Statistical Methods**

168 Point-biserial-correlation-coefficients examined relationships among core endurance, LE  
169 hypermobility, and balance. A stepwise linear regression examined whether core endurance and  
170 LE hypermobility predicted balance. The relationships' strength was operationalized using  
171 previous guidelines, where 0.00-0.25 = little or no relationship; 0.26-0.50 = fair relationship;  
172 0.51-0.75 = moderate to good relationship, and 0.76-1.00 = good to excellent relationship.<sup>30</sup> An

173 0.05 alpha level was set *a priori* and the PASW 20.0 software (IBM Corp, Armonk, NY) was  
174 used conduct all analyses.

175

## 176 **Results**

177 Three dancers ( $18.0 \pm 0.0$  years,  $160.8 \pm 8.4$  cm,  $58.2 \pm 11.4$  kg, dance experience =  $14.3$   
178  $\pm 1.2$  years) were LE hypermobile, while 12 dancers ( $18.3 \pm 0.5$  years,  $166.7 \pm 6.4$  cm,  $65.1 \pm$   
179  $12.3$  kg, dance experience =  $12.0 \pm 5.0$  years) did not demonstrate LE hypermobility. See Table  
180 1 for overall participants' descriptive statistics. LE hypermobility and balance ( $87.2 \pm 8.3\%$  LL)  
181 were positively correlated  $r(14) = .67, p = .01$  to each other. However, core endurance ( $103.9 \pm$   
182  $42.5$  sec) and balance ( $87.2 \pm 8.3\%$  LL) not correlated  $r(14) = .32, p = .26$ .

183 The regression analyses revealed that LE hypermobility significantly predicted 36.9% of  
184 the variance in balance ( $F_{1,13} = 9.20, p = .01$ ; standardized beta coefficient = .644, standard error  
185 = 6.58). LE hypermobility status was statistically coded with not LE hypermobile status = 0 and  
186 LE hypermobile status = 1. The regression model analyses resulted in the following equation:  
187 Balance score = 12.9 (LE hypermobile status) + 84.6. So theoretically, if a dancer's balance  
188 score – if she were *not* LE hypermobile – was 84.6% LL [ $12.9 * (0) + 84.6$ ], then her balance  
189 score – if she *were* LE hypermobile – would be [ $12.9 * (1) + 84.6$ ] = 97.5 % LL.

190

## 191 **Discussion**

### 192 *Primary Findings*

193 The primary findings of the current study were that LE hypermobility and balance  
194 showed moderate to good positive correlations in collegiate female dancers. Core endurance and

195 balance were not correlated in female dancers. LE hypermobility, but not core endurance,  
196 influenced balance in the study dancers.

### 197 *LE Hypermobility and Balance*

198 Twenty percent (3/15) of the study dancers were LE hypermobile. The authors  
199 purposefully chose only LE specific measures for the operational definition of hypermobility  
200 because of the interest in examining whether these LE specific measures influenced LE balance.  
201 If the dancers' hypermobility status was classified using the unabridged 9-point Beighton score  
202 criteria that also uses trunk and upper body measures to classify participants' hypermobility (>  
203 4/9), 46.7% (7/15) of the study dancers would have been categorized as hypermobile, close to the  
204 2-44 % hypermobility ranges in dancers noted by previous researchers.<sup>25,31,32</sup> Based on the 9-  
205 point Beighton score, the LE hypermobile dancers' Beighton score was  $5.3 \pm 0.6$ , the non-LE  
206 hypermobile dancers' Beighton score was  $2.8 \pm 1.5$ , and overall all dancers' Beighton score was  
207  $3.3 \pm 1.8$ .

208 In the study participants, LE hypermobility and balance were positively related, and  
209 hypermobility status predicted 36.9% of the variance in their balance scores. Specifically, the LE  
210 hypermobile dancers had better balance than the non-hypermobile dancers. This finding was  
211 unexpected as prior researchers<sup>33,34</sup> have indicated that increased hypermobility is associated  
212 with decreased proprioception. Part of the explanation for this finding may lie in the actual  
213 demands of the SEBT. The SEBT requires participants to reach as far as they can with one leg –  
214 and examines their functional stability strength limits and neuromuscular control.<sup>35</sup> Previous  
215 researchers have found that individuals with hypermobility syndrome had higher passive knee  
216 ranges of motion than healthy controls.<sup>36</sup> Thus, while the current authors did not explicitly record  
217 range of motion, the hypermobile participants in the current study may have had increased knee

218 range of motion as reported in previous work,<sup>36</sup> allowing them to reach farther on the SEBT.  
219 Still, how this knee hypermobility allows participants to maintain balance while reaching farther  
220 needs additional study.

221 How LE hypermobility status affects LE injury risk also remains unclear. Briggs et al.<sup>24</sup>  
222 noted that while 50% of their hypermobile dancers had at least one tendon injury, only 21% of  
223 non-hypermobile dancers had at least one tendon injury. Also, they found that while 61% of  
224 hypermobile dancers took time off from dancing due to injury, only 32% of non-hypermobile  
225 dancers took time off for injury. The researchers suggested that although joint hypermobility  
226 may be associated with a better chance of getting selected as a dancer at the beginner levels, it  
227 may also be associated with higher injury risk and/or prolonged periods of recovery post-injury  
228 at elite levels.<sup>24</sup> Combining the participant demographics of collegiate level dancers in the  
229 current study with this prior literature, it appears that while the LE hypermobile dancers in the  
230 current study may currently have better balance, they may be more vulnerable to greater LE  
231 injury risk as they progress in their dance careers.

232 The participants' SEBT composite scores ( $87.2 \pm 8.3\%$  LL) were similar to previously  
233 reported score ranges (87.9 to 89.4 % LL) in female collegiate athletes.<sup>18,20</sup> Plisky et al.<sup>11</sup> have  
234 reported that  $> 4$  cm side-to-side differences in anterior reach scores predicted injury status in  
235 various sports. While the current authors did not examine LE injury, the dance participants'  
236 anterior (right side=  $87.5 \pm 9.0$ , left side= $87.2 \pm 9.6$ ) and overall (right side=  $70.0 \pm 9.1$ , left  
237 side= $69.9 \pm 8.8$ ) reaches were remarkably symmetrical. One possible explanation for this  
238 observation could be that performing modern dance may be bilaterally challenging and thus not  
239 have required the dancers in the current study to have a dominant lower extremity, resulting in  
240 bilaterally symmetrical scores. Further, the study participants' composite reach scores ( $87.2 \pm 8.3$

241 were also close to 89.6% LL cut-off score reported by Butler et al.<sup>7</sup> as the score below which an  
242 athlete was 3.5 more times likely to get injured than one who scored more. Thus, compared to  
243 prior literature, the dancers in the current study neither demonstrated side-side asymmetry nor  
244 had scores predictive of increased LE injury risk.

245 Another factor to consider when comparing the current findings with those of  
246 McCormack et al.<sup>21</sup> is the genre of dance performed by participants. The dancers in McCormack  
247 et al.'s study were ballet dancers, while the dancers in the current study were primarily  
248 modern/contemporary dancers. Similar to other types of athletics, where different sports have  
249 differing physical demands and subsequently different injury patterns (e.g. in tennis versus  
250 wrestling), different dance genres also have differing physical demands and injury patterns.<sup>2</sup>  
251 Ballet dancers often perform repetitive LE-centric movements whereas  
252 modern/contemporary dancers often incorporate more upper and whole body movements.<sup>2,37</sup>  
253 Therefore, it is possible that the physical demands of ballet may have placed hypermobile ballet  
254 dancers in the McCormack et al. study at different injury risk than the modern/contemporary  
255 dancers in the current study. The clinical implication of this finding is that clinicians should  
256 consider their dancers' genre demands when treating them and designing training programs for  
257 them. Specifically, LE training programs can improve balance<sup>38</sup> and decrease LE injury risk.<sup>39</sup>  
258 Clinicians can thus identify hypermobile dancers early before the dancers become injured and  
259 design programs that use multiple muscle groups to improve their dancers' balance and possibly  
260 positively impact dancers' LE injury risk.

#### 261 *Core Muscle Endurance and Balance*

262 The study participants' side plank core endurance scores (right: 75.7 $\pm$ 37.8, left = 65.1 $\pm$ 35  
263 s) were similar to prior scores in healthy collegiate (right: 61 $\pm$ 33, left = 66 $\pm$ 38 s)<sup>40</sup> and resistance

264 trained females (right:  $72 \pm 31$ , left =  $77 \pm 35$  s).<sup>41</sup> The current study participants' anterior core  
265 endurance scores ( $170.8 \pm 78.7$  s) were also close to previously published flexor core endurance  
266 scores in healthy collegiate ( $149 \pm 99$  s)<sup>40</sup> and resistance trained females ( $163 \pm 106$  s).<sup>41</sup> Consistent  
267 with prior work, the dance participants' core endurance scores had large standard deviations,  
268 possibly due to the nature of the tests that allowed participants to use different strategies to  
269 maintain test positions.

270       Theoretically, the greater the core musculature strength and endurance, the less the body  
271 has to compensate to maintain stability during perturbations and movement.<sup>13</sup> However, core  
272 muscle endurance and balance were not related in the current study. The study findings are in  
273 agreement with other reports that core muscle function is not associated with balance.<sup>18,20</sup> In  
274 contrast, Zazulak et al.<sup>12</sup> did find that core stability did predict LE injury risk in female athletes.  
275 The difference between these observations may partly be due to the different measures of core  
276 function and stability used in these different studies and the lack of consensus in how to measure  
277 core stability in all research. Specifically, Ambegaonkar et al. used the McGill plank tests and  
278 Gordon et al.<sup>20</sup> used the bent knee-lowering test to measure core function. Both these tests  
279 require participants to maintain core stability in a static (plank), or in a slow velocity dynamic  
280 position (bent knee lowering test). Conversely, Zazulak et al. used a sudden perturbation and  
281 examined the participant's ability to maintain or return to equilibrium after this perturbation in a  
282 seated position within a custom-made apparatus that fixed the participants' lower body. Core  
283 stability exists in a continuum where there the core muscles need to produce increasing amounts  
284 of force over decreasing amounts of time from core endurance to strength to power.<sup>42</sup> The  
285 measures used in the current study, and by Gordon et al. and Ambegaonkar et al. were closer to  
286 the core endurance spectrum while the measure used by Zazulak et al were closer to the core

287 power spectrum. Thus, it appears that core endurance may be less influential – and rather that  
288 core power, reaction ability, and neuromuscular control may be more influential in maintaining  
289 LE stability and subsequently have an effect on LE risk during activity.

290 In addition, Gordon et al. found that that hip external rotator muscle strength was  
291 moderately positively correlated to balance (SEBT reach distances).<sup>20</sup> Other researchers have  
292 likewise noted that females with greater hip flexor, extensor, and abductor strength had better  
293 anterior and posterolateral SEBT scores.<sup>18</sup> The researchers suggested that having females  
294 participate in hip muscle strengthening programs might improve their balance scores.<sup>18</sup> Prior  
295 researchers also have noted that LE strengthening can improve balance,<sup>28,43</sup> and that balance  
296 training, when used as part of a multi-intervention program can decrease LE injury risk.<sup>39</sup> Hip  
297 muscle strength may be more influential in altering balance than core endurance. Overall, the  
298 practical implication of combining the findings of the current study with prior information is that  
299 instead of using extensive core endurance muscle-centric training, clinicians should use  
300 integrated training programs – that may include core power and reactive training as part of the  
301 program – to improve their dancers’ balance and possibly decrease their dancers’ LE injury risk.

302 Some of the limitations of this study include the small sample size (LE hypermobility  
303 was identified in only three participants), and the limited generalizability of the study findings to  
304 other groups. In the current study, the authors also used anterior and lateral plank tests to  
305 examine core musculature. Other tests<sup>15,16,40,44</sup> exist in the literature that examine the ‘core’. We  
306 specifically chose the plank tests as they are commonly used in the literature,<sup>18,45</sup> are valid global  
307 core muscle function measures,<sup>46</sup> and activate the abdominal muscles.<sup>47</sup> Furthermore, plank tests  
308 are easy to administer, and it is relatively easy to ensure that participants are using proper  
309 technique when performing the tests. Still, whether other tests such as those suggested by

310 McGill<sup>40</sup> may be more appropriate to examine core endurance in dancers needs study. Other  
311 muscles may also have influenced core endurance. For example, different dancers may have used  
312 their shoulder and leg musculature differently to maintain their bodies in the plank position.  
313 Thus, researchers should examine other test positions that isolate the core muscles and those  
314 positions that use core muscles as part of a functional chain to examine the core muscles' role in  
315 influencing balance and motion. The authors of the current study also chose to use only two of  
316 LE-specific items from the 9-item Beighton scale to define LE hypermobility. Thus, the current  
317 findings are limited to only the LE and cannot be generalized to overall hypermobility.

318         The current authors also did not record ranges of motion of the dance participants. As  
319 some prior work indicates that ankle dorsiflexion ranges influence SEBT scores,<sup>48</sup> future  
320 investigators should examine the role of joint ranges of motion and their influence on balance.  
321 While participants did have adequate rest between tests, researchers should also examine  
322 whether fatigue may have altered SEBT and core endurance test performance. Finally, while the  
323 current authors chose a valid and reliable balance test that allowed for comparisons of the current  
324 findings to prior work, future researchers may also consider other tests more closely related to  
325 dance movements to examine dancers' balance.

## 326 **Conclusions**

327         The results of the current study demonstrated that LE hypermobility, but not core muscle  
328 endurance may be related to balance in female collegiate dancers. Although the LE hypermobile  
329 dancers in this study had better balance than non LE hypermobile dancers, how this  
330 hypermobility affects their LE injury risk as they progress in their dance careers needs  
331 longitudinal study. As core muscle endurance was not related to balance, the current findings  
332 indicate that rather than using isolated core endurance-centric training, clinicians may encourage

333 dancers to use training programs that incorporate multiple muscles - in order to improve their  
334 balance, and possibly reduce their LE injury risk.

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459 **Figure Legends**

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462 **Figure 1 – Star Excursion Balance Test (SEBT) Directions**

463

464 1a – Anterior Reach Direction

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466 1b – Posterolateral Reach Direction

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468 1c – Posteromedial Reach Direction

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470

471 **Figure 2 –Core Strength-endurance Tests**

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473 2a – Anterior Plank Test

474

475 2b – Right Plank Test

476

477 2c – Left Plank Test

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479

480 **Table 1:** Star Excursion Balance Test (SEBT) Scores (% Leg Length) and Core Endurance  
 481 Scores (s) (Means  $\pm$  SD)

482

<b>Test</b>	<b>Side</b>	<b>Direction</b>	<b>Mean</b>	<b>SD</b>
<b>SEBT</b>	Right	Anterior	70.1	9.1
		Posteromedial	96.7	7.5
		Posterolateral	95.6	10.5
	<b>Average of Right Side Reaches</b>			<b>87.5</b>
<b>SEBT</b>	Left	Anterior	69.9	8.8
		Posteromedial	97.1	9.3
		Posterolateral	94.7	10.6
	<b>Average of Left Side Reaches</b>			<b>87.2</b>
<b>Overall Composite Average of Right and Left Reaches</b>			<b>87.2</b>	<b>8.3</b>
Core Endurance		Anterior Plank	170.8	78.7
		Right Lateral Plank	75.7	37.8
		Left Lateral Plank	65.1	35.2
<b>Overall Average of all three Plank Tests</b>			<b>103.9</b>	<b>50.6</b>

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