Balance Differences between Retired Female Dancers and Age-Matched Non-Dancers

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Abstract

Background: Falls are increasing prevalent in older adults especially in females. The study aims to determine whether retired female dancers with historically better postural control retained better balance even after stopping dance as compared to age-matched counterparts with no dance experience.

Methods: 20 older females (66±6.52yrs; 10 retired dancers and 10 age-matched non-dancers) completed the following balance tests: Romberg, Functional Reach, Timed Up and Go, Berg Balance and Tinetti.

Results: Retired dancers performed better non dancers in the primarily static (Romberg and Berg Balance), but not in the dynamic balance tests.

Conclusion: Overall, dancers had better static balance, but both groups had similar dynamic balance. Retired dancers may have better static balance skill retention from their prior dance careers, whether these balance skills transfer over in dynamic activities and possible fall risk reduction needs further examination. Researchers should also consider which balance constructs are being tested when selecting balance tests.

Keywords: postural balance, elderly, dance, female

Introduction

Overall, although some researchers report that dancers may have better balance in some conditions, whether historical habitual exercise during adulthood can provide protection after it has stopped within a currently non-exercising senior population is unclear. Specifically, if retired dancers would retain their ability to balance more than non-dancers, practitioners can encourage adults to begin dancing or add dance to their physical activity regimens to decrease future falls risk. Thus, the purpose of this study was to examine whether retired dancers maintained their ability to balance when compared to age-matched sedentary non-dancers.

Literature Review

Falls in older adults, especially in females and those with osteoporosis, can cause fractures which can carry a high morbidity and mortality rate (Gillespie et al., 2012). Falls can be devastating to the affected individual but are also expensive to manage with an estimated cost of £2.7 billion per year in the UK (Poole, Smith, & Davies, 2015). Researchers consistently note declines in...
balance ability with increasing age in the post-60 year old population linked to the gradual decline in sensory, motor and cognitive abilities (Novak, Komisar, Maki, & Fernie, 2016). Manchester et al (1989) compared the contribution of the sensory, motor and cognitive systems to balance control between older and young adult population and reported that the older adults were less stable when peripheral vision was occluded and ankle somatosensation was limited. Though it is hard to isolate the function of the vestibular system within balance as it is linked into the vestibulo-ocular and vestibulo-spinal reflexes, its function decreases with age (Agrawal, Carey, Della Santina, Schubert, & Minor, 2009) characterized by vertigo (i.e. an illusory sense of motion) and its disruption of the two aforementioned reflexes (Tian, Shubayev, Baloh, & Demer, 2001) thereby leading to postural instability.

Examinations of postural control across the lifespan studies have shown that older adults and very young children use co-activation of agonist/antagonist muscle strategies to reduce sway (Woollacott & Shumway-Cook, 1990) whilst healthy adults control balance using three postural strategies; the first two strategies involve neuromuscular reflex adjustments made at the ankle and hip joint whilst the third strategy is a lowering of the body’s centre of gravity by flexion of the ankle, knee and hip flexion (Woollacott & Shumway-Cook, 1990). Manchester et al’s (1989) noted that older adults had a greater activation of the proximal antagonist leg muscles (i.e. hip strategy). Increasing age is associated with slower nerve conduction velocity and lower muscle spindle sensitivity which delays the response to centre of mass perturbations (Miwa T, Miwa Y, & K, 1995) thereby increasing the recovery distance of the centre of mass, though other studies have shown no loss in muscle response latencies (Manchester et al., 1989). Interestingly however, physical activity and exercise seems to mitigate some of these deleterious changes. Specifically, when lifelong senior exercisers (exercising for the past 30 years) to age-matched sedentary controls and active young men - researchers found that the senior exercisers’ muscles were actually more similar to young adults than their sedentary counterparts with better signaling pathways controlling muscle mass and metabolism (Zampieri et al., 2015). These better signaling pathways resulted in better maintenance of skeletal muscle structure, function and bioenergetics characteristics. Others (Sundstrup et al., 2010) also found similar results when comparing older men who had trained and played soccer all their life with age-matched sedentary controls. The researchers reported that the trained group had better muscle function and postural balance than their sedentary counterparts and similar functional characteristics to untrained men 40 years their junior (Sundstrup et al., 2010).

Zampieri (2015) suggested that it was regular exercise that maintained these physiological adaptations and therefore reduced fall risk. Consequently, the benefits of the intervention programmes will be lost unless exercise is maintained (Zampieri et al., 2015). Overall, for older adults, a wide variety of exercise interventions ranging from Pilates to jump-training, individual to group exercise, can decrease fall risk and improve physical activity, mobility and muscle strength, and balance (Hill, Hunter, Batchelor, Cavalheri, & Burton, 2015).

Similar to overall functional activity, balance is an integral part of dance. Dance choreography requires dancers to demonstrate difficult balancing activities (Hugel, Cadopi, Kohler, & Perrin, 1999). Prior researchers have found that dancers have faster postural responses and enhanced proprioceptive sensitivity with increased skill levels (Golomer, Dupui, Sereni, & Monod, 1999), and when compared to other athletes (Perrin, Deviterne, F, & C, 2002) and controls (Kiefer et al., 2013). Previous researchers also note that dancers, who are required to balance at times for several seconds on very small areas and have better neuromuscular response to postural perturbations than sedentary counterparts (Ambegaonkar et al., 2013; Simmons, 2005). Generally, these studies suggest heightened responses and sensitivity may exist in dancers because they dancers have higher dependence on visual proprioceptive inputs. However, researchers also note that when this visual proprioceptive input is removed, dancers perform less well than athletes and similar to untrained controls (da Silveira Costa, de Sá Ferreira, & Felicio, 2013). Hegel et al (1999) also suggested that these were specific modalities of balance which were not transferred to posture control in daily life situations and were limited to static balance(da Silveira Costa et al., 2013).
Research Design

Participants

We used a cross-section age-matched cohort design. We performed projected power analyses to detect differences between dancers and non-dancers based on prior studies with similar cohorts and study design (Dewhurst, Peacock, & Bampouras, 2015); indicating that 20 dancers and controls were required for a power exceeding 90% (5% error). Twenty females age range 60–82 years volunteered for the study. Ten retired dancers (65 ±7.3 years, 65.9 ±8.5 kgs, 165 ±5.5 cm) who had stopped dancing professionally at least 10 years ago, were initially recruited prior to selection of ten non-dancers from the volunteer pool that most closely resembled the dancers (67 ±5.7 years, 66.4 ±7.9 kgs, 165 ±5.8 cm). All the participants were healthy with no neurological conditions or joint replacement surgery and injury free in the last 3 months.

Compliance with Ethical Standards

Ethical approval in accordance with the Declaration of Helsinki (1964) was obtained prior to participant recruitment. All participants signed a pre-test questionnaire and an informed consent form. Data storage and analysis between the research group complied with the General Data Protection Regulation (GDPR) 2018.

Protocol

Participants all underwent a familiarization session one week prior to the testing date in a laboratory setting. They were asked to refrain from strenuous or unfamiliar exercise the day preceding testing and to wear comfortable clothing. On the test day, participants were asked to refrain from exercise in the 3 hours prior to the test and completed an informed consent and Par-Q prior to completing the tests. A single tester performed all data collection, intraclass correlation coefficients showed excellent reliability ranging between r=0.93 and 0.98 for all tests. Participants then performed five different balance tests (Romberg, Functional Reach, Timed Up and Go, Berg and Tinetti) on the same day in set order as described below:

Procedures

Romberg Test

Participants were allowed to choose their test (supporting leg) and carried out the test in 3 conditions with: 1) eyes open, 2) eyes closed and, 3) eyes open on a foam square, with bare feet and arms crossed (Khasmis & Gokula, 2003). The lifted leg was not allowed to touch the supporting leg during the test. The timing began as soon as the non-supporting leg left the floor and until balance was lost and the foot returned to the floor. We recorded the how long (s) the participants were able to maintain balance in 3 conditions.

Functional Reach Test

Participants were asked to stand sideways to the wall and position the arm nearest the wall at 90° from the shoulder with a closed fist (Duncan, Weiner, Chandler, & Studenski, 1990). The position of the 3rd metacarpal head was then recorded. The participants were then asked to reach as far forward as they were able to with their fist, without moving their feet or losing balance and the furthest position was marked. The difference between the start and end positions of the fist was measured (cm). Each participant performed the test three times and we used the average of the last two for analyses.

Timed Up-and-Go (TUG) Test

A cone was placed at 3 metres from a chair which had a seat height of 46 cm and no arm rests. The time it took each participant to stand up from the chair, walk around the cone and return to the seated position on the chair, with their back touching the chair’s back, was recorded with a stopwatch (s) (Wall, Bell, Campbell, & Davis, 2000).

Berg Balance Scale (BBS)

In this scale, participants performed 14 tests that ranged from standing unsupported, retrieving an object from the floor to standing on one leg. Each test was scored between 0–4, with 0 indicating the lowest level of function and 4 the highest level of function with specific descriptors for each test (Berg, Wood-Dauphinee, Williams, & Maki, 1992). Cumulative scores below 20 indicate a high fall risk, 21–40 a medium fall risk and 41+ a low fall risk.
Tinetti Test

In this test (Tinetti, Williams, & Mayewski, 1986), participants performed 9 balance (e.g. sitting balance, immediate standing balance, turning 360 degrees) and 7 gait (e.g. step symmetry, trunk engagement, stance) tests. The test is scored on a three-point scale from 0–2, where 0 represents the most impairment and 2 no impairment, with specific descriptors for each element. A score of <19 indicates a high risk of falls, and a score of 19–24 indicates a risk of falls.

Statistical Analyses

Group Means Were Compared Using Independent Sample T-Tests With 95% Confidence Interval (CI) And Effect Size (Partial $\eta^2$). Significant Statistical Difference Was Set At $P \leq 0.05$.

Results

Balance test scores for both groups across all tests are presented in Table 1. In all three conditions on the Romberg's test, the dancers performed significantly better. Specifically, dancers stood 48% longer with eyes open, ($t_{11.4}=-2.2$, $p=0.04$; CI $-69.8$, $0.2$; $\eta=0.3$); 82% longer with eyes closed ($t_{9.1}=-2.5$, $p=0.03$; CI $-34.7$, $-1.9$; $\eta=0.3$), and 62% longer with eyes open on the foam square ($t_{12}=-2.4$, $p=0.04$; CI $-40.3$, $1.5$; $\eta=0.2$); than non-dancers. Dancers also performed better than non-dancers on the BBS ($t_{13.4}=-4.2$, $p=0.001$; CI $-13.1$, $-4.3$; $\eta=0.2$).

Dancers and controls had similar balance in the Functional Reach test, ($t=0.752$, $df=18$, $p=0.462$; CI $-6.5$, $13.7$), the TUG, ($t=0.808$, $df=18$, $p=0.430$; CI $-0.99$, $2.22$) and the Tinetti test ($t=-0.293$, $df=18$, $p=0.773$; CI $-0.82$, $0.62$).

Discussion

Primary Findings

In the current study, we examined if retired dancers, who had historically highly developed postural control retained better balance even after stopping dance as compared with age-matched counterparts with no dance experience. As a whole, all participants in the current study were healthy and successfully completed all tests. Our primary findings were that retired dancers performed better non dancers in static but not dynamic balance tests.

Comparisons with Prior Literature

Our finding that dancers had better static balance is similar to prior reports (Ambegaonkar et al., 2013; Simmons, 2005). Interestingly, this finding that retired dancers’ static balance was better was more pronounced when the eyes were closed, which is in contrast to other previous reports (Perrin et al., 2002) (da Silveira Costa et al., 2013). In those studies, the authors suggest that dancers’ enhanced balance was due to greater dependence on visual proprioceptive inputs (da Silveira Costa et al., 2013). Specifically, da Silveira Costa (2013) reported participants who were currently dancing had better static balance than other athletes or controls, mainly due to heightened visual proprioception as during blind-folded trials dancers performance were similar to controls. A partial explanation of this discrepancy between the present study and previous studies may be that our dancers were retired but the dance participants in da Silveira Costa’s study were actively dancing (da Silveira Costa et al., 2013). However, another explanation may be that retired dancers having better static balance may be due to possible skill retention from their life-long dance careers, where they had to balance at times for several seconds on very small areas during performances. A final explanation may be with the actual constructs measured by the static balance tests in the participants of the current study. Specifically, ballet is a very upright dance form.

Table 1: Balance scores (M +SD) across different balance tests in Retired Dancers and Non-Dance controls

<table>
<thead>
<tr>
<th>Test</th>
<th>Ex-Dancer (n=10)</th>
<th>Non-Dancer (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romberg (eyes open), sec$^{-1}$</td>
<td>74.4 ±47.3</td>
<td>39.6 ±17.8</td>
</tr>
<tr>
<td>Romberg (eyes closed), sec$^{-1}$</td>
<td>22.9 ±22.9</td>
<td>4.6±1.6</td>
</tr>
<tr>
<td>Romberg (foam), sec$^{-1}$</td>
<td>34.5 ±20.1</td>
<td>13.6 ±12.2</td>
</tr>
<tr>
<td>Functional reach, cm</td>
<td>37.8 ±11.0</td>
<td>41.4 ±10.4</td>
</tr>
<tr>
<td>Timed Up and Go, sec$^{-1}$</td>
<td>6.8 ±1.6</td>
<td>7.4± 1.8</td>
</tr>
<tr>
<td>Berg Balance Scale</td>
<td>54 ±2.9</td>
<td>45 ±5.8</td>
</tr>
<tr>
<td>Tinetti</td>
<td>27 ±0.9</td>
<td>27 ±5.2</td>
</tr>
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</table>
that promotes stability often on a very small contact area (metatarsals) during static holds (e.g. relevé) and dynamic movement (e.g. pirouettes and grande allegro), whilst other dance genres promote finding and challenging the limits of stability (Laws, 2002). Therefore, this could explain why the retired dancers – who primarily were ballet dancers – performed better in tests that did not challenge functional stability limits.

**Balance and Falls Risk**

Interestingly, none of the participants in our cohort (age range 60–82 yrs old) had scores that placed them at risk of falls in any of the tests (Berg, Maki, Williams, Holliday, & Wood-Dauphinee, 1992; Duncan et al., 1990; Khasmis & Gokula, 2003; Tinetti et al., 1986). For example, the Functional Reach test has a predictive validity of <15cm for increased fall risk, the whole cohort in the present study scored considerably further than this threshold. Although the test is sensitive to changes from intervention programmes it only measures balance in one plane and tests 3 of the 9 criteria of the SFPC (functional stability limits, underlying motor systems and anticipatory postural control). Although the TUG test has no published predictive or construct validity, it does have concurrent validity linked to daily living measures (Podsiadlo & Richardson, 1991) and the SFPC rates the TUG as 3/9 as the test examines the construct related to functional stability limits and changing to dynamic stability. Overall, both the dancers and the non-dancers had balance scores similar to those previously reported in healthy older adults (Bennie et al., 2003; Briggs, Gossman, Birch, Drews, & Shaddeau, 1989; Bruyere et al., 2005; Donoghue & Stokes, 2009; Steffen, Hacker, & Mollinger, 2002)

**Balance Constructs Measured Across Tests**

In the current study we used multiple balance tests, as different balance tests examine different constructs across the 9 criteria of the Systems Framework for Postural Control (SFPC) (Sibley, Beauchamp, van Ooteghem, Straus, & Jaglal, 2015). The static balance tests (Romberg’s and BBS) offer limited information of an individual’s balance capabilities benefit as it challenges just 3 of the 9 of the SFPC criteria focusing on underlying motor systems, functional stability limits and anticipatory postural control. (Sibley et al., 2015). Both the Berg Balance scale and Tinetti are multi-item tests, although there are 7 similar items within the two scales the grading systems are very different, the Berg Scale uses a 5-point system with detailed descriptions for each point, whilst the Tinetti’s 3-point system descriptors are more open to interpretation (0 represents the most impairment, while a score of 2 represents independence). The Berg Scale has 6 static balance items of the total 14 items and a functional reach item, while the 16 items in the Tinetti test are more focused on dynamic balance. The retired dancers had significantly higher scores in the Berg Balance Scale, but for the Tinetti test, there was no significant difference between groups. In both tests, neither groups were considered at risk of falls, Berg Scale <20 (Berg, Maki, et al., 1992) and Tinetti <24 (Tinetti et al., 1986). The significantly higher BBS scores in retired dancers could reflect the group’s increased skill in static balance as highlighted in the Romberg tests whereas the lack of difference in the Tinetti test may be due to its emphasis on dynamic stability.

Taken as a whole, the observed differences between the two groups in the multi-item balance tests could be due to the items within the test. However, these varied findings across balance tests highlights the fact that static skill abilities are not necessarily transferred to postural control (da Silveira Costa et al., 2013; Hugel et al., 1999). Therefore, the past exercise history of the individual possibly needs to be considered when selecting a balance test with a clear need to use tests that have examine multiple constructs of balance (Sibley et al., 2015).

**Clinical Implications**

A major clinical implication of the current study is that although dancers seem to have better static skill balance skills than non-dancers, these balance skills do not transfer universally across all dynamic activities. Therefore retired dancers and all older adults need to continue engaging in exercise/physical activity programs to reduce the risk of falls.

**Strengths, Limitations, and Future Recommendations**

One of the strengths of this study is that it is one of the first comparisons of retired professional dancers – an elite group of physically active participants – as compared to...
a matched cohort. As Sibley et al (2015) note, different balance batteries examine different construct of balance. In this study, we used multiple balance tests to examine differing constructs of balance – including static and dynamic balance so that we could examine balance across multiple tasks. Still we recognize some study limitations. For example, although our participant numbers met the calculated sample size, the findings have limited generalizability outside of our participants. Thus, researchers should examine balance across larger cohorts and in other populations that also need highly developed balance skills for their work life (e.g. circus performers, gymnasts, figure skaters) and check if these groups also differ from sedentary older adults.

Also, as mentioned earlier generally, both groups were above the “at increased risk of falls” threshold (Berg, Maki, et al., 1992; Duncan et al., 1990; Khasmis & Gokula, 2003; Tinetti et al., 1986). Therefore, the tests we used may not be sensitive enough to test any possible balance deficits in these healthy participants. So, future researchers should consider which balance constructs are being tested when selecting balance test batteries.

Given our mixed findings of static but not dynamic balance group differences in the current participants, it seems while that previous habitual exercise does have lasting effects, these effects are limited to specific balance constructs (i.e. static balance skills). The benefits do not transfer across all balance constructs (i.e. dynamic balance skills). Thus, which habitual exercises offer balance benefits across multiple balance constructs needs examination. Finally, longitudinal studies using the same groups and examining their balance repeatedly as participants age will help clinicians recognize examine how balance skills change with increasing age and how these change influence falls risk in older adults.

### Conclusions

Overall, retired dancers had better static balance, possibly as a skill retention from their to habitual skills honed during their dance careers. Still, whether these balance skills transfer over in dynamic activities and possible fall risk reduction needs further examination. Researchers should also consider which balance constructs are being tested when selecting balance test batteries.

### Table 1: Mean and standard deviation of participant descriptors of ex-dance and non-dance groups

<table>
<thead>
<tr>
<th></th>
<th>Age (yrs)</th>
<th>Body mass (kg)</th>
<th>Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex-Dance (n=10)</td>
<td>65 ±7.36</td>
<td>65.9 ±8.49</td>
<td>165 ±5.45</td>
</tr>
<tr>
<td>Non-Dance (n=10)</td>
<td>66 ±5.66</td>
<td>66.4 ±7.86</td>
<td>165 ±5.75</td>
</tr>
</tbody>
</table>

### Table 2: Group mean and standard deviation data for all the tests.

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Ex-Dancer (n=10)</th>
<th>Non-Dancer (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romberg (eyes open) (sec⁻¹)</td>
<td>74.4 ±47.28</td>
<td>39.6 ±17.75</td>
<td></td>
</tr>
<tr>
<td>Romberg (eyes closed) (sec⁻¹)</td>
<td>22.9 ±22.96</td>
<td>4.6 ±1.64</td>
<td></td>
</tr>
<tr>
<td>Romberg (foam) (sec⁻¹)</td>
<td>34.5 ±20.11</td>
<td>13.6 ±12.16</td>
<td></td>
</tr>
<tr>
<td>Functional reach (cm)</td>
<td>37.8 ±11.02</td>
<td>41.4 ±10.38</td>
<td></td>
</tr>
<tr>
<td>Timed up and go (sec⁻¹)</td>
<td>6.8 ±1.62</td>
<td>7.4 ±1.79</td>
<td></td>
</tr>
<tr>
<td>Berg balance</td>
<td>54 ±2.96</td>
<td>45 ±5.76</td>
<td></td>
</tr>
<tr>
<td>Tinetti</td>
<td>27 ±0.95</td>
<td>27 ±5.2</td>
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### References


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