International Journal of EXERCISE SCIENCE

Original Research

Insights on Ten Weeks of Classical Ballet Training and Postural Stability in Older Adults

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ABSTRACT
International Journal of Exercise Science 13(1): 101-112, 2020. Older adults show an increased risk of falling as they age, but dance interventions of various genres have been shown to improve postural stability in this population. The purpose of this study was to investigate the effects of a ten-week beginning ballet intervention on postural stability for older adults. Eleven participants enrolled in the Dance Group (DG; 73.3 ± 10.6 years) while six enrolled in the Control Group (CG; 69.5 ± 11.9 years) via convenience sample. Following the intervention, no significant differences were seen within the DG from pre- to post-testing or when comparing delta values (post minus pre) between groups in the center of pressure area, displacement, or speed ($p > 0.05$). While no differences were seen with this intervention, the ballet barre was used for approximately half of each dance class; future ballet interventions for older adults may benefit from training without a barre to enhance potential effects on postural stability.

KEY WORDS: dance training, balance, aging

INTRODUCTION

Older adults frequently report difficulty with balance and ambulation, showing an increased risk of falling as they age (2, 18). Postural stability, which involves the use of skeletal muscles to control the position of the body in relation to gravity, declines with age as well, impacting balance and gait (18, 42). Over time, healthy older adults demonstrate a decline in the sensory systems used to maintain postural stability, including diminishes in proprioception, visual acuity, vestibular input, and pressure sensations on the base of support, all of which contribute to a higher risk and rate of falls (35, 42, 48, 51, 54).

Dance is a low- to moderate-intensity form of exercise that has been shown to improve physical function across many populations including people with Parkinson’s disease (1, 5, 15, 23), rheumatoid arthritis (39, 41, 45), and developmental and intellectual disabilities (4, 14, 22), and in young (3, 13, 58) and older adults (2, 6, 11, 17, 18, 21, 23, 31, 32, 43, 52, 53). Specific physical benefits for older adults following dance training may include aerobic (6, 11, 17, 25, 26, 28, 43) and muscular fitness (6, 11, 17, 25, 26, 28, 30, 31, 28, 43), flexibility (11, 25, 26, 30, 43), gait (24, 31, 38, 50), motor agility (11, 30, 43), proprioception (36), and balance (2, 6, 11, 17, 18, 21, 23, 31, 32, 43, 52, 53).

Many studies have shown improvements in either balance or postural stability for older adults following the practice of dance across various disciplines including ballroom (6), Colombian Caribbean folk dance (43), contemporary (18), creative dance (11), jazz (2), salsa (21), tango (23, 53), Turkish folklore dance (17) and traditional Greek (52) and Korean dance (31, 32). Cross-sectional studies have shown that older adults who dance regularly have better balance than non-dancers (12, 55, 56, 61). These findings indicate that dance interventions may help to reduce the risk of falls in older adults (2, 11, 18, 21, 32, 52, 53). Additionally, dance training may have mental and social benefits for older adults through positive social interactions in a community setting (34), and dance interventions have been shown to improve health-related quality of life and life satisfaction in older adults (17, 30, 33). Dance classes share many qualities with exercise programs that are associated with long-term compliance including group participation, use of music, positive feedback, enthusiastic leadership, and an emphasis on variety and fun (15, 47).

Professional dancers rely more on proprioception and less on visual input to maintain balance than non-dancers, which is associated with advanced balance abilities (20, 29). The ability to rely more on proprioception than visual input is a trainable skill; pre-professional classical ballet dancers who participated in a balance training program that targeted proprioception by removing visual input showed improved balance (29). Proprioceptive input from the legs is the primary and most sensitive form of input in detecting postural sway during normal standing and is therefore desirable in all populations (19). Research suggests that professional classical ballet dancers have the same balance abilities as non-dancers when standing with eyes closed, suggesting that ballet dancers in particular rely too heavily on visual input to detect postural sway (9, 27). However, professional ballet dancers show superior balance abilities with eyes open than non-dancers, even in positions with a reduced base of support (9).

Classical ballet technique requires advanced postural control in order to execute its complex static and dynamic movements (9). Despite the inherent postural control required in the practice of classical ballet and the success of other dance interventions for older adults (2, 6, 9, 11, 17, 18, 21, 23, 31, 32, 43, 52, 53), classical ballet interventions for older adults have been underrepresented in the literature. Thus, the purpose of this study was to examine changes in older adults' postural stability following exposure to a beginning ballet dance program. It was hypothesized that significantly reduced postural sway, and therefore improved postural stability, would be observed following ten weeks of ballet technique training.

METHODS

Participants

Healthy adults who were at least 55 years of age, were independent with activities of daily living, and had never participated in dance training were enrolled for this study through a convenience sample (Table 1); an intake form was used to assess if participants met these inclusion criteria. Exclusion criteria included active participation in a physical therapy program with the goal of improving functional mobility, using a walking aide regularly, and/or diagnosis of cardiovascular or neurological disease. Participants were not excluded if they had a pacemaker if they had been cleared by a physician as a 'no restrictions' status for physical activity as indicated on the required intake form. Participants in the Dance Group were also excluded if more than five of the ballet classes were missed during the 10-week program. All participants self-reported they were 'physically active' via intake form prior to the start of this study.

Table 1. Subject characteristics expressed as means (± standard deviation).

Group	Control	Dance	*P*-value
Age (years)	69.5 (±11.9)	73.3 (±10.6)	0.512
Height (cm)	167.64 (±12.44)	163.25 (±5.60)	0.579
Weight (kg)	72.20 (±13.05)	69.30 (±17.41)	0.365
BMI (kg/m^2)	25.82 (±4.91)	26.04 (±6.45)	0.841

Assignment to either Dance Group (DG; n = 11, 10 female, 1 male) or Control Group (CG; n = 6, 5 female, 1 male) was determined by the individuals themselves based on their desire to participate in the ballet classes. This quasi-experimental community-based initiative required participants to consent to partake in a 10-week exercise protocol and therefore utilized a convenience sample to assure participants were both willing and appropriate to engage in this type of physical intervention. Recruitment of participants was conducted via posters around a college campus, at a local senior center, and at an independent living community. This study was approved by the college's Institutional Review Board, and all participants provided written informed consent prior to any testing. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (40). This study was conducted at Skidmore College in the fall of 2018 (*clinicaltrials.gov #NCT03691259*).

Protocol

Dance Intervention: One-hour ballet classes were held twice per week over a 10-week period in the dance theater of a collegiate dance department. Unlike in most ballet studios, no mirrors were present to promote proprioceptive balance training and limit reliance on visual input. An undergraduate dance student served as the lead teacher for the dance classes and was assisted by at least one additional undergraduate dance student at each class. The lead teacher worked alongside a dance professor/physical therapist to determine the curriculum for the dance classes. Attendance was taken at the start of every class. Chairs were set up around the stage so participants could easily take a break if needed at any point during the dance classes.

Each ballet class started with approximately 30 minutes of warm-up exercises while holding onto the ballet barre, then progressed towards doing exercises in the center (standing unsupported) as is the typical progression in a ballet class (Figure 1). The class was taught using traditional classical ballet technique and closely followed the conventional format that this art-form entails. Movement 'combinations' were taught by the lead teacher who would physically demonstrate a series of ballet steps. Participants would then perform this movement to music alongside verbal cues from the lead teacher. Following each 'combination', the teacher would give comments and individual corrections as needed. Participants stayed in a standing position while receiving feedback and while learning new ballet movements unless they self-determined the need for a seated break. 'Combinations' would typically be performed more than once to allow for mastery before moving on. Participants were taught the foundational positions and combinations used in ballet, including but not limited to: plié, tendu, degagé, rond de jambe, chassé, pas de bourrée, glissade, and reverence. This class format is consistent with professional ballet training, yet the class was tailored to older adults by teaching simplistic ballet movements which were both safe and attainable by the participants. Members of the CG did not participate in any intervention and their outside activity was not controlled for.

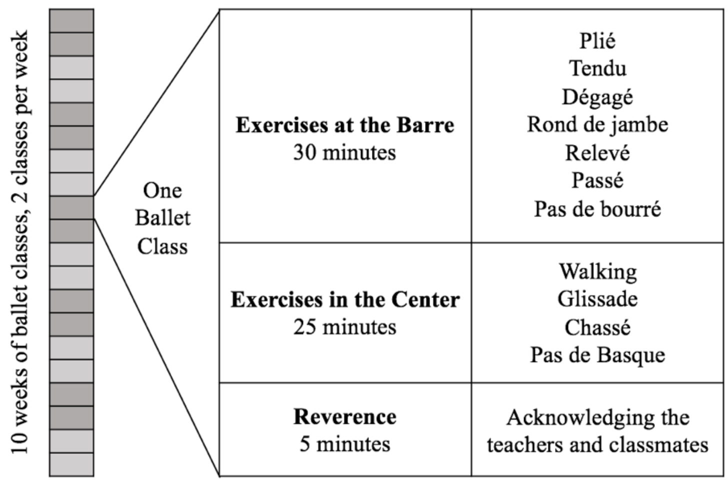

Figure 1. Outline of the beginning ballet class intervention utilized in this study.

Assessments of Postural Stability: Postural stability of participants in both the CG and DG was assessed prior to the first ballet class and again after the final class of the intervention. A static standing position was maintained for 30 seconds in two conditions: a bilateral stance with eyes open (EO) and a bilateral stance with eyes closed (EC). Participants were given 15 seconds of rest between each trial with two trials completed in each condition. Participants were guarded during each trial, and a chair was available if participants began to feel unsteady and needed to rest.

While force plates are considered the gold standard for assessing postural stability, the use of a Wii Balance Board (WBB) alongside specialized balance software is a more affordable option which has high reliability and validity for use in scientific research (7, 57, 60). A WBB was used in conjunction with BrainBLoX software (8) to track and record movements of the center of pressure (CoP) throughout the postural stability assessments. Assessments of postural stability were conducted by members of the research team with two researchers present at each data collection session. Researchers were not blinded to the participants' group assignments.

During each trial, the CoP's position was monitored continuously and recorded to gain information about postural sway as determined by the CoP's mean and maximal movements including displacement and speed. Five measures of postural stability were examined during each 30-second trial: the area traveled by the CoP, the CoP displacement in the x- and y-planes, and the absolute value of the average speed of the CoP in the x- and y-planes. Decreased postural sway, as indicated by decreases in area, displacement, and/or speed in any direction, would indicate an improved ability in controlling the positions of the body to maintain stability and therefore improved postural stability (42).

Statistical Analysis

Non-parametric Wilcoxon signed ranks tests were used to compare values at baseline and post-testing within each group. Non-parametric Mann Whitney U tests were used to analyze the delta (post minus pre) values in order to compare changes in postural stability over time between groups. All analyses were completed using SPSS Version 25.0 (IBM Corp, 2017). Significance for all tests was determined at $\alpha = 0.05$. All statistical analyses were conducted by a single member of the research team. Participants were de-identified prior to data analysis and instead represented with a participant identification number and corresponding group membership.

RESULTS

Twenty-one participants were initially identified as meeting inclusion criteria, but four withdrew prior to post-testing (Figure 2). As such, 17 participants were included for data analysis (CG $n = 6$; DG $n = 11$). No significant differences were found when comparing the delta values for the five measures of postural stability in the EO and EC conditions between the CG and DG (Table 2). Similarly, no significant differences were found when comparing baseline to post-testing values within each group in the EO condition. For the EC condition, the CG displayed a decrease of 7.29 mm in x Displacement from pre- to post-testing ($p = 0.028$), and the DG displayed an increase in |x Speed| by 0.04 mm/s ($p = 0.041$); no other significant differences in postural stability were found in the EC condition. Members of the DG were absent from an average of 3.17 (± 2.12) ballet classes (Figure 3).

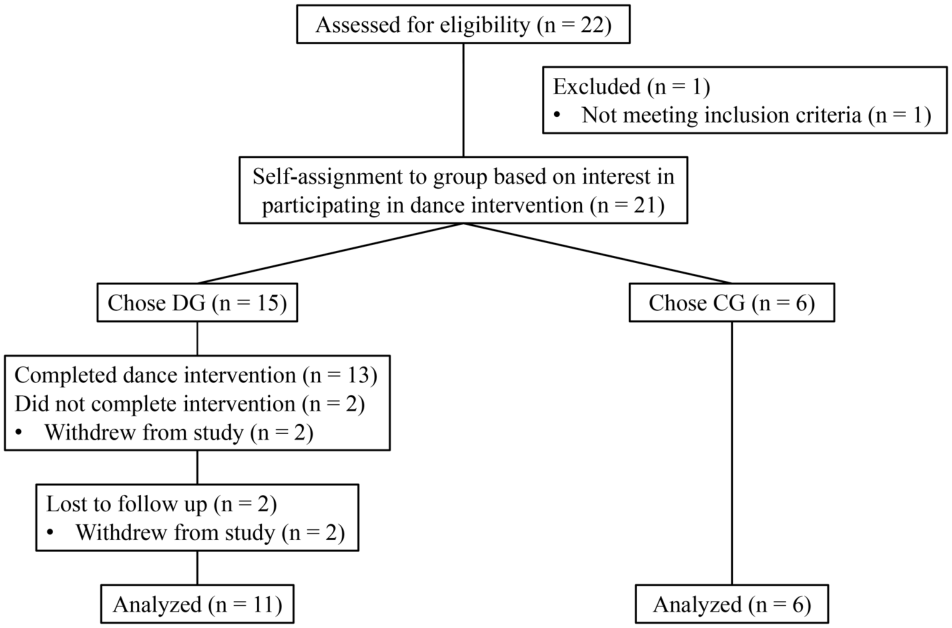

Figure 2. Participant flow from recruitment through data analysis.

Table 2. Mean (± standard deviation) CoP movements at pre- and post-testing during EO and EC trials (*n* = 17).

Measure	Trial	Group	Pre	SD	Post	SD	*p*-value[a]	Delta	SD	*p*-value[b]	r[c]
Area (mm^2)	EO	Control	0.05	±0.02	0.05	±0.02	0.345	0.00	±0.00	0.301	0.26
		Dance	0.05	±0.03	0.05	±0.02	0.657	0.00	±0.02		
	EC	Control	0.07	±0.03	0.09	±0.14	0.600	0.03	±0.12	0.808	0.07
		Dance	0.08	±0.05	0.07	±0.03	0.594	-0.01	±0.04		
xDisplacement (mm)	EO	Control	22.75	±8.91	21.79	±13.14	0.463	-0.96	±15.46	0.733	0.09
		Dance	17.51	±7.59	17.71	±7.35	0.859	0.20	±7.96		
	EC	Control	23.60	±5.21	16.31	±8.77	0.028*	-7.29	±8.11	0.180	0.34
		Dance	17.91	±9.04	17.86	±8.46	1.000	-0.05	±7.79		
yDisplacement (mm)	EO	Control	27.66	±4.54	24.44	±3.35	0.249	-3.22	±5.94	0.301	0.26
		Dance	23.61	±6.21	23.38	±5.23	0.790	-0.23	±7.92		
	EC	Control	31.85	±4.98	28.05	±15.27	0.345	-3.79	±15.24	0.180	0.34
		Dance	29.49	±8.57	27.11	±7.96	0.328	-2.38	±7.79		
|xSpeed| (cm/s)	EO	Control	0.68	±0.46	0.98	±0.76	0.249	0.30	±0.55	0.660	0.12
		Dance	0.57	±0.39	0.64	±0.41	0.722	0.08	±0.64		
	EC	Control	0.65	±0.49	0.66	±0.54	0.917	0.01	±0.80	0.256	0.292
		Dance	0.37	±0.41	0.85	±0.63	0.041*	0.48	±0.71		
|ySpeed| (cm/s)	EO	Control	0.71	±0.33	0.65	±0.83	0.753	-0.05	±0.80	0.660	0.12
		Dance	0.57	±0.69	0.49	±0.35	0.859	-0.08	±0.82		
	EC	Control	0.98	±0.78	0.81	±0.73	0.753	-0.16	±0.64	0.404	0.18
		Dance	0.70	±0.60	0.80	±0.68	0.534	0.09	±0.72		

[a] Non-parametric Wilcoxon signed ranks test comparing pre/post within group
[b] Non-parametric Mann-Whitney U tests comparing delta values between groups
[c] Effect size calculation
Asterisk (*) indicates statistical significance ($p < 0.05$)

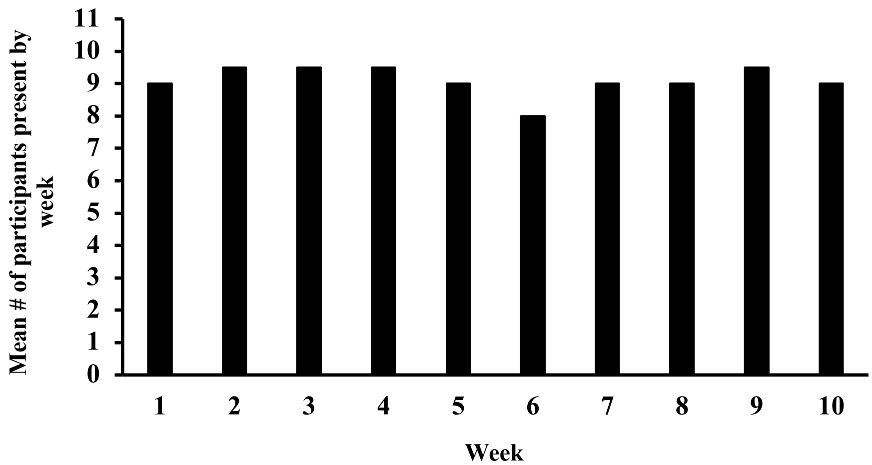

Figure 3. Weekly attendance of participants (n = 11).

DISCUSSION

No significant differences in postural stability were found from pre- to post-testing within a group of older adults participating in classical ballet training and when compared to a healthy control group. While a few significant differences were observed between values at baseline and post-intervention, these findings appear to be anomalies and do not support the previous literature (2, 6, 11, 17, 18, 21, 23, 31, 32, 43, 52, 53) or the hypothesis that postural stability would improve in older adults following classical ballet training.

This intervention had a unique aspect in its dance training in comparison to previous dance intervention studies: the use of the ballet barre. Unlike other concert dance interventions for older adults that saw subsequent improvements in postural stability (2, 18), participants in this study held onto the ballet barre for approximately half of their dancing time in each class, a unique aspect of ballet training not utilized in other forms of dance. While exercises were crafted to be more challenging throughout the intervention and progressed from holding onto the barre with both hands to one hand, a considerable portion of each ballet class was performed with the support of the barre. This portion of these ballet classes may have interfered with the proprioceptive aspect of balance training. While professional and pre-professional ballet dancers do show better balance skills than non-dancers, they also train extensively without holding onto the barre both in technique classes and in performing repertoire (9, 10, 27). Additionally, pre-professional ballet dancers have been shown to rely heavily on visual cues to maintain postural stability, which may be due to the presence of mirrors in ballet studios (29). The ballet classes in this intervention took place in a dance theater without mirrors, which may have influenced visual input for the participants. Challenging the sensory systems used to maintain postural stability and specifically focusing on proprioceptive input may yield different results for older adults participating in an intervention of classical ballet training.

While possible psychological benefits were not assessed as a part of this study, this intervention attempted to create an environment in which older adults had positive social interactions and felt a part of a community. Dance programs, even more so than other group exercise programs, have been shown to promote positive social interactions and form this unique sense of community for older adult participants (34) and are associated with improvements in health-related quality of life (17, 30, 33). In the present study, participants were compliant with the intervention as demonstrated by their high attendance rates. While exercise programs for older adults are often plagued with poor attendance and program adherence (46, 59), participants maintained good attendance throughout this intervention, demonstrating some evidence that participants may have enjoyed the experience.

As literature review has revealed that no prior studies utilized classical ballet interventions for older adults, this study provides unique insight that classical ballet training using standard, foundational ballet movements may not translate into improvements in static balance. This same concept may potentially be reflected in elite ballet dancers, as little is known about how training at the barre translates to performance without it (37). While barre exercises may help ballet students to develop strength and flexibility (49) and to focus on proper body alignment (44), natural dynamic postural responses with various dance movements may be limited (37). In fact, intermediate collegiate ballet dancers reported that they were uncertain why they used the barre and how the barre exercises prepared them for work without it (37). Other dance interventions across a wide variety of genres have shown improvements in postural stability in older adults without the use of the barre (2, 6, 11, 17, 18, 21, 23, 31, 32, 43, 52, 53), indicating that the ballet barre should not be used in future dance interventions aiming to improve postural stability.

While no significant changes in postural stability were observed following this ballet class intervention, the small sample size and different sized CG and DG may have impacted the results of this study and increased the variability of results. Participants in the current study were predominately female, so larger sample sizes with more male participants enrolled are recommended for future studies. Additionally, a convenience sample was used for this study, and participants who are likely to enroll in dance training programs may be more likely to engage in other healthy practices, which limits the generalizability of these results (2). Data collectors and statisticians were not blinded in this study which has potential to biased results. Moreover, confounding factors such as outside physical activities, age, and medical history were not controlled for which must be acknowledged in the interpretation of these data.

This study provides useful insights that may shape intervention design in future studies wishing to examine the effects of dance interventions for older adults. Specifically, future ballet interventions for older adults that aim to enhance postural stability may benefit from performing most, if not all, of the exercises in the center of the room as opposed to using a ballet barre. While following the standard progression of exercises found in ballet classes, participants could all stand in a circle to complete these exercises, increasing proprioceptive input while reinforcing the dance class community and social benefits of dance training. Furthermore, comparisons between classical ballet interventions and other balance training programs for older adults may lead to a deeper understanding of interventions to enhance postural stability. Continued research may benefit from specific evaluation of the physical, social, and emotional aspects of exercise programs that appeal to older adults, encourage adherence, and enhance overall functional mobility.

No significant changes were seen in postural stability for older adults who participated in ten weeks of classical ballet training, as the use of the ballet barre may have inhibited improvements in proprioception and postural stability. However, high attendance rates indicate good overall program compliance. Future classical ballet interventions for older adults may benefit from increasing dancing time in the center to increase proprioceptive input and encourage improved postural stability.

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