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Integrative Dance for Adults with Down Syndrome: Effects on Postural Stability

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ABSTRACT

International Journal of Exercise Science 13(3): 1317-1325, 2020. Postural stability, one's ability to maintain an upright stable position, is a crucial aspect of functional mobility and independent living. The purpose of this study was to examine if integrative dance classes have the potential to improve the postural stability in individuals with Down syndrome (DS). Utilizing a one group design, seven participants with DS were evaluated before and after a 12-week integrative dance class (ClinicalTrials.gov#NCT03660423). Postural stability was evaluated in uni- and bilateral quiet standing using a Wii Balance Board. Stability levels were measured based on changes in center of pressure (CoP) variables. Pre to post changes were found in in CoPx displacement ($Z = -2.028$, $p = 0.043$) and average speed ($Z = -2.197$, $p = 0.028$) in the eyes closed condition and in CoPy displacement with eyes open ($Z = -2.366$, $p = 0.018$). These data indicate improved postural stability following an intervention of integrative dance and a potential for improved functional mobility and decreased fall risk for the participants involved. This preliminary study suggests the need for further research into the effects of integrative dance on postural stability in those with DS and its use as a rehabilitative tool.

KEYWORDS: Dance, disability, integrative dance, postural stability, balance

INTRODUCTION

Down syndrome (DS), also known as Trisomy 21 or Trisomy G, is a genetic syndrome characterized by an additional copy of the 21st chromosome. Individuals affected by this relatively common chromosomal addition may exhibit a variety of developmental differences, extending from intellectual, physiological, and anatomical variances. Individuals with DS may present with low muscle tone (28), ligament laxity (22), decreased vision (18), reduced postural stability (5, 43), and decreased rates of learning, speech and language acquisition (6, 7). Furthermore, decreased judgement, attention span, and processing speeds can be observed (6, 7). DS can also pose a risk factor in congenital heart defects and poor cardiovascular health (40). While many individuals with intellectual and developmental disabilities (86.5%) do not meet the daily recommended physical activity standards (2, 41), individuals with DS have an even lower average of meeting these important health guidelines (24). These lifestyle differences may place a considerable strain on the health of those with DS, leading to a potential decreased lifespan when compared to their non-disabled counterparts (20, 23, 33).

Posture may be defined as one's ability to keep themselves upright and stable whilst resisting gravity in both static and dynamic situations (45). Standing postural stability is achieved by maintaining the center of pressure within the base of support (i.e. area between feet) (29). The human body is in a constant inverted pendulum-like swaying motion when standing with both feet on the ground in response to the high quantity of external and internal information and variables provided to the body (i.e. auditory, visual, proprioceptive, physical and mental stress, fatigue, aging, etc.) (39, 45). In a typically developing individual, an ankle strategy is used to manage minor perturbations in anteroposterior direction and a hip strategy is used in mediolateral direction during quiet standing (i.e. upright bilateral stance) (45). However, individuals with DS more frequently employ a hybrid postural strategy using both hip and ankle strategies to maintain stability in both directions (i.e. anteroposterior and mediolateral). This more variable method of postural control may result in a reactive postural stability technique instead of a preventative one, increasing the chances of falling outside their limits of stability, as well as increased energy expenditure leading to fatigue (31). As such, individuals with intellectual disabilities have a high incidence of falls, often resulting in medical attention and/or fracture (16, 42).

Postural stability is an essential component of overall functional mobility, supporting the uninterrupted ability to perform activities of daily living (31). Daily tasks such as opening doors, transfers from sit to stand, and stair negotiation increase in difficulty as postural stability declines. Thus, more complex physical tasks may become arduous or even inexecutable without assistance, negatively impacting an individual's independence and ability to fully engage within their environment. Decreased postural stability has been correlated to an increased risk of falling (4, 32, 34) and more specifically, decreased stability in the mediolateral direction, shown as increased sway in the x-axis, has been suggested as a predictor of falls (32). As previous research demonstrates, individuals with DS may have reduced postural stability (5, 13, 41, 43). The relationship between this variable and an individual's ability to thrive within their environment and community becomes a salient point of discussion.

Research has suggested that individuals with DS demonstrate higher speeds of postural sway than their non-disabled counterparts (15, 36). In addition to the aforementioned differences in postural strategies, this impairment may be resultant of decreased experiences in adapting to variable environmental stimuli as well as insufficiencies in overall motor learning (5). Correlations have been found between low muscle tone and a lack of successful proprioceptive feedback processing regarding kinetic and postural stability (21). This implies a cyclical deficit in people with DS as they not only embody physiological challenges in postural stability but are less likely to be exposed to environmental stimuli to improve these impairments, and thus are in need of proprioceptive training.

The use of dance as an intervention for people with DS and other developmental disabilities has been suggested as a method of improving physical and psychological variables. McGuire and colleagues (26) report positive outcomes in motor abilities and participation following an adaptive dance program while Reinders (35) suggests in a single subject design that dance may benefit an individual socially, psychologically and physically. Cosma and colleagues (9) suggest that there is a significant relationship between the completion of the dance program and an increase in proprioceptive abilities and functional mobility following an 8-month dance program, further encouraging the exploration of the capabilities of this mode of intervention. Moreover, a positive relationship had been found between exercise interventions and activities of daily living in adults with DS (10). Dance training appears to be a ripe environment to investigate potential improvements in postural stability in people with DS.

The purpose of this study is to examine the changes in postural stability in adults with DS following exposure to an intervention of integrative dance. It was hypothesized that a significantly reduced body sway would be observed in participants following 12-weeks of integrative dance training.

METHODS

This study was constructed as a Community Based Participatory Research initiative (27) utilizing a one group pre-test post-test design (ClinicalTrials.gov#NCT03660423).

Participants
The participants included seven individuals with Down syndrome recruited via convenience sample from a nearby day-habilitation facility (Table I). Inclusion criteria was being an age of 18 or older and a statement from the physician in the participant's medical files allowing unrestricted activities. The exclusion criteria were active participation in a physical therapy program with the goal of improving functional mobility or participation in a consistent exercise class that had the potential to improve physical function. Participants were initially contacted for recruitment through day-habilitation staff members and individuals self-selected if they would like to engage in the intervention.

Table 1. Participant Demographics. n = 7

Sex	Male	5
	Female	2
Age (yrs)	Range	23 - 46
	Mean	31
	SD	±7.95
Height (m)	Range	1.40 – 1.71
	Mean	1.55
	SD	±0.10
Weight (kg)	Range	50.35 – 91.17
	Mean	65.29
	SD	±12.84

Registered participants were transported to the college campus to partake in an integrative dance class twice per week for 60 minutes each session over the course of 12 weeks. Individuals were partnered with a college student who danced alongside them throughout the duration of each class, providing social, emotional and/or physical support as needed. In this context, "integrative dance may be defined as dance that encourages the participation of all individuals, regardless of ability, supporting and celebrating these differences as a community" (11). The dance intervention comprised of contemporary dance technique which included a 30-minute continuous warm up, 15 minutes of traveling dancing across the floor and 15 minutes of a more complex combination performed in the center of the dance space.

Informed consent was signed by either the participant or court appointed legal guardian and an additional informed assent, written in simplistic language, was read aloud to each participant and signed by the individual prior to testing. This procedure was approved by the Skidmore College Institutional Review Board, the Saratoga Bridges Institutional Review Board, and the New York State Office for People with Disabilities. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (30).

Protocol

While force platforms are the gold standard of measurement for CoP, the Wii Balance Board (WBB) has been suggested as a portable, low cost, and reliable method of CoP measurement with a Pearson's correlation coefficient suggested to be as high as $\geq 0.998 \pm 0.003$ in both the x and y directions as compared to a force platform (17). Furthermore, testing participants with DS outside of a laboratory in an environment in which they are comfortable must not be disregarded when collecting data within this population. In the present study, a single WBB was connected via Bluetooth to a laptop computer utilizing BrainBLOX software (8).

Variables of postural stability were collected through the software program including: CoPx displacement (mediolateral sway), CoPy displacement (anteroposterior sway), absolute value (ABS) of speed on the x and y axis, and average sway area for each trial. There is an inverse relationship between postural stability and the aforementioned variables; as an individual's postural stability improves, a decrease CoP variability will be observed.

Participants were tested within one week prior to the first dance intervention session and again within one week of the commencement of the 12-week course. During testing, participants were asked to stay in a static standing position on a Wii Balance Board sampled at 100Hz for three trials; each trial consisting of four conditions which were held for 30 seconds each. The four conditions tested included: (1) bilateral stance with eyes open (EO), (2) bilateral stance with eyes closed (EC), (3) unilateral stance on the right limb with eyes open (4) unilateral stance on the left limb with eyes open. Each of the three trials were completed in that order, then repeating the cycle to minimize fatigue bias. Participants were given a minimum of 15 seconds to rest in between each trial and condition and were able to refuse to continue testing at any time. Baseline testing revealed considerable difficulty for participants to maintain a unilateral stance for a full 30 second trial, therefore, individuals were asked to maintain the stance as long as possible and the trial was concluded when the participant lost their balance and the lifted limb first made contact with the floor.

Statistical Analysis

A priori alpha was set a 0.05 to determine statistical significance and SPSS (version 26; IBM Corp., Armonk, NY) was used for statistical analysis. Data presented with a non-normal distribution, therefore a non-parametric analysis utilizing a Wilcoxon signed rank test was utilized to assess change from pre-to post-testing.

RESULTS

Statistical significance was found from pre- to post-testing in CoPx displacement ($Z = -2.028$, $p = 0.043$) and ABS average speed ($Z = -2.197$, $p = 0.028$) with bilateral EC and in CoPy displacement with bilateral EO ($Z = -2.366$, $p = 0.018$) (Table II). No statistical differences were found in any other variables in EO or EC conditions or from pre-to post-testing on the right limb or the left limb single legs stances ($p<0.05$) (Table III).

Table 2. EO and EC; Mean ± standard deviation results for CoPx and CoPy displacement, area and ABS speed.

Variable	Condition	Mean Pre	SD	Mean Post	SD	Z	p
CoPx Displacement (mm)	EO	97.066	± 63.371	65.37653	± 35.983	-0.845	0.398
	EC	72.09	± 45.989	42.801	± 24.274	-2.028	0.043*
CoPy Displacement (mm)	EO	64.46	± 24.717	42.629	± 10.942	-2.366	0.018*
	EC	53.407	± 20.467	43.484	± 10.386	-1.352	0.176
Average Area (cm^2)	EO	0.578	± 0.559	0.209	± 0.204	-1.521	0.128
	EC	0.361	± 0.349	0.265	± 0.400	-0.676	0.499
CoPx ABS Average Speed (cm/s)	EO	0.260	± 1.893	0.199	± 2.028	-0.507	0.612
	EC	1.213	± 3.142	0.368	± 0.703	-2.197	0.028*
CoPy ABS Average Speed (cm/s)	EO	0.212	± 1.870	0.314	± 1.810	0.000	1.000
	EC	0.134	± 1.434	0.162	± 1.520	-0.169	0.866

Note: * denotes a significant difference from pre- to post-testing.

Table 3. Right & left; Mean ± standard deviation results for CoPx and CoPy displacement, area and ABS speed.

Variable	Limb	Mean Pre	SD	Mean Post	SD	Z	p
CoPx Displacement (mm)	R	122.833	± 67.988	147.159	± 69.591	-0.734	0.463
	L	141.259	± 55.914	148.619	± 40.429	-0.314	0.753
CoPy Displacement (mm)	R	46.397	± 14.026	53.725	± 8.0349	-0.734	0.463
	L	50.325	± 17.049	61.781	± 16.277	-1.153	0.249
Average Area (cm^2)	R	3.389	± 3.145	4.640	± 4.980	-0.524	0.600
	L	3.323	± 2.866	5.429	± 4.392	-1.363	0.173
CoPx ABS Average Speed (cm/s)	R	27.35	± 38.942	83.709	± 118.940	-1.153	0.249
	L	25.258	± 27.285	55.875	± 77.555	-0.105	0.917
CoPy ABS Average Speed (cm/s)	R	4.637	± 14.133	8.276	± 13.351	-0.105	0.917
	L	5.115	± 15.532	0.312	± 15.363	-0.314	0.753
Time spent in Single Leg Stance (msec)	R	3002.404	± 1065.311	3497.388	± 2310.941	-0.105	0.917
	L	2913.167	± 925.427	3943.667	± 2280.489	-0.943	0.345

Note: * denotes a significant difference from pre- to post-testing.

DISCUSSION

The purpose of the present study was to examine the changes in postural stability in adults with DS following exposure to an intervention of integrative dance. Results demonstrate a rejection of the null hypothesis in the CoPx displacement and speed with EC and CoPy displacement with EO while the null was accepted regarding all variables in the y-axis, all variables tested in single-leg stances, and all other variables tested in the EO condition. The decrease in CoPx displacement and speed with EC indicates improved postural stability in this condition following an intervention of integrative contemporary dance training.

The lack of any significant improvements in the single leg stance test may indicate a lack of fit for this test with individuals with DS or other developmental disabilities. Participants in the current study demonstrated difficulty maintaining this unilateral stance for the full 30-second trial, averaging less than 4 seconds in standing at both pre- and post-testing. Participants often reported verbally their discomfort when asked to attempt this position and even demonstrated this discomfort physically by attempting to reach towards the data collectors for support. Future research may consider other conditions to challenge postural stability in adults with DS including the use of a foam pad or other tools to inhibit somatosensory input during testing.

It was hypothesized that improvements in postural stability would be seen in all conditions with both eyes open and eyes closed. Only one variable of postural stability, CoPy displacement, was improved with from pre- to post-testing with EO. This result may be indicative of the heavy reliance on visual input with individuals with DS (44). Bieć and colleagues (5) suggest that a primary difference in the postural stability of individuals with DS as compared to their non-disabled peers is seen under unfamiliar conditions. Participating in a bilaterally supported quiet stance position likely posed little to no challenge for an individual with DS when able to visually engage throughout the trial as visual sensory information likely allowed for a stabilization of body sway (14). Future research may benefit from a focus on testing conditions of postural stability that pose more of a challenge for the participants involved.

Conversely, the improvement in CoP displacement and speed with EC, specifically in the x-axis, may shed light on the way dance interventions may impact the physical function of individuals with DS (Figure I). The high postural sway in individuals with DS may be attributed to a hazardous feedback loop in which common proprioceptive deficits are exacerbated by lack of experiential motor learning (5) and poor vision (18), further increasing somatosensory deficits (5). Moreover, increased CoP speed has been correlated to increased postural stiffness, which is known to lead to a reduction in healthful postural form (43). Due to largely sedentary lifestyles, the bodies of those with DS may be focused primarily on remaining safe rather than balanced, utilizing compensatory hybrid and hip-based balance strategies as opposed to anticipatory strategies (38). Over time, the central nervous system may react by shifting to stiffer postural strategies, discouraging positive changes in postural strategy adaptations (5). Furthermore, individuals with DS may struggle to receive and interpret proprioceptive feedback (5, 9), disrupting postural reflexes and impairing all aspects of volitional movement (1).

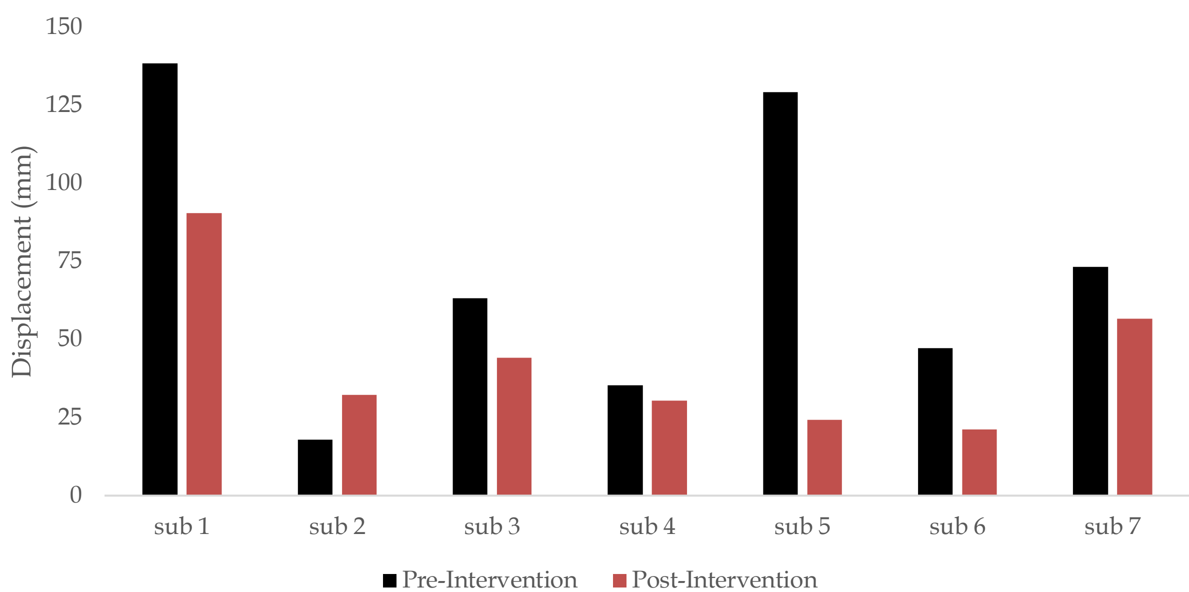

Figure I. CoPx Displacement with EC from pre- to post-testing. Error bars excluded due to high variability.

Engaging in challenging or unfamiliar movement requires increased selection of more complex synergistic motor patterning within the body (5). As such, engaging in novel and stimulating practice conditions may be an appropriate intervention to enhance postural stability in individuals with DS (5). The art of dance is inherently filled with repetition in basic movement patterns alongside continuous variations in choreographic and artistic endeavors. Dancing, therefore, may meet this criterion providing individuals with an opportunity to engage in unfamiliar motor learning experiences and proprioceptive training in a safe and relatively controlled environment. Exposure to weekly practice of unusual movement patterning alongside variable external and internal stimuli simultaneously may have a somatosensory and/or proprioceptive benefit resultant of dance training (18).

Although these data are preliminary, the decrease in speed and displacement in the x-axis with EC and decrease in displacement in the y-axis with EO seen in the present study may indicate a more appropriate use of balance strategies and/or use of proprioceptive feedback in participants following an intervention of dance training. Furthermore, the significant decrease in displacement on the x-axis with EC aligns with previous literature suggesting a linear relationship between CoPx displacement and risk of falls (4, 32). Dancing has been utilized in other populations to improve and/or enhance physical function (3, 11, 12, 25) and may indeed be an appropriate tool for adults with DS as well. Successful and independent mobility is reliant on efficient postural stability (19) therefore, the use of dance training to improve postural stability may have indirect positive effects on one's ability to perform activities of daily living (10) and decrease risk of falls (37) in individuals' with DS. While not yet common practice in the field, integrative dance may serve as a preventative and/or rehabilitation strategy for improving postural stability within this population. These data support the notion of continued research to determine further the effects of dance on the postural stability of adults with DS.

This study encountered several limitations that must be noted in the interpretation of these data. A small sample size recruited via convenience without the use of a control or monitoring of participants outside activities limits the generalizability of this work. Additionally, the small sample size resulted in a large variability among participants, limiting effect size. The use of the single leg stance and EO conditions did not present as the most appropriate tests for this population creating conditions that appeared either too challenging or were not discriminatory enough for the participants. Therefore, future research may benefit from a focus on more challenging somatosensory conditions and/or the use of perturbations. Future research may also benefit from the use of a longitudinal research design to more fully understand the impact of dance on the postural stability of individuals with DS over time.

This study provides preliminary evidence that integrative dance training over the course of 12 weeks has the potential to significantly reduce CoP displacement and speed in individuals with DS. Moreover, the improved postural stability observed along the x-axis suggests that integrative dance may be a useful rehabilitative tool to decrease mediolateral sway which may in turn, lead to a decrease risk of falls (4, 32).

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