The Effect of an Exercise-Based Balance Intervention on Physical and Cognitive Performance for Older Adults: A Pilot Study

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Abstract:

Background: Several exercise-based falls prevention interventions produced significant long-term reductions in fall rate, but few demonstrate long-term improvements in falls risk factors. A strong body of evidence supports a protective effect of aerobic or strength-training exercise on cognition. Individuals participating in an exercise-based balance improvement program may also experience this protective effect. This may contribute to the decreased rate of falls reported in the literature.

Purpose: To determine if individuals participating in an evidence-based exercise program to reduce falls would demonstrate improvements in both physical and cognitive performance.

Methods: In this nonexperimental, pretest, posttest design study, 76 adults (65-93 years) participated in a scripted 12-week, 24 session exercise-based balance improvement program. Each 60 minute class incorporated balance, strength, endurance, and flexibility exercises. Participants completed baseline assessments of physical and cognitive performance measures 1 week prior and 1 week following the intervention.

Results: Fifty-two participants completed posttest measures. There were significant improvements in 3 physical performance measures (chair rise time, 360° turn, and 4 square step test). There also was similar improvement in the Symbol Digit Modality Test, a measure of processing speed and mental flexibility. When participants were dichotomized into 2 groups based on achieving/not achieving, a baseline walking speed of at least 1.0 meters/second, secondary analysis revealed greater improvements in cognitive performance measures of Trails A and Trails B tests by faster walkers compared to slower walkers.

Conclusions: Participation in balance programs can have a positive impact on cognition and physical outcomes. This may provide insight about how exercise influences fall risk. Therapists can utilize this information clinically by educating patients about the potential positive effect of balance exercises on cognition.

Keywords: aging; balance; cognition; falls

Background And Purpose

More than one-third of community-dwelling older adults aged 65 years and older will fall this year.[1] Falls are a complex problem with over 70% of falls due to multiple, interacting risk factors.[2] Research has demonstrated that exercise interventions incorporating strength, balance, flexibility, and aerobic components significantly improve falls risk factors and reduce the rates of falls in community dwelling older adults.[3] Interestingly, several researchers have reported upon completion of the intervention and during follow-up assessments, the protective effect against falls outlasts the improvements in falls risk factors, leading one to question the mechanisms resulting in falls reductions.[4–6]

One area currently under investigation is the potential effect of exercise interventions on cognitive processes. A known relationship exists between participation in regular physical activity and either higher levels of cognitive function,[7,8] or improved performance in cognitive processes.[9] Several researchers suggest participation in physical and cognitive activities may provide a protective effect against later cognitive decline and dementia.[10–12] Of particular importance is the evidence supporting a causal relationship between physical activity and cognitive performance, including studies showing that even fitness interventions without explicit cognitive components lead to improved cognition.[10–12]

This hypothesis was originally explored in relationship to aerobic exercise, but now compelling evidence shows that strength training also has an association with cognitive benefits.[5,13,14] Because effective exercise-based fall prevention programs incorporate both aerobic and strength activities, as well as balance activities, it is plausible that participants may experience similar cognitive benefits.

Maintaining one's balance and thereby preventing a fall requires the cognitive processes of information processing speed,[15,16] and executive control[17], which coordinate ongoing cognitive activity with motor skills (eg, walking while talking). Recent research suggests that executive control functions in particular are independent predictors of falls, balance, and walking speed, and make unique contributions to sensorimotor function.[15,16] Executive control functions can be defined broadly, as the set of cognitive processes involved in planning, sequencing, and directing goal-oriented behavior. There is strong evidence that speed of processing is important to balance,[18] and a wide body of research indicates reduced processing speed underlies much of the age-related cognitive decline, including declines in executive functioning.[19–21] With appropriate practice, performance in dual task activities, which rely on executive function and processing speed abilities,[22,23] can be improved.[24,25] Thus, there is reason to expect that processing speed and executive function are important for improving balance. The effect of participation in a community-based balanceexercise class on these cognitive processes has not yet been examined.

The purpose of this pilot study was to determine if individuals who participated in an evidence-based exercise program to improve balance would demonstrate improvements in physical performance assessments linked to falls risk, and in cognitive performance assessments designed to measure executive function and processing speed.

Methods

This pilot study we used a single group pre-post test design. Participants completed in baseline testing before and after the 12-week exercise program. Eighty-eight individuals enrolled in 1 of 6 classes offered from 2007 to 2009.

Participants

The program was offered as a partnership between the community senior center and the University of North Carolina at Chapel Hill. Class participants were offered the opportunity to volunteer for the research study. Center staff advertised the class in the local senior newspaper, posted fliers in the center, and by word of mouth. Interested seniors were invited to sign up for the class at the center and subsequently were contacted by study staff for screening to determine their interest and eligibility for participating in the research study. Participation in the study was optional and did not affect eligibility to enroll in the class. Those who indicated interest were contacted by phone for an initial screening for the following eligibility requirements: 1) having experienced a fall in the past year and or having significant concerns about their balance; 2) age 65 years or older; 3) no known progressive neurologic disease which could impair balance; and 4) free of major medical conditions limiting safe participation in physical activity such as uncontrolled hypertension or severe joint pain. Participants were excluded from the study if their vision was compromised so that they were unable to see objects on the floor or recognize the instructor's movements, and/or unable to understand, speak, or hear English. Participants who passed the phone screen were scheduled for an onsite session to complete the informed consent approved by the UNC Chapel Hill Institutional Review Board and baseline testing measurements.

Of the 88 individuals enrolled in one of the classes, 80 volunteered for the study and 76 met study eligibility requirements. The most common reason to not participate in the study was “no interest”. The 4 individuals who volunteered but did not meet eligibility requirements either had Parkinson's disease (2), or age less than 65 years[2].

Procedures

The pretesting session was scheduled the week before the start of class and took approximately 1 hour. Posttesting sessions took approximately 45 minutes and were scheduled the week after the last class. Measures included a brief medical screen, a health history identifying major medical conditions, medications, demographic information, a fallssurvey, and physical and cognitive performance measures. All performance measures were selected because they have been associated with increased risk of falls and had good psychometric properties. All performance measures were timed and recorded in tenths of a second.

Balance

Standardized protocols were followed for 2 static balance measures [the tandem stance test (TST)[26],[27] and the single leg stance (SLS)],[28],[29] and 2 dynamic balance measures [timed 360° turn and the Four Square Step Test (FSST)].[30],[31]Individuals unable to hold the TST position for at least 10 seconds are at a higher risk of falls and functional decline.[32],[33]Individuals unable to hold the SLS for 5 or more seconds are at greater risk of falls and injurious falls.[29],[34] Individuals who take longer than 3.8 seconds to turn 360° are at a higher risk of falls[35] and loss of independence in activities of daily living (ADL).[30] A time of greater than 15 seconds to complete the FSST is a sensitive (85%) and specific (88%) measure to identify community dwelling individuals who have experienced at least one fall,[31] and a time of 12 seconds or more is associated with at least one major risk factor for falling.[36,37] Of the measures, the FSST is the most challenging test requiring weight shift, stepping, and directional change.

Strength

We used the timed chair rise task to measure lower extremity strength and function using the protocol developed by Guralnik et al.[32] The ability to rise from a chair multiple times requires strength, vision, proprioception, balance, and sensorimotor skills.[38,39] The inability to rise from a chair 5 times in less than 13.6 seconds is associated with increased disability and morbidity,[40] and is an indicator of frailty.

Mobility

The Timed Up and Go (TUG) and gait speed were used to assess mobility. Individuals who take longer than 14 seconds to complete the TUG[41] or who walk slower than 0.7 m/s are at a higher risk of falls,[42] increased fear of falling,[43] and loss of independence in activities of daily living.[40] Walking is a dynamic activity requiring muscle strength,[44] balance,[45] and attention.[46] We measured self-selected speed using a conventional 10-meter walk course with acceleration and deceleration zones at each end.[47]

Cognition

The ability to maintain one's balance requires executive function for integrating information from appropriate sensory input, choosing the correct musculoskeletal response, and executing that response within the appropriate time frame. Several standardized assessments have been developed to measure processing speed and executive function including the Trail Making Tests A and B, and the Symbol Digit Modality Test (SDMT). The Trails is a pen and paper test requiring individuals to connect sequential numbers (Trails A) and then connect alternating numbers and letters (Trails B).[48] The tests assess components of visual search, sequencing, and motor processing speed.[49] The SDMT requires pairing symbols with numbers and assesses executive function, processing speed, and the ability to switch attention.[50]Performance is measured by the number of correct pairs completed in 90 seconds. Although there are many tests of executive function and processing time, these tests were selected because they have good psychometric properties, require minimal training to administer with reliability and validity, can be conducted easily in the field, and are time efficient.

Intervention Protocol

The exercise program developed for this intervention was based on the key components incorporated in exercise-based research studies recommended by the Centers for Disease Control that have significantly reduced the number of fallsand improved physical risk factors for falls.[51] We offered the class twice a week for 12 weeks. This frequency and duration is supported in the literature, and best fit the class scheduling needs for our community partners.[3] Participants were eligible to take the class a total of 2 times. Data for participants who repeated the class was collected for a separate analysis, and only baseline and 12 week posttest data was included in this study. Two licensed physical therapists were the primary instructors for the class. Each class was scripted for replication and to standardize the content over the 2-year period, the program was delivered.

The format for each class was as follows: 1) 5 to 10 minute warm-up; 2) 10 to 15 minute balance specific segment including at least one narrow base of support exercise and one sensory system challenge exercise; 3) 10 to 15 minute endurance section which incorporated marching, walking, dancing, and several dual task activities; 4) 10 minutes of strength training targeting lower extremity and postural muscles; 5) 10 to 15 minutes of "balance challenge" or skill building exercises which involved a functional activity such as simulating carrying a laundry basket, navigating an obstacle course, or playing soccer; 6) 10 to 15 minutes of flexibility and cool-down section. The class progressed each week in both the difficulty of the balance exercises and the amount of time spent in standing activity.

Data Analysis

After 12 weeks, participants were reassessed on baseline measures. All data were analyzed using SPSS software version 15.0 (SPSS Inc, Chicago, IL). Descriptive statistics and baseline physical and cognitive performance measures were generated for the 52 participants who completed the intervention and the 24 participants, who were not posttested (Table 1). A 1-way ANOVA (Analysis of Variance) and Mann-Whitney U tests assessed for significant differences between baseline measures of these 2 groups.[52] Paired t tests were used to assess differences between performance of physical and cognitive assessments at baseline and 12 weeks (Table 2). Measures were categorized into 3 families of correlated measures: dynamic measures (TUG, timed 360° turn, TCR, FSST, walking speed), static measures (TST, SLS), and cognitive measures (SDMT, Trails A, Trails B). A Bonferroni correction was calculated to protect against a type I error for each group as follows: dynamic measures $P < .01$, static measures $P < .03$, and cognitive performance measures $P < .02$. A secondary analysis separated participants into 2 groups based on baseline gait speed of less than 1.0 m/s and at least 1.0 m/s. A 2-way ANOVA mixed design with 1 repeated and 1 between group factor[52] examined main and interaction effects between groups in physical and cognitive performance measures over time.[53]

Table 1: Demographic and Pre-Test Scores for all Participants who Completed the Pre-Testing, Separated by Those who Completed Post-Testing and Those who did not Complete Post-Testing

Variables	Participants who were Posttested		Participants who were not Posttested	
	N	Mean (SD)	n	Mean (SD)
Age	52	79.6 (6.8)	24	79.2 (6.8)
Body Mass Index	52	25.2 (4.7)	24	24.4 (4.3)
Health Conditions	52	3.0 (1.6)	24	3.2 (1.3)
Physical Performance Test: Dynamic Measures				
Timed Up and Go (sec)	52	10.4 (3.7)	24	12.6 (6.0)
Walking Speed (m/s)	52	0.9 (0.2)	21	0.9 (0.5)
Timed Chair Rise (sec)	48	14.8 (4.7)	23	17.9 (6.3)*
Timed 360 Turn (sec)	51	3.5 (1.2)	24	4.7 (2.6)*
Four Square Step Test (sec)	50	13.6 (4.8)	22	19.7 (13.4)*
Physical Performance Tests: Static Measures				
Tandem Stance (sec)	52	12.2 (10.3)	24	11.1 (10.0)
Single Leg Stance (sec)	50	5.6 (6.8)	24	5.6 (6.2)
Cognitive Performance Measures				
Trails A (sec)	48	47.4 (23.8)	20	61.9 (46.3)
Trails B (sec)	48	111.2 (43.3)	16	121.3 (52.1)
Symbol Digit Modality Test (score)	51	39.8 (10.2)	19	35.0 (11.2)
Demographic Characteristics			**Percent of Participants**	
Gender (% female)			71	83
Race	Black		8	25*
	White (non-Hispanic)		83	67
	Asian/White (Hispanic)		8	8
	Other		1	0
Marital Status	Married		29	17
	Widowed		56	50
	Other		15	33
Education	High School/GED		21	30
	Some College		46	35
	Graduate Degree		33	35
Never use ambulatory assistive device			65	67
Number of Falls	0		45	50
	1		30	13
	≥2		25	37

Table 2

Table 2. Comparison of Physical and Cognitive Performance Between Baseline and 12 Weeks (n = 52)

Physical Performance Tests: Dynamic Measures ($P < .01$)	Baseline (n = 52)		12 Weeks (n = 52)	
	Mean (SD)	Range	Mean (SD)	Range
Timed Up and Go (sec)	10.4 (3.7)	5.9-23.9	10.0 (3.8)	6.1-24.9
Timed Chair Rise (sec) (n = 48)	14.8 (4.7)	9.0-30.7	13.2 (3.4)*	8.1-25.8
Timed 360° Turn (sec) (n = 51)	3.5 (1.2)	1.7-7.8	3.3 (1.1)*	1.9-6.8
Four Square Step Test (sec) (n = 50)	13.6 (4.8)	6.3-30.7	12.3 (4.1)*	7.5-27.0
Self-selected Walking Speed (m/s)	0.9 (0.2)	0.5-1.3	1.0 (0.2)	0.4-1.4
Physical Performance Test Static Measures ($P < .02$)	**Baseline (n = 52)**		**12 Weeks (n = 52)**	
	Mean (SD)	**Range**	**Mean (SD)**	**Range**
Tandem Stance (sec)	12.2 (10.3)	0.6-30.0	15.5 (11.0)	1.1-30.0
Single Leg Stance (sec) (n = 50)	5.6 (6.8)	0.8-30.0	5.8 (5.9)	1.0-30.0
Cognitive Performance Measures ($P < .02$)	**Baseline**		**12 Weeks**	
	Mean (SD)	**Range**	**Mean (SD)**	**Range**
Trails A (n = 48)	47.4 (23.8)	21.3-165.0	39.7 (12.3)†	19.0-74.0
Trails B (n = 48)	111.2 (43.3)	46.4-264.5	109.8 (46.9)	45.0-49.0
Symbol Digit Modality Test (n = 51)	39.8 (10.2)	12.0-66.0	41.8 (9.2)*	22.0-70.0

Paired T-test: *Significant at stated P level.
†$P = .03$.
Walking Speed, Tandem Stance, Single Leg Stance, Symbol Digit Modality Test larger numbers = improved performance.

Results

Six sessions of the class were offered during the time period of this pilot study, and each session was filled to maximum capacity of 15 participants. Interest has been strong enough among the center clients and from outside sources that the center has continued to offer the original class upon completion of the grant funding period. Other Senior Centers in the area are also interested in offering the class.

On average, participants exhibited multiple risk factors for falls. The majority of our participants were women, 50% were age 80 years and older, 50% reported one or more falls during the previous 12 months, and 50% of participants had an average gait speed of 1.0 m/s or slower (Table 1).

Of the 76 individuals who initially enrolled in the study, 52 were posttested at 12 weeks. Reasons for not completing the 12-week posttesting include: scheduling conflicts with the posttest (5), moved (2), became ill (5), unrelated knee pain (2), did not show up on posttest date and could not be rescheduled (2), and dropped the class for no specific reason or could not be contacted (8).

A comparison of those who participated in posttesting versus those who did not revealed significant differences in the ability to perform the timed chair rise (TCR), the timed 360, and the FSST. However, no differences between groups were found in Timed Up and Go, gait speed, tandem stance or single leg stance, or any of the cognitive tests. The greatest differences between these groups were in the amount of time required to complete the FSST and TCR tasks (Table 1).

Comparison of pre and posttest scores for those who completed posttesting (Table 2) indicate significant improvements in selected dynamic balance (TCR, FSST, and 360), and cognition (SDMT). There was a trend toward improvement in static balance assessments, but these did not reach significance. Two participants were unable to or did not feel confident enough to attempt baseline measures of the SLS and FSST, and their data was omitted from the analysis of these assessments. These participants were all able to perform these assessments at posttesting with scores ranging from 2 to 4 seconds for SLS and 16 to 10 seconds for the FSST.

Exploration of the data suggested that not all individuals experienced the same improvements in measures. A secondary analysis was performed to determine if baseline walking speed influenced outcome measures. Average walking speeds of 1.0 m/s or less are associated with increased risk of falls,[54] frailty,[55] and increased risk of morbidity and mortality.[40],[56]For our purposes, individuals who walked at 1.0 m/s or faster at baseline were categorized as Fast (n = 24), and all others categorized as Slow (n = 21). Results from the 2-way mixed model repeated measures ANOVA indicated a significant within subject main effect for time on the physical performance outcomes of tandem stance, TCR, timed 360, and FSST, but no significant interaction between time and group. There were also significant main effects for differences between groups in the performance of the TUG, TCR, 360 and FSST ($P < .01$). For the cognitive measures, there was a significant within subject effect of time for the SDMT and Trails A ($P < .05$) and a significant interaction between time and group for outcome measures of Trails A and Trails B ($P < .05$). The mean, standard deviation, and range were then calculated for the baseline and posttest measures to identify where the groups differed in improvements in performance measures (Table 3).

Table 3

Table 3. Mean, Standard Deviations, and Range of Scores of Participants at Baseline and Post-Test with Participants Divided According to Walking Speed

Test or Measure	Slow Walking Speed < 1.0 m/s N = 21		Fast Walking Speed ≥ 1.0 m/s N = 24	
	Baseline Mean (SD), Range	Post Test Mean (SD), Range	Baseline Mean (SD), Range	Post Test Mean (SD), Range
Timed Up and Go (seconds)	12.2 (4.6)	11.8 (4.9)	8.8 (1.8)	8.4 (1.4)
	7.7-23.9	6.9-24.9	5.9-12.9	6.1-13.2
Tandem Stance (seconds)	9.8 (8.8)	13.1 (11.2)	14.3 (11.2)	17.7 (10.5)
	0.6-30.0	1.1-30.0	0.8-30.0	3.8-30.0
Single Leg Stance (seconds)	3.8 (3.9)	4.7 (4.3)	7.2 (8.3)	7.3 (6.9)
	0.8-19.8	1.0-19.1	0.9-30.0	1.3-30.0
Timed Chair Rise (seconds)	17.4 (5.7)	15.1 (3.7)	13.2 (2.9)	11.8 (2.6)
	10.6-30.2	9.7-25.8	9.0-21.8	8.1-17.6
Timed 360° Turn (seconds)	3.9 (1.4)	3.6 (1.2)	3.2 (0.9)	2.9 (0.9)
	2.0-7.9	2.3-6.9	1.7-7.0	1.9-5.9
Four Square Step Test (seconds)	15.3 (4.9)	14.6 (4.9)	12.2 (3.8)	10.5 (1.6)
	9.9-30.7	8.8-27.0	6.3-25.8	7.6-14.1
Self-selected Walking Speed (m/s)	0.8 (0.2)	0.9 (0.1)	1.2 (0.1)	1.1 (0.1)
	0.5-1.0	0.4-1.1	1.0-1.3	0.8-1.4
Symbol Digit Modality Test (score)	36.9 (11.4)	41.0 (7.4)	41.0 (9.1)	42.6 (10.5)
	12.0-55.0	25.0-53.0	23.0-66.0	22.0-70.0
Trails A (seconds)	49.5 (28.6)	44.2 (11.2)	45.5 (18.9)	36.2 (12.3)
	21.4-165.0	23.0-69.0	27.5-118.0	19.0-74.0
Trails B (seconds)	113.7 (41.8)	125.6 (48.9)	108.8 (45.5)	97.3 (45.3)
	55.7-201.0	59.0-249.0	46.4-264.0	45.0-229.0

Mean, Standard Deviations, and Range of Scores of Participants at Baseline and Post-Test with Participants Divided According to Walking Speed

Discussion

The preliminary findings of this study suggest that participation in a 12 week exercise-based balance improvement program can have a positive effect on cognitive as well as physical performance. The improved performance of executive function and processing speed demonstrated by older adults after participating in a community-based group exercise programs is a novel finding. These preliminary results lend support to the hypothesis that exercise-based falls prevention interventions may have a positive association with cognitive performance. This association could be one of the mechanisms contributing to improved balance and, potentially, to decreasing falls risk.[5] Liu-Ambrose studied cognitive performance of 74 older adults (mean age 81 years) participating in the Otago Exercise Program at baseline and after 6 months. This home-based program consisted of three 30 minute sessions of strength training and 2-walking sessions per week.[57] Participants in the intervention group demonstrated significant improvements in response inhibition,[5] which is the ability to inhibit irrelevant information.[58] A striking finding of the Otago exercise study was that the intervention group did not show significant reductions in physiologic falls risk or in functional mobility, but did demonstrate a 47% reduction in falls rates compared to controls.[5] Other exercise-based interventions have reported similar findings of decreased rates of falls after the intervention period without a concurrent improvement in physical performance.[4],[59] Liu-Ambrose was the first to suggest that cognitive performance may be the missing link explaining this outcome.[5]

Our participants demonstrated significant improvements in the SDMT and a trend toward significant differences in the Trails A. The SDMT is a measure of processing speed which plays a role not only in maintaining one's balance but in age-related cognitive decline.[21] The Trails A is a measure of visual search, scanning, speed of processing, and mental flexibility.[49] Participants in the Liu-Ambrose study were tested on cognitive processes of set-shifting, updating, and response inhibition with significant improvements only in response-inhibition. Participants in our study demonstrated improvements in processing speed and mental flexibility, which may be related to the difference in the interventions. Participants in our intervention were in a group setting that required interaction with an instructor and other class participants. Simple dual task (walking while having a conversation), complex dual tasks (walking while counting in a different language, walking, and reciting the alphabet skipping every other letter), motor-motor tasks (walking while tossing a ball) and response-inhibition exercises were incorporated into every class session. The cognitive process of set shifting has been independently associated with the quality of gait during complex dual task conditions.[60] Participants were practicing these complex tasks every week, which may explain the improvements we saw in cognitive performance. The Trails B is more complex than A, requiring participants to locate numbers and letters and alternate between the 2.[49]Participants varied greatly in their ability to perform this task, with 6 participants unable to complete the task at baseline, and a variation in performance of over 218 seconds, which is similar to other findings in the literature.[5] Given this variability, we did not expect to see significant findings with the small number of participants; however, there was a trend toward improved performance in this task.

Our decision to perform a mixed model repeated measures ANOVA to determine if grouping according to baseline walking speed influenced outcomes provided interesting results. Those who walked slower at baseline also tended to have lower scores on the other physical and cognitive measures compared to the group with faster walking speeds. However, both groups demonstrated significant improvements in almost all the measures. There were no significant interactions between time and walking speed group for the physical measures, indicating that both groups improved, and baseline performance did not impact outcomes. A significant interaction did exist between walking speed group and time for the cognitive performance measures of Trails A and Trails B, indicating those with faster walking speeds demonstrated significantly greater improvements on these 2 cognitive measures.

Several baseline measures in the Slow Group (tandem, SLS, TCR, FSST, Walking Speed) were below standardized cut off times indicating the participants were at risk for falls and functional decline. After the 12-week intervention, the mean times were all above the cut offs for these measures than the cut-off measures, indicating the average score was no longer in the ‘at risk' range. The Fast Group demonstrated mean performance measures close to or greater than the scores typically used as cut offs associated with decline.

Both groups demonstrated improvements in the cognitive measures with the fast group improving significantly more that the slow group on Trails A and B. This finding suggests those with better physical performance at the onset may benefit in different ways from participation in the class. Walking speed has a strong association with executive function.[61] It may be that those with baseline faster walking speeds may have more attentional resources to devote to the intervention and may experience different benefits. Further studies with larger samples should explore this question, as it may provide some clarifications in the variability of outcomes demonstrated in these types of interventions. Understanding why some individuals may benefit more than others or in different ways from an intervention has ramifications for clinicians. Understanding these differences could indicate a potential different focus for interventions and long-term falls, prevention given the physical skills of the individual in the class.

There were no clear differences at baseline between those who were posttested and those who were not. In general, the group that was not posttested had significantly worse performance of the timed chair rise, the 2 dynamic assessments of balance, and trends toward worse performance on all other measures except for walking speed and the single leg stance. A closer look at this group revealed that it was composed of 2 subgroups. One group could be defined as low performers in all areas. This group was composed of 10 individuals who could not perform the cognitive assessments or took all of the allotted time to complete and had physical performance scores that placed them in the very high-risk category of falling. Group 2 had a mix of individuals who were high performers on some assessments, and low performers on others. The characteristics of group 2 closely matched those that completed the post-test assessments. Individuals from group 2 did not finish the class due to scheduling conflicts, unrelated injuries, or lack of interest. Individuals from group 1 were those that stopped coming to class either because they were no longer interested, had health issues, or would not give a reason.

The main limitation to this study is the lack of a control group. We partnered with the local senior center to conduct this pilot study. A key aspect of this partnership was allowing all individuals who met class criteria to take the class. As this was a pilot study to gather preliminary data, we felt that the single group design was a viable option; however, it does not allow us to compare our results to a control group, which would provide insight to other factors affecting our results such as task learning, the effect of social interaction, and changes in self-efficacy. A second limitation was the attrition rate of the class. A total of 24 individuals (33%) did not complete the class for various reasons. These adherence rates may be the norm for community-based programs for seniors. Shumway-Cook et al[62] also reported similar adherence rates for participants in the Enhanced Fitness program. Approximately, 35% of participants in that community-based exercise intervention attended fewer than 33% of classes over a 1-year period. Reasons for not attending class were similar to our study: illness, scheduling conflict, vacations, and busy schedules. Attendance was taken at all classes in our program and attendance rates ranged from 40% to 100% for any given 12-week session.

The delivery of the intervention by 2 different therapists could contribute to different outcomes between classes. To address this lack of consistency and insure fidelity to the class content, a script was developed for each class and replicated for each session. The therapists discussed the class curriculum and clarified any inconsistencies or confusion in wording. The therapists observed a minimum of 5 class sessions and provided feedback and critique to each other. To further assess if differences existed in content delivered, a 2-way ANOVA found no significant differences in outcomes of physical and cognitive performance between the groups taught by therapist #1 ($n = 26$). and therapist #2 ($n = 26$), found no significant differences in outcome measures. Finally, the short duration of the intervention and lack of follow up did not allow us to accurately track falls rates. Given the apparent improvement in physical and cognitive measures, we plan to address these limitations in a larger randomized controlled trial with subgroups based on initial balance ability.

The results of this study suggest that participating in an exercise class to improve balance may have an impact on cognition, and those individuals with better balance skills may experience greater cognitive benefits. Future randomized controlled trials with larger sample sizes need to refine these findings. First, we need to determine if cognition is a component of the protective effect against falls typically seen in exercise interventions. Then, if cognition is a factor we need to create algorithms to identify an individual's baseline level. Once identified, the individual could be placed in a class with a standardized curriculum based on baseline physical abilities that would progress the individual appropriately through a program that focused primarily on strength and balance, and then continue on to a more challenging program that incorporated more cognitive tasks.

Conclusion

Balance is a skill that requires both physical and cognitive components. Research has demonstrated that participating in aerobic exercise and strength training exercise interventions can have an impact on cognitive performance. These interventions had primary goals of improving either endurance or strength. The program developed for this study had the primary focus of improving balance, but overlaps with other interventions by including aerobic and strengthening components. Results from this study suggest that participation in a multicomponent exercise program that includes strength and aerobic components but has a primary focus on improving balance skills can also have a positive impact on cognitive as well as physical outcomes. The effect on cognition may be modified by the physical abilities one has when starting this type of intervention. Therapists can utilize this information clinically by educating patients about the potential positive effect of balance exercises on cognitive processes. Future studies may help us predict which patients will receive the maximum benefits from this type of intervention.

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