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The Effects of a 10-Week Group-Based Exercise Program on Lower Extremity Strength, Balance and Functional Mobility in Community-Dwelling Older Adults: A Pilot Study

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Abstract

Background: Many factors contribute to falls including strength deficits, balance impairments and fear of falling. Evidence suggests frequency of falls can be reduced through group-based exercise.

Purpose: To 1) determine if a 10-week moderate intensity group-based exercise program focused on strengthening, conditioning and balance training would impact lower extremity muscle strength and functional mobility among healthy individuals 60 and over and 2) to examine the impact of this exercise program on specific quantitative aspects of balance including sway and stability using the Zeno Walkway System (Protokinetics).

Number of subjects: Seventeen community-dwelling older adults (14 females, 3 males with a mean age of 77 years) participated in a group-based exercise program twice a week for 10 weeks.

Methods: The program consisted of 45 minutes of exercise following: a 10-minute warm-up, flexibility exercises, upper and lower extremity strengthening exercises with weights and elastic bands, and balance training. Pre and post data were collected using the following measures: Timed Up and Go test to assess functional mobility; 30- Second Chair Rise test to measure functional lower extremity strength and endurance, and Zeno Walkway System to quantify changes in static (eyes open and closed) and dynamic balance (Four Square Step test).

Results: Participation in a group-based exercise program resulted in statistically significant differences in Timed Up and Go scores (p=0.001), 30-second Chair Rise test (p=0.001), and Four Square Step test for duration (p=0.049) and velocity (p=0.004). No significant changes were noted in static balance.

Keywords: Falls; Exercise; Balance; Group-based; Older adults

Introduction

Falls represent the leading cause of injury, fractures, and death among the older population [1,2]. In fact, one out of every three adults over the age of 60 will experience one or more falls annually [2,3]. While men and women are both at risk for falls, women are two times more likely to sustain hip fractures, whereas men have a higher mortality rate due to falling [1]. The Centers of Disease Control and Prevention [1] have estimated that by the year 2020, direct and indirect medical costs related to falls could reach nearly $54 billion dollars.

It is widely known that strength, cardiovascular endurance and balance control tend to decline with age [4-6]. Lower extremity muscle weakness increases a patient's likelihood of requiring multiple steps to recover from a forward loss of balance [7]. Many falls occur while older adults are performing mobility tasks such as walking or moving from sit to stand [8]. Furthermore age-related lower extremity weakness has been associated with difficulty with stair negotiation, sit-to-stand, gait, and overall balance [9,10]. It is also well known that balance decreases with age resulting in reduced postural control and increased likelihood of falls [11].

In 2011, the American Geriatric Society (AGS) and British Geriatric Society (BGS) updated their guidelines for treatment to reduce the risk of falls [5,11]. While a multi-factorial fall risk assessment is key to the identification of the individual risk factors for falling, exercise programs have been shown to have significant impact on reducing rate of falls, improving balance and gait, and decreasing fear of falling. The panel recommended that resistance strength training along with balance, gait, and coordination training should be part of each multifactorial intervention. Exercise programs were shown to have significant impact on reducing rate of falls, improving balance and gait, and a decrease in fear of falling [1,5,12-15].

Many studies [12,16,17] have determined that exercise is a key component in improving physical function in older community-dwelling adults. Successful exercise programs include a specific balance component, in addition to strengthening, flexibility and conditioning exercises [5,6]. It is also widely accepted that participation in regular exercise can reduce falls rate, improve the ability to perform activities of daily living (ADL), and improve quality of life (QOL) [12,15,17-23]. Several studies [12,15,20,21,23] that assessed the effects of combined low to moderate intensity exercise interventions have shown improvements in balance control, muscular strength, flexibility, functional mobility and an overall reduction in falls risk.

Performance-based measures of balance such as the Berg Balance Scale (BBS), Performance Oriented Mobility Assessment (POMA) and the Functional Reach Test (FRT) are clinical tools used to ascertain the level of risk for falls as it relates to problems with balance [24]. While there are advantages and disadvantages of these tools, at best, each provides only an assessment of how well an individual can perform the tasks. Unfortunately these tools are not able to provide quantitative measure of balance such as sway or changes in center of pressure as they relate to the various phases of task performance. The Zeno Walkway

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System by Protokinetics (Havertown, PA, formerly GAITRite®) [25] is a portable mat embedded with pressure sensors designed to assess static and dynamic balance using temporal and spatial parameters such as velocity and center of pressure. This system has been shown to have strong concurrent validity when compared to the Clinical Stride Analyzer, a commonly used tool to quantify gait parameters as well as strong test retest reliability [26]. Additionally, Menz et al. [27] found that the GAITRite resulted in highly reliable measurements for these same temporal and spatial parameters. This computerized walkway system provides a quick and simple way to obtain accurate data [26]. Therefore, using the Zeno Walkway System may enhance the quality of the balance data collected.

To date, no studies have examined the benefits of moderate intensity group-based exercise programs that encompass strengthening, balance and functional training with older adults lasting 10 weeks in duration. Additionally, while many studies have assessed balance following exercise training, no studies have quantified balance before and after the exercise intervention to determine the specific spatial and/or temporal parameters that might be impacted. The purposes of this study were therefore to 1) determine if a 10-week moderate intensity group-based exercise program that focused on strengthening, conditioning and balance training would impact lower extremity muscle strength and functional mobility among healthy individuals 60 years of age and over and 2) to examine the impact of this exercise program on specific quantitative aspects of balance including sway and stability using the Zeno Walkway System (Protokinetics).

Methods and Materials

Subjects

Twenty-three participants (20 females and 2 males, average age of 77) were recruited from a local church in Southwest Philadelphia. The program was held at the church in order to increase convenience and compliance. Two months prior to the start of the study, subjects were recruited through a series of meetings at the church during which they were informed about the objectives of the study, the nature of the exercise program, and the schedule of classes and assessments. Written informed consent was obtained from subjects in accordance with procedures approved by the University of the Sciences Institutional Review Board. Participants were included in the study if they were >60 years old, received signed medical clearance from their physician, and were independent with ambulation. Subjects were excluded if they were unable to follow directions.

Procedures

Prior to beginning the 20-session group-based exercise program, all subjects completed pre-testing measurements that assessed lower extremity functional strength and endurance, functional mobility, and balance. The same measures were completed at the end of the exercise program.

Outcome measures

Balance Assessment using the Zeno Walkway System: This system developed by Protokinetics (Havertown, PA, formerly GaitRite M_sq) [23] consists of 4'×4' mat with eight pressure sensors designed to assess static and dynamic balance using temporal and spatial parameters such as velocity and center of pressure. This system has been shown to have strong concurrent validity when compared to the Clinical Stride Analyzer, a commonly used tool to quantify gait parameters as well as strong test retest reliability [28-30]. The pre-test assessments performed on the Zeno Walkway consisted of three balance activities: 1) static standing with eyes open in normal stance for 30 seconds, 2) static standing eyes closed in normal stance for 30 seconds, and 3) performance of the Four Square Step Test. The Zeno Walkway System allows for the capture of key spatial and temporal variables important in the quantitative assessment of balance. Data was computed using the PKMAS software developed by Protokinetics (Havertown, PA). In this study the variables examined included center of pressure and center of mass stability and mean velocity. Both velocity and stability were further categorized into anterior-posterior (x) and medial-lateral (y) velocity.

The Four Square Step test (FSST), a clinical test of dynamic standing balance, has been shown to be effective in predicting falls in community dwelling older adults [31]. It assesses a person's balance and limits of stability when changing directions horizontally (citation). FSST has shown to have excellent interrater (ICC=>.99) and test-retest reliability (ICC=98) [31]. Subjects performed one trial of the FSST following a demonstration by the tester.

The 30-Second Chair Rise test (CRT): This test measures a person's lower body strength and endurance [9]. An individual's performance on the CRT correlates with their ability perform everyday tasks such as climbing stairs, getting in and out of a vehicle or a bathtub [28]. To perform this test, subjects were seated in a chair without arm rests. They were asked to stand up (full standing) and sit down as many times as they could in 30 seconds. The number of times that they could stand up was then recorded. This test has been shown to have excellent reliability with an ICC of 0.84 for males and 0.92 for females [9].

Timed Up and Go test (TUG): The Timed Up and Go test (TUG) is a widely used standardized outcome measure that assesses mobility in older adults [29]. The test involves timing participants while they stand up from being seated in a chair, walk 3 meters, turn around, walk back 3 meters and sit down. This test was performed 3 times after which the average of the three trials (in seconds) was calculated and used for analysis. Older adults who require >14 seconds to complete the TUG are said to be at a very high risk for falls [30]. The TUG was originally developed as a clinical measure to assess balance in the elderly and it has shown to have excellent inter and intra-rater reliability [30]. The intra-class correlation coefficient (ICC) has been reported to be >0.95 [8].

Intervention: The exercise program was designed by a physical therapist using current evidence-based programs as a guide to specifically address the physical falls risk factors [12,15,23]. The classes were conducted twice weekly for 10 weeks in a large open space the basement of a local church.

The program began with a 10-minute warm up including a combination of seated and standing exercises for major muscle groups including general flexibility exercises. Lower extremity strengthening exercises followed using weights and resistance bands initially performed in the seated position and later progresses to standing. Upper extremities resisted exercises also used a combination of weights and bands and were performed seated to ensure proper performance. Functional exercises such as repeated sit to stand practice were also included. The continuing nature of the program also promoted cardiovascular conditioning. Balance exercises included both static and dynamic activities including standing with narrow base of support with eyes open and closed, tandem stance, and single leg stance with both eyes open and progressed to eyes closed. Additionally, modified Tai Chi exercises that challenged participants to move outside of their base of support were an integral part of the balance exercises. Individuals who demonstrated difficulty with balance exercises received one-on-

one guarding. A cool-down period consisted of gentle active exercises along with diaphragmatic breathing. All exercises were performed to music that was suggested by the participants. The complexity and speed of exercise and the resistance were all steadily increased over the course of the program. The entire class lasted 45-50 minutes with rest breaks as needed. Attendance was taken each session. The majority of participants were members of the church and had pre-existing relationships with one another.

Data analysis

Statistical analysis was performed using SAS v9.3 (SAS Institute, Cary, NY) and Microsoft Office Excel (2007). The paired t-tests were used to compare pre and post data for the Timed Up and Go and the 30-second chair rise. Non-parametric analysis, specifically, the Wilcoxon Signed Rank test, was used to analyze change in duration and velocity from baseline measurements for the four-way step test and static balance due to the fact that the data was not normally distributed. The level of significance was set at $P<0.05$.

Results

Subjects

Seventeen of the 22 subjects recruited completed this pilot study (Table 1). Two subjects were lost to follow up due to medical issues affecting their return. Four subjects were lost to attrition for unknown reasons. The mean attendance rate was 87% with 8 of the 17 participants attending 90% or more of the scheduled sessions.

Pre and post data for the TUG and CRT was collected for seventeen subjects (Table 2). There was a significant (p=0.001) decrease in TUG scores with a mean change of 1.40 seconds from pre to post intervention. For the CRT, there was a significant (p<0.001) mean increase of 2.5 repetitions following completion of the intervention.

Fourteen subjects were included in the data analysis of the Four Square Step test (FSST) that was performed on the Zeno Walkway. Three subjects were excluded due to incomplete data collection. There was a significant (p=0.049) change in the overall speed during the performance of the FSST following completion of the intervention (Table 3). There was also significant (p=0.003-0.004) change in both anterior-posterior movement as well as overall movement as subjects moved through the four squares. There was no significant change in medial-lateral movement (Table 3). Regarding static balance, there were no statistically significant differences found among the variables tested for static balance (Table 4).

Gender	
Female	16
Male	1
Age (years)	77
Ethnicity	
White	0
AA	17
Hispanic	0
Asian	0
Assistive Device	
Inside	1
Outside	1
No	0
Number of chronic diseases	
0-3	7
4-6	10

Table 1: Characteristics of Subjects.

Timed Up and Go Test (TUG)	**Pre**	**Post**	**Change**	**p-value (one-tailed)**
TUG Scores (sec) Mean ± SD	11.96 ± 2.99	10.56 ± 2.46	-1.60 ± 1.40	**0.001***
Functional Lower Extremity Strength 30-Second Chair Rise Test (CRT)				
CRT (reps) Mean ± SD	8.60 ± 3.18	11.10 ± 2.04	2.47 ± 2.50	**<0.001***

*Significant: p<.05

Table 2: Mobility and Functional Lower Extremity Strength.

Four-way step test	**Pre**	**Post**	**Change**	**p-value (one-tailed)**
Duration (sec) Mean ± SD	19.03 ± 2.99	17.39 ± 2.46	-1.64	**0.049***
Anterior-Posterior Movement(cm/sec) (COMe X Velocity) ± SD	17.73 ± 5.85	20.02 ± 6.19	2.30 ± 2.57	**0.004***
Medial-Lateral Movement (cm/sec) (COMe Y velocity) ± SD	31.62 ± 6.80	33.75 ± 6.81	2.13 ± 3.65	**0.058**
Overall Movement (cm/sec) COMe Mean velocity ± SD	41.32 ± 10.12	45.21 ± 10.59	3.89 ± 4.11	**0.003***

*Significant: p<.05

Table 3: Dynamic Balance Using the Zeno Walkway System.

Eyes Open	**Pre**	**Post**	**Change**	**p-value (two-tailed)**
Sway in Anterior-Posterior Direction (Mean x velocity)	0.87 ± 0.30	0.97 ± 0.86	0.10 ± 0.46	**0.384**
Sway in Medial-Lateral Direction (Mean y velocity)	0.98 ± 0.35	1.05 ± 0.37	0.07 ± 0.41	**0.847**
Eyes Closed				
Sway in Anterior-Posterior Direction (Mean x velocity)	1.32 ± 0.783	1.01 ± 0.26	-0.53 ± 0.76	**0.169**
Sway in Medial-Lateral Direction (Mean y velocity)	1.26 ± 0.64	1.10 ± 0.29	-0.17 ± 0.73	**0.303**

*Significant: p<.05

Table 4: Static Balance.

Discussion

This study examined the effects of a moderate intensity 10-week group-based exercise program on lower extremity strength, balance and functional mobility in older adults >60 years of age. Although the duration of the program was shorter than what the current evidence suggests in order for change to occur, the results of this study support the supposition that a moderate intensity exercise program of 10 weeks in duration can improve lower extremity strength, balance and functional mobility. Subjects demonstrated significant improvements in TUG scores, 30 second CRT, and dynamic balance after completing this program. We found changes in 10 weeks noting enhanced mobility, strength and dynamic balance despite the evidence suggesting that programs shorter than 12 weeks are not likely to produce tangible outcomes.

As a widely used tool to predict falls and monitor functional mobility, the TUG provided valuable data regarding the impact of this specific exercise programs. According to the normative values, individuals between the age of 70-79 should perform the TUG within 9.2 seconds while those between 80-89 years should complete the test

in 11.3 seconds. The participants in this study, with a mean age of 77 years, had a mean TUG greater than 11.3 prior to the intervention but improved significantly and were closer to the normative value at post testing. This suggests that the exercise intervention had a beneficial effect on functional mobility and a reduction in falls risk [30,32].

The CRT, which assesses the number of times an individual can move from sit-to-stand in 30 seconds, can predict risk of falling in high-risk older adults. Those who perform the test should be able to perform above the cut-off score for their age. The normative values for those between the ages of 75-79 for the number of rises for women are 10-15 and 11-17 for men [9]. The participants in this study demonstrated improvement in number of rises from pre to post testing however, the mean scores were still slightly below the age-related normative values.

As mentioned, balance plays an essential role in determining falls risk and it is also negatively affected with age. The present study aimed to quantify specific balance variables. The FSST and Zeno Walkway System were used to assess and quantify static and dynamic balance (Table 3). Although there was no significance noted in sway (both anterior-posterior and medial-lateral) for static balance, a statistical trend was determined in regards to anterior-posterior sway suggesting that this exercise program may have led to significant improvement in both sway variables following a longer duration of practice. Research [16] indicates that a decrease in medio-lateral sway can indicate reduction in falls risk.

Considerable planning was done to maximize participation in the exercise program. There were several meetings with the pastor of the church as well as with the senior guild providing both with clear explanations as to the goals of the program. The exercise classes were provided at no cost to the participants and were offered at the church. By offering incentives to all participants, the mean attendance rate was 87%. Program evaluation data was gathered to determine participant satisfaction with the program and 100% of participants reported being satisfied. Martin et al. [19] found that group-based exercise programs promotes greater participant satisfaction and exercise adherence. Our participants engaged in exercise activities with age-related peers that were from the same church or living community. This closeness promoted a collegiality that fostered a motivating environment. This was proven to be true in the present study, in that motivation and the social aspect of a group-based intervention showed positive benefits for those who needed external means of encouragement. These aspects may be part of the explanation to why there were significant improvements in just 10 weeks, despite previous studies reporting that this is too short of a time to achieve change.

This study had a number of limitations including that it used a sample of convenience instead of having a control group. This lack of a control group makes it difficult to know what part of the program had the greatest effect such as the exercise program or just having the social interaction between group members. However, since we found significance in several variables one can assume that the main effect was due to the exercises but further randomized controlled trials are needed. Although the sample size was small, it did not seem to impact the ability to see a difference in function with treatment. The lack of change noted in static balance may have been the one measure that was impacted by the shorter duration of the training. Despite these limitations we were able to detect significant improvements over time, which indicates that this type of exercise program might be of great benefit to the older population.

Conclusion

This 10-week group-based exercise program that incorporated strength, flexibility, functional mobility and balance training had a positive effect on lower extremity strength and functional mobility among community-dwelling adults. In addition, quantitative balance improvements were noted with multidirectional movement further supporting this program as a beneficial intervention against falls as most functional tasks involve this type of movement. Finally, the benefits of group support cannot be overlooked as a powerful tool to promote exercise adherence over time.

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