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THE EFFECTS OF FUNCTIONAL BALANCE TRAINING ON BALANCE, FUNCTIONAL MOBILITY, MUSCLE STRENGTH, AEROBIC ENDURANCE AND QUALITY OF LIFE AMONG COMMUNITY-LIVING ELDERLY PEOPLE: A CONTROLLED PILOT STUDY

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Summary

Aim. The aim of this study was to investigate the effects of functional training on balance, functional mobility, muscle strength, aerobic endurance and quality of life among community-dwelling elderly people.

Material and methods. Eighteen women were in the exercise group taking part in functional training program for 25 weeks; the control group did not participate in any exercise program. The Fullerton test for balance, Timed Up and Go test for functional mobility, Five-Times-Sit-to-Stand Test for lower limb strength, Two-Minute-Step-in-Place Test for endurance and the quality of life were measured at baseline and after 25 weeks.

Results. After the training period in the exercise group the balance and the functional mobility improved more significantly than in the control group ($p = 0.027$; $p = 0.0004$, respectively). The quality of life showed a marginal significance ($p = 0.083$). In terms of lower limb muscle strength and aerobic endurance, the difference between the groups did not reach statistical significance ($p = 0.276$; $p = 0.147$).

Conclusion. This 25-week functional training improves balance, functional mobility, as well as quality of life among community-living elderly adults; however functional training exercises might require to be completed with more tailored strength exercises.

Clinical Rehabilitation Impact. Based on our results, functional training might be a promising exercise program for improving balance, functional mobility and quality of life for community-living elderly people.

Key words: task-oriented exercise, functional balance training, functional mobility, elderly people

INTRODUCTION

Safe balance is needed during the most activities of daily life (e.g., walking, sit-to-stand and sit down, transfer from one place to another, which are commonly referred to as functional mobility). The balance control is a complex process which requires the coordination of the sensory, musculoskeletal and nervous systems. Several parts of the nervous system including brain cortex and its projections, basal ganglia and other extrapyramidal components, cerebellum, as well as spinal cord take part in balance control. They are responsible for integrating the somatosensory, visual and vestibular information and then developing motor responses to maintain balance in changing environmental conditions (1). Further-more, producing corrective movement for balance demands adequate musculoskeletal functions as well.

Studies examining age-related changes of balance control showed that sway during quiet stance begins to increase approximately at the age of fifty (2). Many of the age-related balance problems may stem from deterioration of sensory systems or neuromuscular system playing role in balance control (2).

With the increase of ageing population, improving of the elderly adults' balance control is becoming more and more important.

In the rehabilitation of neurological diseases associated with injuries of neuromuscular and sensory systems functional training has been used with great

success (3). Functional training consists of tasks which are important, meaningful, useful for people simulate their everyday activities (4). An animal study showed that practicing of meaningful tasks produced increased motor cortical representations than repetition of exercises without meaning (5). Since then, several clinical studies have proved that this therapeutic approach results in greater improvement which lasted longer in balance, functional mobility than usual stroke physiotherapy (6).

So far only three studies have evaluated the effects of functional training among ageing population but they focused on institutionalised elderly adults (7-9). To our knowledge, there is no functional balance training study conducted among community-living elderly adults.

Based on the results of previous studies, in agreement with the American College of Sports Medicines recommendations (10), we have developed a funtional balance training program consisting of exercises simulating everyday activities which required rotating head and trunk, weight transfer over different base of support. The exercises were accompanied by instructions reflecting selfcare, household or leisure-time activities which were meaningful and familiar to elderly people. The assumption underlying our exercise program was that practice and repetition of challenging task-oriented exercises accompanied by instructions recalling known situations might help imagine and perform the movement correctly, hence might help the process of motor learning.

The aim of present prospective, controlled study was to investigate the effects of a 25-week functional balance training program on static and dynamic balance, functional mobility, lower limb strength, aerobic endurance and quality of life among community-living elderly adults.

METHODS

Design

We conducted a parallel two-armed trial using an age and gender matched control group from March 2012 to September 2012. The study was conducted according to the 2008 revision of the 1975 Declaration of Helsinki (http://www.healthscience.net/resources/declaration-of-helsinki).

Study sample

Participants were recruited by advertisements in the local newspapers from the population of two districts in Budapest, Hungary. The volunteers' general practitioners were informed in a letter about the aim of the study and and the extent of exertion required by the training. They had to decide if their patients were able to participate safely in the program. Potential participants were suitable for the experiment if they met the following criteria: aged 60 years or over, living in com-

munity, being able to move independently. Subjects were excluded if their general practitioner did not recommend the participation because of having progressive neurological or unstable cardiovascular diseases which would limit participation in the exercise program, if they had severe pain in lower limb in weight-bearing positions or if they had participated in an organized exercise program (sport or physiotherapy) recently or in the past 6-month period.

After eligibility was confirmed, eligible participants were matched by age (± 5 years) and gender with a control group of individuals who were recruited through advertisements in the local newspaper and posters displayed in senior centers.

After being explained the aim and procedure of the study, the subjects yielded consent to participation. They were aware of their right to withdraw from the study at any stage.

Intervention

Subjects in the experimental group participated in a group-based functional balance training program twice a week for 25 weeks. Training sessions were provided in a gymnasium situated in a local sports centre and were conducted by a physiotherapist with extensive geriatric clinical experience and with assistance of a physiotherapist student.

Each session lasted for 60 minutes starting with a five-to-ten-minute warming-up, including flexibility exercises and ended with a five-to-ten-minute stretching and breathing exercise program.

Exercises simulating everyday activities included sit-to-stand, sit down, turning, squatting, reaching to different directions, stepping up and down, stepping to different directions with weight transfer, standing and walking on narrow base of support, walking on uneven and soft surfaces, walking to different directions, walking avoiding obstacles, walking with changing directions. During the initial phase of training period (first 5-6 weeks), exercises were practiced separately, then they were combined. During the later phase of training period (after 6 weeks), exercises were combined with additional tasks including manipulation (e.g. holding and carring glass or tray, passing and throwing a ball) and conversation.

During the training safety was provided by allowing participants to lean on or hold on to a chair if needed. Instructions commenting the exercises were such as: "imagine that you take something off the shelf"; "imagine that you pick up something from the ground"; "imagine that you open a door; imagine that you carry a tray in your hand.

Subjects in the control group were asked to keep their usual daily activities unchanged during the 25-week study period. All participants were asked to maintain their medications and habitual diet.

Measurements

At baseline, the following data were obtained with a questionnaire: sociodemographic data (age, gender and marital status), physical and medical characteristics (weight, height and BMI was calculated, use of glasses, falling in the previous year, medications and medical history).

Dependent variables including static and dynamic balance, functional mobility, lower limb strength, aerobic endurance and health-related quality of life were assessed at baseline and at the end of the 25-week intervention period by two physiotherapist students.

The static and dynamic balance were measured with Fullerton test (11). This test includes 10 tasks simulating everyday life activities such as standing with feet together, eyes closed, reaching forward to an object, turning around, stepping up and over, tandem walk, standing on one leg, standing on foam rubber with eyes closed, two-foot jump, walking with head turns, reactive postural control. Each item was scored according to a five-point ordinal scale (from 0 to 4). Then scores were summed to produce a total index with a range from 0 to 40. A decreased total score showed poor balance of the subject. Fullerton test has excellent test-retest reliability (Correlation Coefficients = 0.96) and intrarater reliability (Correlation Coefficients = 0.97) (11).

The functional mobility was assessed with the Timed Up and Go (TUG) test (12). In TUG test, each participant was asked to stand up from a chair (approximate seat height of 46 cm), walk at a comfortable but secure speed to a cone on the floor 3 metres away and return to sit down on the chair. The time required was recorded. The digital stop-watch was stopped when he/she reached the sitting position with back against the backrest. The subject was allowed to wear their regular footwear and use the arms of the chair to get up. No physical assistance was given. The subject performed a trial once before testing. We calculated the average time of two consecutive performances and the participant was allowed to rest for 30 seconds between the trials, if needed. The TUG test has high interrater (Correlation Coefficients = 0.99) and intrarater (Correlation Coefficients = 0.99) reliability (12).

The lower limb strength was assessed with the Five-Times-Sit-to-Stand Test (13). Each participant was asked to stand up from a chair (approximate seat height of 46 cm) and sit down five times with arms crossed over chest. The time required was measured with a digital stop-watch which was started when the participant raised his/her legs and stopped when he/she reached the standing position after five repetitions. This test has good test-retest reliability (Correlation Coefficients = 0.89) and moderate intrarater reliability Correlation Coefficients = 0.64) (13).

The aerobic endurance was assessed with the Two-Minute-Step-in-Place Test which is an alternative to the Six Minutes Walking Test for ageing population with or without balance impairment. The participant was asked to march in place for two minutes lifting the knees to a predetermined height (midway between the patella and the iliac crest) as many times as possible. The participant was allowed to rest or hold onto the wall, if needed. The number of steps completed was counted (14).

The health-related quality of life was assessed using the EQ-5D (EuroQol) self-report questionnaire with which the respondent could classify his/her health according to five dimensions (mobility, self-care, usual activity, pain/discomfort, anxiety/depression) and rate his/her health on a visual Analogue Scale. The information derived from the EQ-5D dimensions was converted into a single summary index (EQ-5D index). The EQ-5D index ranged from 0 to 1, with higher value reflecting better self-experienced health-related quality of life (EQ-5D User Guide. www.eurowol.org)

Statistical Analysis

For the statistical analysis we used SPSS version 19.0 for Windows software. Difference with a significance level (p-value) less than 0.05 was considered statistically significant. First, the distribution of continuous data was checked using Kolmogorov-Smirnov test. Participants' demographic and clinical characteristics were analyzed using descriptive statistics and were present as mean (with Standard Deviation) for continuous data, absolute and relative frequency for categorical data. Baseline values of exercise and control group were compared using independent-sample t-tests for continuous data and χ^2 test for categorical data. Independent-sample t-tests were used to test whether there were any statistically significant differences between groups at postintervention. Within group differences between baseline and postintervention were investigated by paired t-test. Compliance with the exercise program for each participant was calculated as the number of performed training divided by the total training.

The sample size calculation (alpha = 0.05; beta = 0.2) estimated that 15 participants were needed in each group. Allowing a dropping out rate of 20%, 18 participants were recruited per group.

RESULTS

A total of 23 community-living elderly people volunteered to participate in the experimental group. One of them did not meet the inclusion criteria due to the age below 60. In addition, four elderly people were excluded due to participation in sports activity in the past 6-month period. We recruited an age and gender matched control group. Table 1 shows demographic and clinical characteristics of the participants of the study.

The experimental and the control group were similar in all of the sociodemographic data and physical characteristics.

Table 1. Baseline characteristics of the participants.

Variables	Exercise group n = 18	Control group n = 18
Age (years), mean (SD[a])	71.5 (± 6.2)	70.6 (± 5.1)
BMI (kg/m²), mean (SD[a])	25.7 (± 4.2)	27.4 (± 4.1)
Female, number (%)	3 (17)	3 (17)
Living situation		
Alone, number (%)	8 (44)	5 (28)
In family, number (%)	10 (56)	13 (72)
Education		
At least 12 years, number (%)	8 (44)	15 (83)
More than 12 years, number (%)	10 (56)	3 (17)
Medical history		
Hypertension, number (%)	12 (66)	9 (50)
Diabetes mellitus, number (%)	1 (6)	3 (17)
Lower limb arthritis, number (%)	9 (50)	7 (61)
Osteoporosis, number (%)	11 (61)	14 (78)
Use of bifocal-eyeglasses, number (%)	4 (22)	3 (17)
Medication > 4, number (%)	8 (44)	5 (28)
Persons who fell last year, number (%)	8 (44)	12 (33)

[a] SD: Standard Deviation

Compliance with the exercise program

Participants completed an average of 76% (SD: 17.9; min-max: 48-96) of their prescribed training. Three participants did not complete the 25-week study, resulting in a loss of 16.6%. The reasons for dropping out were moving to another district (n = 1) hospitalisation (n = 1), or loss of motivation (n = 1). Their data were analised because they completed more than 80% of the prescribed sessions. There were no adverse events during the study period.

Effects of functional training

The outcome data are presented in table 2. In the experimental group, Fullerton test improved significantly (p < 0.001), while there was no statistically significant change in the control group (p = 0.889). At the end of the exercise program, the difference between the groups was significant.

In the experimental group there was also a statistically significant improvement in TUG time (p = 0.002), while a marginally significant deterioration was found in the control group (p = 0.056). At the end of the exercise program, a significant difference was found between the groups.

The Five-Times-Sit-to-Stand test remained unchanged in both groups during the period of the study.

The Two-Minute-Step-in-Place Test did not change in the experimental group (p = 0.909), while a significant deterioration was noted in the control group (p = 0.014).

According to the health-related quality of life measured by EQ-5D questionnaire, a mild improvement was found in the experimental group (p = 0.04), while a mild deterioration was found in the control group (p = 0.08) over the same period. The difference between the groups showed a marginal significance (p = 0.083).

Table 2. Balance, functional mobility, muscle strength, aerobic endurance, and quality of life scores at baseline and after the intervention period.

	Exercise group		Control group		P value (between groups after intervention)
	at baseline	at 25 weeks	at baseline	at 25 weeks	
Fullerton test (point)	30.35 (± 4.19)	33.35 (± 3.35)	30 (± 5.22)	29.9 (± 5.1)	0.03
TUG[a] test (seconds)	9.88 (± 1.46)	8.75 (± 1.23)	10.91 (± 2.07)	11.15 (± 2.13)	0.0004
Five-Times-Sit-to-Stand test (seconds)	12.83 (± 2.33)	13.01 (± 2.52)	13.39 (± 1.65)	13.83 (± 1.6)	0.28
Two-Minute-Step-in-Place test (number of steps)	64.5 (± 16.9)	64.8 (± 16.1)	59.3 (± 14.5)	57.3 (± 13.2)	0.15
EQ-5D[b]	0.76 (± 0.2)	0.87 (± 0.16)	0.83 (± 0.15)	0.77 (± 0.13)	0.083

[a]Timed Up and Go
[b]EuroQol-5

DISCUSSION

This study was designed to evaluate the effects of a 25-week functional balance training program on static and dynamic balance, functional mobility, lower limb strength, endurance and quality of life among community-living elderly adults.

We found that the experimental group was significantly better in static and dynamic balance, functional mobility and health-related quality of life after the training period compared with the control group. However, we could not demonstrate improvement in lower limb strength and aerobic endurance.

Previous studies have reported the beneficial effects of functional training among people suffering from neurological diseases. In comparative studies conducted among hemiplegic patients, the effects of functional training were investigated in contrast to individualized usual physiotherapy (15) or low intensity functional training (16). Similarly to us, they reported a significant improvement in functional mobility.

Studies evaluating the effects of functional training among institutionalized elderly adults showed that static balance, dynamic balance and functional mobility improved following both a 4-week and a 12-week task-oriented functional training programs (7-9). However, the aerobic endurance did not improve in any studies conducted among ageing population. Only one of the studies investigated the lower limb strength, but improvement was not revealed (9). To our knowledge, our study is the first functional balance training study which focused on community-living elderly adults. Similarly to studies focusing on institutionalized elderly adults, we also observed improvement in static balance, dynamic balance and functional mobility. Our findings that aerobic endurance and lower limb strength did not improve are also in accordance with results from past geriatric trials (7-9).

Several observational studies indicate that leisure time physical activity is associated with health related quality of life (17-18). In our trial a significant improvement was detected in the experimental group, while a marginally significant deterioration was found in the control group. Better quality of life could be explained by a significant improvement in functional mobility. Our result that exercise program improves quality of life even among elderly people is consistent with previous studies in this area (19-20).

Attendance rate of our study (83%) is considered high in comparing to attendance rate of training program among institutionalized elderly adults (75%) (9).

Some limitations of our study must be mentioned. Firstly, the lack of a randomized control group limits generalization of our results. Secondly, the sample size was small; however, we were able to demonstrate that functional training was effective on static and dynamic balance and functional mobility among community-living elderly people. Thirdly, the measurements were performed only at the end of the 25-week training period, however it would be useful to know when the gain is lost after finishing the exercise program.

Further studies should be conducted to examine how long the beneficial effects last. In the future trials it also would be worth investigating the effects of functional training in contrast with other training programs, such as multimodal balance training or traditional Tai Chi exercises.

CONCLUSION

Initially functional training was used only in neurological rehabilitation. In the recent 10 years this therapeutic approach was applied among institutionalized elderly adults as well. Our results showed that functional balance training might be an acceptable, safe and effective type of exercise program for even community-living elderly adults to maintain and improve their functional abilities. We believe that our study might stimulate further researches to confirm our results.

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