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The effect of functional balance training in frail nursing home residents

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ABSTRACT

The purpose of this study was to design and evaluate the specifically targeted functional balance training for a group of frail nursing home residents. Fifty residents of two nursing homes were assigned to an exercise and control group. Thirty-three participants (age 75.7 ± 6.7 years) in the balance training group finished 12 weeks of training protocol that consisted of 14 activities that challenged different balance subsystems. The results showed that the participants in the training group reached higher score on Berg Balance Scale (BBS) ($p < 0.001$), were able to stand longer on a compliant surface with eyes opened and closed ($p < 0.01$ and $p < 0.02$, respectively), and were faster at both, the four square and ten meter walk tests ($p < 0.001$), whereas there were no changes for the control group during the same time period. Anyhow, functional improvement of balance did not reflect in the parameters of postural sway. In conclusion our results suggest that the specifically targeted functional balance training is effective as far as functional activities are concerned while this kind of training does not reflect as a change in the steadiness of the center of pressure (CoP).

1. Introduction

Balance is a complex motor, sensory and cognitive function. For balance to be maintained, a person needs accurate coordination between the afferent information coming from the proprioceptive, vestibular and visual systems, and the descending motor program for the adjustments of posture during all functional activities. There is a need for accurate performance of a goal-directed movement on the one hand, and the maintenance of equilibrium and an appropriate posture or a set of postures, on the other (Massion et al., 2004). Quality and accuracy of balance function are age-related and their changes are associated with decline in physical and functional capability. With aging, there is a substantial decrease in all systems that contribute to decrease balance capabilities. The changes in muscle mass and strength are well documented (Carter et al., 2001) as are somatosensory, visual and vestibular systems changes (Carter et al., 2001). Studies of the effect of age on vestibular function indicate that the likelihood of falling in any situation of sensory conflict increases with age (Horak et al., 1989). Weighting of different sensory stimuli varies among the elderly population. Some normal elderly subjects appear to become more dependent on visual information to control posture (Ring et al., 1988) while others rely more on somatosensory information (Horak et al., 1989). Deficits in any sensory system can be expected to change not only the way sensory information is used to control posture, but also the form of the motor responses that serve postural control (Horak et al., 1989). In addition to the musculoskeletal and senso-motoric factors involved in balance control, there is a significant attention-requirement for postural control, and these requirements vary depending on the postural task, the age of the individual and their balance abilities (Woollacott and Shumway-Cook, 2002). This may lead elderly people to a sedentary lifestyle and further deconditioning. Among other age-related problems, falls are the leading cause of injury, hospitalization and institutionalization. Balance impairment is believed to be one of the major factors that contributes to an increased risk of falling (Horak et al., 1989).

A better understanding of the relationship between falls, balance function, senso-motor integration and dual attention tasks is needed. Various exercise protocols have been proposed for improvement of balance function and they report different results. In the review of Keysor and Jette (2001), out of 31 controlled studies only 13 assessed the influence of exercise on balance, and 8 out of 13 reported significant beneficial effects of exercise interventions. There is no agreement between researchers what kind of training, what intensity of the training is optimal for the enhancement or maintenance of the balance function in the frail elderly subjects. General exercises may have beneficial influence on the muscle force and capacity where as the influence on balance function is minimal (Judge et al., 1993; Skelton et al., 1995; Schlicht et al., 2001) or completely absent (Crilly et al., 1989). The same holds true for the training for muscle power (Lichtenstein et al., 1989; Topp et al., 1993). These results suggest that improvement of muscle capacity is not directly transferred to balance function. The

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Table 1
The results of the initial assessment of the participants in both nursing homes.

	Exper. 1st nursing home	Exper. 2nd nursing home	Control
No. of participants	13	20	17
Gender (F: female, M: male)	8 F/5 M	16 F/4 M	13 F/4 M
Age (years)	76.5 ± 8.3	75.2 ± 5.7	79.1 ± 6.4
Sensory organization test			
Solid surface: eyes opened (s)	60	60	60
Solid surface: eyes closed (s)	60 ± 0	57.0 ± 10.3	51.5 ± 19.7
Compliant surface: eyes opened (s)	37.3 ± 27.5	36.8 ± 21.4	41.8 ± 26.3
Compliant surface: eyes closed (s)	14.8 ± 25.8	15.1 ± 11.0	21.9 ± 26.9
Functional tests			
Four square test (s)	17.2 ± 4.5	20.8 ± 7.0	20.1 ± 9.2
Ten meter walk test (s)	11.4 ± 3.3	12.5 ± 3.3	12.4 ± 4.9
BBS (scores)	44.6 ± 6.7	44.5 ± 3.7	47.1 ± 5.8
BI (scores)	18.1 ± 3.2	17.8 ± 1.9	18.8 ± 1.1

intensity and frequency of the programs also differs between the programs and ranges from two times weekly (Steadman et al., 2003; Hue et al., 2004; Hendwood and Taaffe, 2005), three times weekly (Brandon et al., 2000; De Vreede et al., 2004).

On the other hand specifically targeted balance training programs are reported to have impact on functional performance of the elderly subjects (Shumway-Cook et al., 1997; Wolf et al., 2001; Nagy et al., 2007; Westlake and Culham, 2007). Improvement as measured with clinical balance tests have been shown after a functional training program (Shumway-Cook et al., 1997). Individualized balance training significantly improved performance of older subjects compared to the controls on the BBS and Dynamic Gait Index (Wolf et al., 2001). Sensory-specific balance training enabled elderly subjects to decrease the destabilizing effect of vibratory stimuli (Westlake and Culham, 2007).

The assumption underlying our research was that repetition of challenging activities triggers the process of motor learning and the more closely the demands in the practice resemble those in the actual environment, the better the transfer into the every day life. Based on this assumptions the purpose was to design and evaluate the set of exercises that would specifically target functional balance and would challenge most of the aspects of the balance performance: reaching borders of stability, balancing on compliant surface, stabilizing during head movements and dual attention. The training program we developed consists of daily activities that require dynamic postural stability.

2. Subjects and methods

2.1. Participants

The study was approved by the National Medical Ethic Committee and all of the enrolled participants gave written informed consent at the beginning of the study. Residents of two public nursing homes located in two small towns participated in the study. The two nursing homes are a part of national public association of nursing homes and meet national care standards. 358 residents of both nursing homes underwent screening for inclusion in the study. Inclusion criteria: (1) frail but independently mobile subjects. (2) Residents of nursing home without a known neurological, cardiovascular or musculoskeletal condition that would interfere functional mobility. 145 individuals met the inclusion criteria and 59 gave informed consent for participation in the study. The 39 residents of the first nursing home were randomly allocated to the experimental (20) or the control group (19) whereas the remaining 20 participants from the second nursing home formed another experimental group. After 2 weeks, 7 participants stopped exercising. Due to dropout in the exercise group, the age-difference between the two groups became significant. Consequently, we excluded the two oldest clients from the control group. For the final analysis 33 clients were available in the experimental group, 13 in one nursing home and 20 in the other nursing home and 17 in the control group. In order to make comparison between the groups initial tests for both experimental and control groups (Table 1) were subject to one-way ANOVA. The results revealed that there was no statistically significant difference between the groups at the initial stage of the experiment. This allowed us to consider exercise groups of both nursing homes as one experimental group and further analysis was performed for the two groups, i.e. one experimental and one control.

2.2. Outcome measures

Due to complexity of balance we performed a combination of tests that measured various components of balance on different levels. The outcome measure that reflected the impairment was the sensory organization test, tests that measure different functional aspects of balance were the four square step test, ten meter walk test, BBS and Barthel Index (BI). Additionally, 20 subjects, all from the experimental group, participated in the stabilometric test on the force platform.

The sensory organization test is a clinical tool for assessment of the relative contribution of proprioceptive, vestibular system and vision to postural integration. The validity and reliability of the test is well-established (Shumway-Cook and Horak, 1986). Subjects were standing with their feet close together and arms at their sides and were timed in 4 different sensory conditions: standing on the hard surface with their eyes opened and closed and standing on the Airex® mat with their eyes opened and closed. The timed four square step test is a valid and reliable clinical tool that assesses agility, capability for weight shift, change of direction and stepping over obstacles, and has a pronounced cognitive component (Dite and Temple, 2002). Two 1 cm high bars were perpendicular to each other and formed four squares. Subjects were asked to face the therapist and step as fast as possible from the first to the fourth square and back. The ten meter walk test is a valid and reliable test for functional mobility in older adults without additional known neurological or orthopedic conditions (Steffan et al., 2002). Subjects walked in a corridor that was marked at 0, 2 and 10 m. First 2 m allowed subjects to develop their walking speed and next 10 m were timed by the therapist who stood at the middle point. The BBS consists of 14 functional activities graded on a scale from 0 to 4. It is valid (Berg et al., 1992), reliable (Berg et al., 1995) and sensitive to change (Wood-Dauphinee et al., 1997; English et al., 2006). Participants were asked to perform the activities in the order from the least demanding to the most demanding activities. The BI is widely used for measuring functional independence and it