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Original Article

Comparing the Effects of Balance Training with and Without Cognitive Tasks on the Quality of Life and Balance Performance in Community-Dwelling Older Adults: A Single-Blind Randomized Clinical Trial

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ABSTRACT

Background: Aging process can deteriorate the ability to maintain balance, specifically under dual-task conditions. Thus far, different methods of exercises therapy have been applied to improve balance performance of older adults. The present study was designed to compare the effects of two protocols of balance training on the quality of life (QoL) and balance performance in older adults with mild balance impairments.

Methods: Twenty-four older adults over 60 years old were allocated randomly into single-task (n=12) and dual-task (n=12) exercise groups. Single-task group received routine balance exercises, over a four-week period and dual-task group was treated by the same exercise program plus a cognitive task. QoL and balance status were assessed by the Short-Form Health Survey (SF-36) and Fullerton Advanced Balance scale (FAB) questionnaires, before and after the interventions.

Results: After four weeks of training, balance performance and some factors of QoL improved significantly in both groups (P<0.05). However, there were no significant differences in any of the variables between the two groups.

Conclusion: Balance exercises, under both single- and dual-task conditions can improve the balance level and some aspects of QoL in older adults with mild balance impairments, with no priority of one group over another.

Introduction

The process of aging is generally accompanied by unavoidable changes in both sensory and motor functions. With old age, muscle mass and consequently, muscle power and torque decrease and these alterations, specifically in postural muscles, can eventually lead to instability and imbalance [1]. Abnormal postural control increases the risk of falling and its subsequent problems, which will decrease the general quality of life (QoL) in older adults. It has been shown that the people who regularly do physical activities will encounter the mentioned problems of ageing less and encounter them later and hence, they are able to preserve their functional tolerance more than the sedentary people [2].

The aging process can decrease visual, vestibular, and somatosensory inputs, which can reduce the perception of environment and motion. Decreased balance-related sensory inputs can increase postural sway, which is more noticeable in older people than in young adults [3]. In addition to the sensory and the motor systems, the cognitive system also plays a major role in postural control and similar to other involved systems, will lose

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its ability during the aging process to some extent [4]. The inability to control balance is more significant when older adults need to perform two distinct tasks simultaneously, which is known as a dual-task condition [5]. In this situation, the demands on attention increases and on the basis of the limited attention capacity in the older adults, one or both of postural and cognitive tasks will be impaired [6].

Up to now, various types of exercises have been proposed to improve balance and/or QoL in geriatric people, including strengthening, stretching, aerobic, multisensory, and dual-task exercises [7-9], as well as specific training programs such as dancing, swimming, tai chi and so forth [10,11].

To the best of our knowledge, as yet, no study has compared the effect of single-task and dual- task exercises on both the QoL and the balance ability of older adults. Such a comparison can determine the relation between the balance level and the sense of well-being in the older adults. Therefore, we designed this study in order to survey the effectiveness of these two different methods of training in order to elicit more advantageous protocol of training for this population of the society.

Methods

Subjects

Twenty-four older adults (8 males, 16 females) were selected from a community center for older adults, considering the inclusion criteria. The written, informed consent was obtained from each and then, the subjects were divided into two groups by simple randomization; 12 received single-task balance training and 12 received dual-task balance training. The ethical approval was obtained from the local medical ethical committee (Reference number: IR.SUMS.REC.1394.148). This clinical trial has also been registered by ClinicalTrials.gov (Identifier: IRCT2016020624149N4).

Subjects between 60 and 75 years of age were included, if they satisfied the following criteria:

Acquiring scores between 45 and 52 out of 56 on the Berg Balance Scale (BBS) [5], more than 23 out of 30 on the Mini-Mental Status Examination (MMSE) [12], and lower than 7 on the Geriatrics Depression Scale (GDS)[13]. These scores ensured that the subject were functionally independent older adults, with no significant depression or cognitive impairments. Also, the subjects were required to be able to retain their static balance with open eyes for at least five minutes.

The participants were excluded if they had any history of serious neurological (Parkinson's disease, stroke, neuropathy, etc.), musculoskeletal, cardiovascular, visual, or auditory disorders (color blindness, Meniere's syndrome, peripheral sensory neuropathy, macular degeneration, etc.). The subjects who had received any kind of balance training in the last three months and who could not complete the trial were also excluded.

Procedures

Firstly, the subjects were assessed by the BBS, MMSE, and GDS questionnaires for their eligibility for entering this study. A trained therapist evaluated their balance and QoL, using the Fullerton Advanced Balance (FAB) Scale and the Short-Form Health Survey (SF-36).

The SF-36 questionnaire has 36 questions for evaluating different aspects of physical and mental well-being, including physical functioning, physical role, pain, general health, vitality, social functioning, emotional role, and mental health subscales. The validity of these tests had been proved before [14,15]. Afterwards, the participants were divided into two groups of 12 persons each, by simple randomization. One group received single-task and the other one received dual-task balance training, in such a way that the subjects were unaware of the interventions in the other group.

The single-task balance training program comprised of 1) active movements of trunk and limbs while keeping balance on a gym ball, 2) controlling balance during Romberg test, semi-tandem, tandem, and single-leg standing, 3) throwing and catching a ball while standing, and 4) changing position from lying to standing. In the dual-task group, a cognitive task was added to the above-mentioned balance exercises. This secondary task included 1) naming things or words (e.g. flowers, streets, etc.), 2) random digit generations between 0 and 300, 3) counting backwards by twos or threes, and 4) the n-back task (reciting days, months, etc. backwards) [16,17].

Groups of four persons accomplished these exercises in 45-minute balance training sessions (with five minutes of warming up at the beginning and five minutes of cooling down at the end of each session), three times a week, for four weeks. According to the literature, 10 to 12 hours of balance training can effectively improve the balance performance in older adults [18]. After the fourth week, the QoL and the balance level of the subjects were reassessed and compared with the baseline measurements.

Statistical Analysis

The data were analyzed using the software Statistical Package for Social Sciences (SPSS), version 18 (IBM Inc., Chicago, IL, USA). Regarding the non-normal data due to the small sample size, the Mann-Whitney U test and Wilcoxon rank-sum test were used for the inter-group and intra-group comparisons, respectively. The significance level for all statistical tests was set at $P<0.05$.

Results

Based on the flow diagram of the progress of the study depicted in Figure 1, all the 24 participants completed the trial. The demographic data and the baseline characteristics of subjects are presented in Table 1. The two groups were well matched and there were no significant differences between the groups for any of the baseline values and also, for the overall score and eight subscales of SF-36, assessed by the t-test ($P>0.05$). As Table 2 demonstrates, the balance was improved significantly after the interventions in both the groups ($P=0.002$). Regarding SF-36, "physical functioning", "bodily pain", and "general health" subscales in the

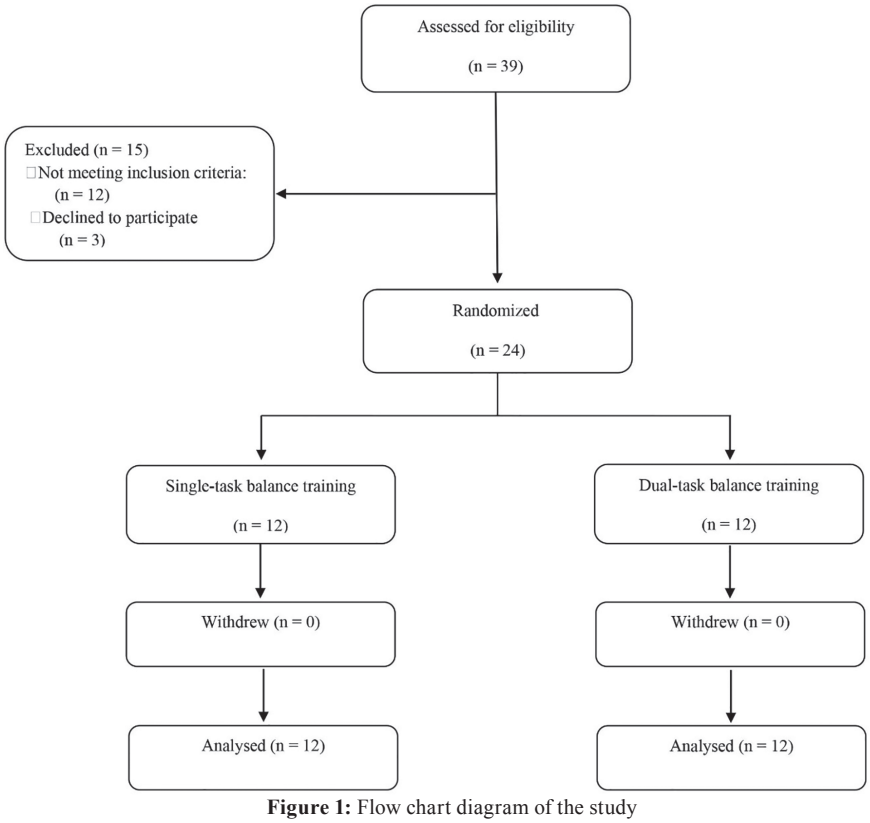

Figure 1: Flow chart diagram of the study

Table 1: The subjects' general characteristics (page 8, in RESULTS)

	Single-task Balance Training (Mean±SD) (N=12)	Dual-task Balance Training (Mean±SD) (N=12)	P value
Age (yr)	65.16±4.93	63.75±5.01	0.334
Height (cm)	159.50±8.97	159.33±7.03	0.795
Weight (kg)	67.41±11.81	68.75±8.14	0.908
Body Mass Index (kg/m^2)	26.62±5.05	27.24±4.45	0.603
Mini-Mental State Examination (0–30)	27.75±1.71	28.16±1.99	0.377
Geriatric Depression Scale (0–15)	3.33±1.43	3.58±1.44	0.635
Berg Balance Scale (0–56)	50.08±2.06	49.75±2.00	0.551

Table 2: Intra- and inter-group comparisons of balance and quality of life, before and after the interventions (page 8, in RESULTS)

	Single-task Balance Training (N=12)			Dual-task Balance Training (N=12)			P value
	Pre	Post	Change	Pre	Post	Change	
Balance (Mean±SD)							
FAB†	32.00±4.53	35.33±4.81	3.33±1.30*	31.75±3.01	34.91±3.67	3.16±1.19*	0.882
SF-36 (Mean±SD)							
Physical functioning	47.50±30.18	59.58±27.00	12.08±16.84*	64.16±25.83	69.16±21.19	5.00±10.66	0.184
Role-physical	56.25±37.11	64.58±37.62	8.33±19.46	56.25±44.11	72.91±40.53	16.66±32.56	0.568
Bodily pain	44.44±18.95	60.18±20.35	15.74±13.77*	56.48±26.57	69.44±27.67	12.96±9.27*	0.762
General Health	64.58±15.73	72.08±18.52	7.50±8.66*	69.58±18.64	72.08±14.84	2.50±7.22	0.276
Vitality	67.91±20.27	60.00±15.22	-7.91±14.05	67.50±16.30	57.50±10.55	10.00±14.14*	0.703
Social functioning	76.04±24.69	81.25±20.98	5.20±8.35	79.16±17.94	86.45±17.23	7.29±9.91*	0.615
Role-emotional	80.55±38.81	86.11±33.20	5.55±31.24	55.55±38.49	72.22±31.24	16.66±30.15	0.119
Mental health	78.66±12.80	78.00±15.11	-0.66±4.11	74.66±19.24	75.00±18.53	0.33±2.05	0.713
General score	62.60±13.29	64.87±11.51	2.26±10.08	68.06±10.14	71.00±11.15	2.94±9.75	0.954

†Fullerton Advanced Balance Scale; * Significant change in intra-group comparisons (P<0.05)

single-task group and "bodily pain", "vitality", and "social functioning" subscales in the dual-task group showed significant changes after the interventions, although the overall score did not change significantly in any of the groups. Nevertheless, there was no significant difference between the groups for any of the variables (P>0.05).

Discussion

The results of our study showed that a four-week balance training program in both single- and dual-task conditions can significantly improve the balance level in older adults with mild balance impairments. Previous pertinent studies are mostly consistent with our results, although their different methods of assessment impede us from an accurate comparison between the studies. Most of the studies have used BBS or center of mass alterations to evaluate the effects of balance training on balance performance, while we chose the FAB for this assessment. One of the advantages of FAB is the fact that as a straightforward functional test, it obviates the need for the motion analysis system. Also, FAB provides real-time results which augment its clinical value. In addition, unlike the BBS, the FAB test does not have a ceiling effect and being more sensitive to the impairments of the sensory system, it is better for surveying mild balance impairments [16].

In a similar study, Patima Silsupadol et al., 2009 divided 23 older adults with balance impairments into single- and dual-task balance training groups and evaluated their balance by the BBS and the Gait Speed tests [5]. They concluded that four weeks of exercise under both conditions could improve the balance level significantly, although, at the 12th week, this improvement was reported only in the dual-task group. In another congruent investigation, Tarjino et al. examined the effects of balance training on the treadmill [19]. Evaluating by BBS, they showed that both single- and dual-task training would improve balance, and analogous to the mentioned study by Silsupadol et al., the long-term effects were seen just in the dual-task group, as measured one month after the study. Of course, Tarjino et al. surveyed only six old women and his results may not be highly reliable due to this small sample size. Both of the above-mentioned studies had the benefit of long-term follow-up, which was not performed in our study. Such follow-ups will provide more reliable results due to the elimination of emotional and psychological impressions of participating in a novel training program, and also, it should be considered that a major goal of such exercises is the maintenance of their effects, which necessitate long-term follow-ups in the future studies.

Another implication of the FAB is its ability to assess both static and dynamic balance ability, which turns it to a predictor of falling risk among the older adults in different environments [20]. It is obvious that one of the most important drawbacks of poor postural control is falling, which can cause a variety of mental and physical problems including depression and seclusion, fractures, and even death, particularly in the elderly. Therefore, taking measures to improve the balance level can be a priority for the healthcare providers. In 2008, Hernandez reported a reverse linear relation between the FAB score and the probability of falling, to the extent that one point increase in the FAB score would be equal to an 8% decline in the possibility of falling [21]. Regarding the mentioned report, the increase of 3 to 4 points of the FAB score in our study could lead to about 24 to 32 % decrease in the possibility of falling in both groups.

According to the literature, postural control is the result of the cooperation and the integrity of the motor, sensory and cognitive systems, all of which would undergo inevitable degenerative changes following aging [22]. During the aging process, both strength and the flexibility of the muscles will decrease, especially in the lower extremities. As a result, the elderly cannot apply hip and ankle strategies immediately upon confronting perturbations and this disability can eventually increase the risk of falling [1]. Golding and Lindsay reported a 14.5% reduction in hamstring flexibility for every ten years, which can decrease the hip external rotation by 15% and abduction by 11% [23]. Hence, it can be concluded that exercises in both groups could improve the balance by muscle strengthening while increasing the flexibility and the joints' range of motions in the lower extremities of the subjects.

As far as the sensory system is concerned, the main effect of the exercises is to augment the proprioception inputs from the various muscles and joints e.g. ankle, knee, cervical facet joints and so forth, which decrease owing to the aging process. As the motor section of the dual-task balance training was exactly the same as the single-task group, we should attribute the probable differences in the cognitive section and so, the effects of training on the cognitive system. Based on the reviewed literature, issues such as attention, concentration, and planning can lead to making timely decisions and planning an effective strategy upon facing postural control disruptions [24]. These procedures are all under the control of the central nervous system, specifically frontal lobe which undergoes many deteriorative changes, e.g. decrease in neurons and blood supply in the brain and the increase of free radicals in the brain, that altogether impair brain performance [25]. Exercise, on a regular basis, can decelerate this process and consequently, reinforce the cognitive part of postural control.

The previous studies have shown that exercise can increase blood flow to the brain. [26]. In one of the studies, Colcombe et al. reported a significant increase in the brain volume, in both the gray and white matter regions, following aerobic exercises [27]. The lack of a difference between the groups in terms of balance performance, after single- and dual-task balance training, can be attributed to the more complicated nature of the cognitive system compared to the sensory and the motor systems. This necessitates longer-term surveys to detect significant changes. Consequently, in terms of balance performance, it can be concluded that in a four-week period of balance training in the geriatric population, the nature of the exercise, rather than its type, could play a more significant role. A study conducted by Konak et al. confirms our claim, although they compared the effect of the single-task and dual-task balance exercises on balance in adults with osteoporosis. Following a four-week balance exercise program, some of their tests showed greater improvement in the single-task group, while some other tests revealed better results in the dual-

task group [28].

In terms of QoL, our results showed that neither the single- nor the dual-task balance training could change the overall status of QoL, even though 3 out of 8 subscales in each group improved significantly following the exercises; i.e. "physical function", "bodily pain", and "general health" in the single-task group and "bodily pain", "vitality", and "social function" in the dual-task group improved. These findings can imply that physical changes are dominant following the single-task balance training, while the dual-task training is more effective on the mental subscales. There are some studies which investigated the effects of exercise on the QoL in geriatric populations, although only a few of them were done on healthy subjects [10,29]. But up to now, there has been no study to compare the effect of the different methods of balance training on QoL. Thus, our study is not comparable to the other previous studies. According to the literature, the general premise is that people with a moderate to high level of physical activity show better QoL than the ones with a low level of physical activity [30]. In addition to the previously mentioned advantages of exercise, the mental effects of training in special groups such as patients, children and also, the elderly should be highlighted, particularly when the exercises are performed in groups.

Another salient feature of the balance training program designed for this study was the progressiveness of the exercises. That is to say, that by learning each exercise and performing that correctly, the subjects would be promoted to a more challenging level. By way of illustration, we can compare the different standing positions, in which the Romberg standing was the easiest and the single-leg standing was the hardest position. Such process can effectively enhance motivation and self-confidence of the participants.

Study Limitations

With respect to the limitations of our study, a larger sample size and long-term follow-ups in future studies can provide more accurate results regarding overall status of QoL.

Conclusion

The results of our study showed that balance exercises, both in single- and dual-task conditions, can improve balance and some aspects of the QoL in the elderly. As a result, we can expect to benefit from balance exercises as an effective part of rehabilitation in the elderly people with mild balance impairments, while future studies with long-term follow-ups can provide more reliable results. However, it seems that in some special groups like the geriatrics, the act of doing exercise per se might be more important than the method of the exercise itself.

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Conflict of interest: None declared.

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