Effects of 12-Week Proprioception Training Program on Postural Stability, Gait, and Balance in Older Adults: A Controlled Clinical Trial

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[1]Department of Health Sciences, Faculty of Health Sciences, University of Jaén, Jaén, Spain; [2]Institute of Biopathology and Regenerative Medicine (IBIMER), Department of Anatomy, Faculty of Medicine, University of Granada, Granada, Spain; and [3]Department of Didactics of Musical, Plastic and Corporal, University of Jaén, Jaén, Spain

Abstract

Martínez-Amat, A, Hita-Contreras, F, Lomas-Vega, R, Caballero-Martínez, I, Alvarez, PJ, and Martínez-López, E. Effects of 12-week proprioception training program on postural stability, gait, and balance in older adults: a controlled clinical trial. *J Strength Cond Res* 27(8): 2180–2188, 2013—The purpose of this study was to evaluate the effect of a 12-week–specific proprioceptive training program on postural stability, gait, balance, and fall prevention in adults older than 65 years. The present study was a controlled clinical trial. Forty-four community dwelling elderly subjects (61–90 years; mean age, 78.07 ± 5.7 years) divided into experimental ($n = 20$) and control ($n = 24$) groups. The participants performed the Berg balance test before and after the training program, and we assessed participants' gait, balance, and the risk of falling, using the Tinetti scale. Medial–lateral plane and anterior–posterior plane displacements of the center of pressure, Sway area, length and speed, and the Romberg quotient about surface, speed, and distance were calculated in static posturography analysis (EPS pressure platform) under 2 conditions: eyes open and eyes closed. After a first clinical evaluation, patients were submitted to 12 weeks proprioception training program, 2 sessions of 50 minutes every week. This program includes 6 exercises with the BOSU and Swiss ball as unstable training tools that were designed to program proprioceptive training. The training program improved postural balance of older adults in mediolateral plane with eyes open ($p < 0.05$) and anterior–posterior plane with eyes closed ($p < 0.01$). Significant improvements were observed in Romberg quotient about surface ($p < 0.05$) and speed ($p < 0.01$) but not about distance ($p > 0.05$). After proprioception training, gait (Tinetti), and balance (Berg) test scores improved 14.66% and 11.47% respectively. These results show that 12 weeks proprioception training program in older adults is effective in postural stability, static, and dynamic balance and could lead to an improvement in gait and balance capacity, and to a decrease in the risk of falling in adults aged 65 years and older.

Key Words aging, physical activity, stabilometry, proprioceptive, falls

Introduction

Falls among adults aged 65 years and older often result in moderate to severe injuries and can increase the risk of death. The economic burden caused by fall-related injuries is substantial for developed countries. Approximately 30% of falls result in an injury requiring medical attention (6). Hektoen et al. (16) estimated that health care costs for fall-related injuries treatment was 1.85 times higher than the cost of implementing a fall prevention program.

Postural stability, gait, and balance decrease with age (2,12). Although various factors are associated with falls, gait, and balance deficits have been identified as some of the most important intrinsic fall risk factors in community-dwelling populations (3,36). Many authors have described that dynamic balance improvement is associated with a decrease in risk of falls and fear of falling and improvement in quality of life (21). It has been shown that stabilometric parameters measured with force platforms provide valid information of postural stability that can be used to predict fall risk even among older people without apparent balance problems or fall history (24,27).

Proprioception was defined as "the perception of joint and body movement as well as position of the body, or body segments, in space" (35), and it is considered as the most important sensory system in the maintenance of postural stability in the elderly people (19). Decline in lower limb

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proprioception has been linked to balance problems found in the elderly, which have, in turn, been associated with a higher incidence of falls (20). Gstoettner et al. (15) showed that postoperatory improvements in postural stability and daily life activities have been observed in patients undergoing total knee replacement with preoperative proprioceptive training.

A training that involves strength, balance, and improved transfer must form part of an optimum intervention strategy to prevent falls (41). Older adult's postural stability is considered important to perform common activities of daily living, such as walking, turning, and so forth And because of the elevated number of facts and perceptions involved in the maintenance of postural stability, it is challenging to improve postural stability with the appropriate training (34). Some studies confirm that practicing physical activity may improve motor responses and postural control in the elderly (7,11,34), but not many works have been conducted to examine the effects of regular physical activity on proprioception preservation during aging. Petrella et al. (30) designed a study to investigate knee joint proprioception among young volunteers and active and sedentary elderly volunteers and concluded that proprioception is diminished with age and that regular activity may attenuate this decline.

Many studies include unstable surface in proprioception training. This type of training stimulates proprioceptive system producing motor responses and stabilizing the joints from the 3 levels of neural protection (22). Different tools, such as Swiss ball and BOSU, have been used to create instability. It has been showed that a 6 weeks proprioceptive program with both tools provides great differences in core stability and body mass index (BMI) decrease (38).

It seems to be consensual and well established that proprioception diminishes with aging, and regular physical activity seems to have a basic role in the preservation of proprioceptive function. Therefore, it might be important to develop and implement strategies to attenuate the age-related decline in proprioception and its consequences. Since there is no conclusive evidence that any type of gait and balance training program is better than another and the studies focused on proprioceptive training with Swiss ball and BOSU are scarce, the purpose of this study was to compare the effects of traditional and proprioceptive training programs on postural stability, gait and balance, and fall prevention in adults aged 65 years and older. We hypothesized that significant improvements in static posturography (primary outcome) and in functional balance tests (secondary outcome) could be achieved through a 12-week proprioceptive training program with Swiss ball and BOSU in adults older than 65 years.

Methods

Experimental Approach to the Problem

A controlled trial with allocation of participants into the experimental ($n = 20$) or control ($n = 24$) groups was carried out from March 2010 to June 2011. For practical and ethical reasons, it was not possible to randomize the patients. We had an ethical obligation with the Andalusian Federation of older people's organizations (Spain) to provide treatment to all older adults willing to participate in the study, but because of limitation of resources, we created a waiting list. The older adults who were in the waiting list agreed to be part of the usual care group (control group) and were offered the intervention program at the end of the follow-up period. Data collected only during the control period were included in the current analysis.

Subjects

We contacted a total of 208 older adults from the Andalusian Federation of older people's organizations (Spain), and 76 potentially eligible older adults responded. The inclusion criteria included subjects who were 65 years of age or older and able to follow simple directions, for example, left, right, up, or down. The exclusion criteria included people with functional blindness (acuity level worse than 20/200) and those with major chronic medical or physical conditions, including rheumatoid arthritis or osteoarthritis; severe low-back pain; severe lower limb deformities, as diagnosed by a physician, that resulted in the inability to ambulate independently or with the use of an assistive device.

A total of 12 patients were not included in the study (8 had physical activity contraindications, 2 had locomotion problems, and 2 reported schedule problems). After the first day of the baseline measurements, 2 patients refused to participate. Therefore, a final sample of 54 older adults started the study, and 44 subjects concluded it (control group, $n = 24$ and experimental group, $n = 20$). Participants were not engaged in regular physical activity >20 minutes on >3 days/week. The investigation was approved by the Ethics Committee of the University of Jaén and written informed consent was obtained from each subject before participation according to the standards of the Declaration of Helsinki (revised2008).

Procedures

Baseline characteristics of the participants (Table 1) were initially collected on the day of consultation by means of self-administered questionnaires in the presence of well-trained interviewers. A 100–130 kg precision digital weight scale (Tefal) and a t201-t4 Asimed adult height scale were used to obtain weight and height, respectively. The question: "have you experienced a fall to the ground in the last twelve months?" was used for collecting their history of falls in the previous year.

Proprioception Intervention. The subjects included in the experimental group participated in a 12-week proprioception training program, performed 2 days per week (Monday and Wednesday), with a total of 24 sessions. Participants of the control group were asked not to change their activity levels and medication during the 12-week intervention period. They met weekly for an hour with the researchers to discuss topics of interest to older people. The exercise sessions were carefully supervised by a fitness specialist and

Table 1. Baseline characteristics of the participants, differentiated by groups.

Variable	Control group (n = 24)	Experimental group (n = 20)	*p*
Age	77.00 ± 6.90	79.35 ± 7.42	0.284
Weight	64.59 ± 9.43	62.07 ± 10.84	0.415
Height	1.60 ± 0.08	1.58 ± 0.09	0.546
BMI	25.41 ± 4.49	24.64 ± 2.97	0.518
Gender (%)			
Female	10 (41.7)	9 (45)	0.824
Male	14 (58.3)	11 (55)	
Falls in the last year (%)			
No	17 (70.8)	13 (65)	0.679
Yes	7 (29.2)	7 (35)	
Berg test			
High balance alteration	15 (62.5)	12 (60)	0.721
Low balance alteration	9 (37.5)	8 (40)	
Tinetti scale			
High risk of falling	16 (66.7)	11 (55)	0.429
Low risk of falling	8 (33.3)	9 (45)	
Marital status (%)			
Married	8 (33.3)	7 (35)	
Single	4 (16.7)	4 (20)	0.936
Separated/divorced/widowed	12 (50)	9 (45)	
Occupational status (%)			
Housewife	2 (8.3)	2 (10)	0.848
Worker	–	–	
Unemployed	–	–	
Retired	22 (91.7)	18 (90)	
Academic status (%)			
No studies	18 (75)	14 (70)	0.711
Primary education	6 (25)	6 (30)	
Secondary education	–	–	
Higher education	–	–	
Income (%)			
€ <12000/year	17 (70.8)	15 (75)	0.877
€ 12000–18000/year	5 (20.8)	3 (15)	
€ >18000/year	2 (8.3)	2 (10)	

Quantitative variables are presented as mean ± *SD*, whereas categorical variables are presented as frequency (%).
BMI, body mass index.

by a physical therapist, who worked with groups of 10–12 older people. This program took place in the exercise room of the self-care residential facilities. The participants were asked to maintain their usual food intake (lunch time from 13:30 to 14:30), 2 L of daily water intake and 8 hours of sleep. The daily training was performed in the morning.

The type and intensity (mild to moderate) of the exercises of the present study were specially chosen so that the participants could perform them. A list of weekly attendance controlled the absences of each patient. Tests were conducted among the participants before and after the 12-week intervention.

Each exercise session included 50 minutes (10-minutes warm-up period with slow walk, mobility and stretching exercises, followed by 30 minutes of proprioceptive exercises program, and finishing with a 10-minute cool down period of stretching and relaxation exercises). A total of 6 Swiss balls (75 cm diameter) and 6 BOSU (BOSU Balance Trainer) were used for the proprioceptive training program (Figure 1). This program training consisted of 6 specific proprioceptive exercises, which were conducted in static and dynamic positions for a period of 30 minutes. Training was progressively structured in 2 or 3 phases, according to the exercise: Initial phase: weeks 1–5; intermediate phase: weeks 5–8; and advanced phase: weeks 8–12. The exercise program was exercises No. 1–No. 5 consisted of 2 sets of 10–15 repetitions with 1 minute of rest between sets. Two sets of 15 seconds and 1 minute rest between sets were performed in exercise No. 6. Training intensity was controlled by the rate of perceived exertion (RPE) based on Borg's conventional (6–20 point) scale. The medium values of RPE were 12 ± 2 on Monday and 13 ± 3 on Wednesday. These RPE values correspond to a subjective perceived exertion of "fairly light exertion and somewhat hard exertion," that is, low to moderate intensity. Tests were conducted among the participants before and after the 12-week intervention. Proprioceptive exercises were adapted to the study population according the method suggested by Franco et al. (13).

Outcome Measures. Pre- and postintervention assessments were carried out on 2 separate days with at least 48 hours between each session, to prevent fatigue and enhance muscle recovery after exercise. The assessment of the tender-points static posturography: stability test with eyes open and closed and Tinetti and Berg tests were carried out on the first and second days, respectively. Both the intervention and usual care groups were assessed the week immediately before the intervention started and the week after the intervention was finished. All measurements were performed in the same order by the same trained physiotherapist.

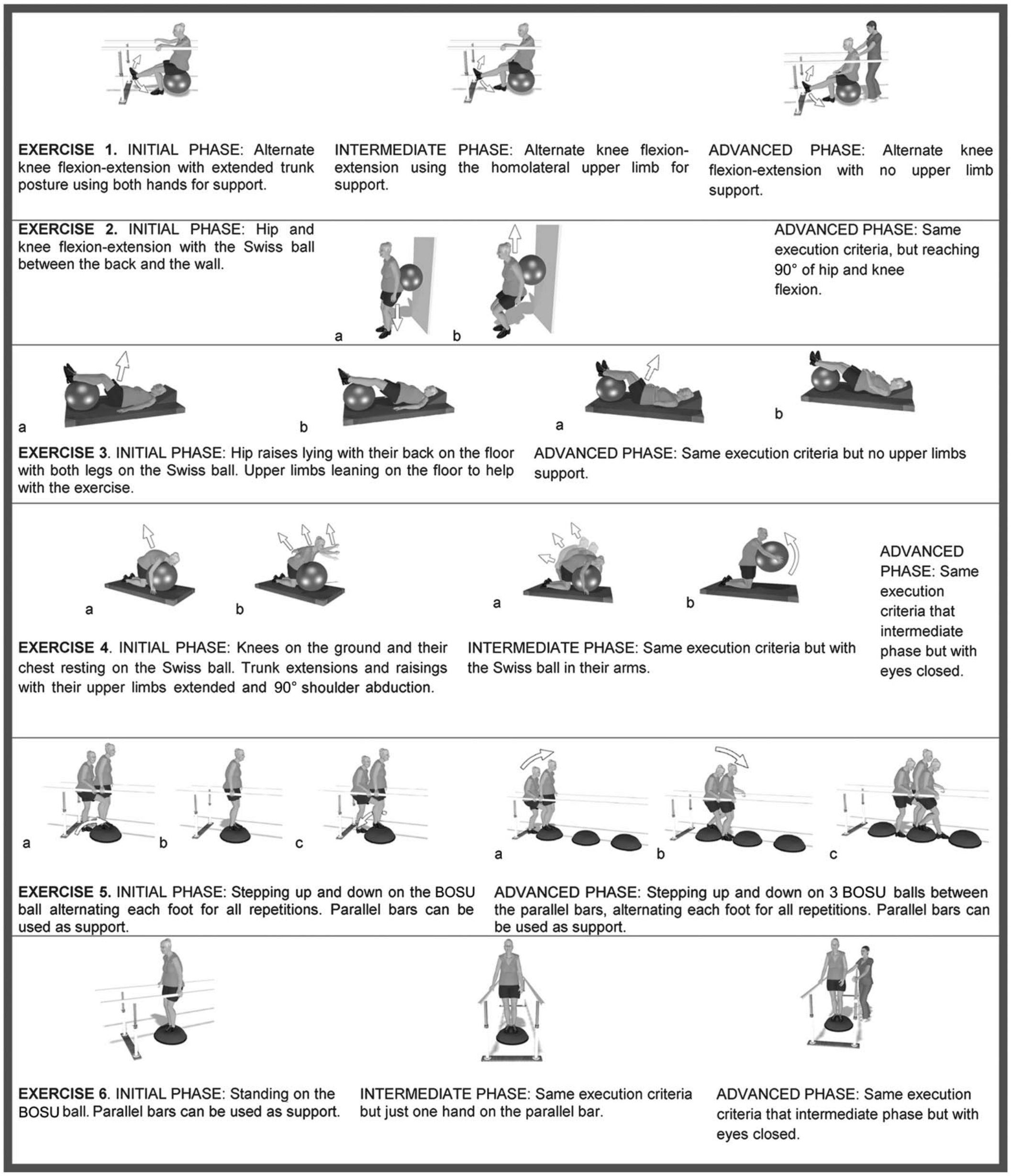

Figure 1. Exercises and protocols. Each session lasted 50 minutes (10 minutes of warm-up period, 30 minutes of proprioceptive exercises program, and 10 minutes of cool down), and 6 exercises were included. Exercises No 1–No 5 consisted of 2 sets of 10–15 repetitions with 1 minute of rest between sets. Two sets of 15 seconds and 1-minute rest between sets were performed in exercise No 6. No warming up exercises were performed. Initial phase: weeks 1–5, intermediate phase: week 5–8, and advanced phase: week 8–12.

Static Posturography (Primary Outcome). EPS/C (Electronic Pressure System/Capacitive) force platform and EPS-System-Footchecker software were used to measure stabilometric parameters. The platform dimensions are 680 × 520 mm, with an active surface of 480 × 480 mm, 5-mm thick, and 2.304 sensors. Reliability of this test has been shown in earlier studies (4,13). All the subjects were asked to stand on both feet on the pressure platform with eyes open (EO) and eyes closed (EC) and for 52 seconds each one to allow the study of visual and vestibular influences on sway parameters. This test was performed twice with a 5-minutes rest. The average results of both tests were used as the final values. This test measures the mean center of pressure (CoP) position in the medial-lateral plane (*X*) and anterior-posterior plane (*Y*). It also measures the surface covered by the center of pressure (S), the speed of the center

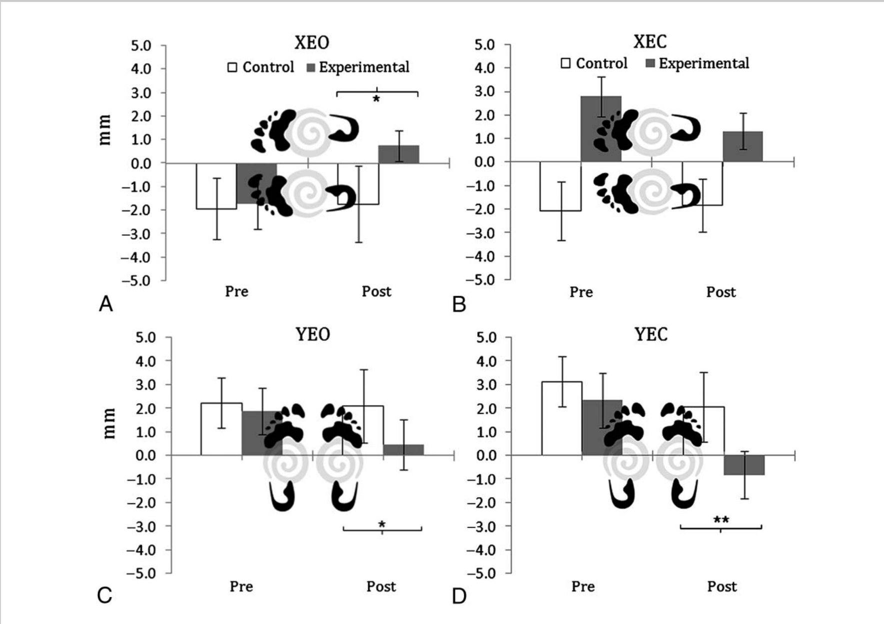

Figure 2. Pre and postresults of the intervention in the experimental ($n = 20$) and control ($n = 24$) groups. (A) XEO = mean position center of pressure in the medial-lateral plane with eyes open; (B) XEC = mean position center of pressure in the medial-lateral plane with eyes closed; (C) YEO = mean position center of pressure in the anterior-posterior plane with eyes open; (D) YEC = mean position center of pressure in the anterior-posterior plane with eyes closed. *$p < 0.05$; **$p < 0.01$ indicates postmeasurement differences between experimental and control groups. Note: Graphic values are real. In the analysis of variance of the CoP, *X* and *Y* negative values were multiplied by -1 to avoid the influence of the positive and negative signs in the analysis of significant differences. There were no presignificant-postsignificant differences in experimental or control groups ($p > 0.05$).

of pressure movement (Sp), the distance covered by the center of pressure (D), and the Romberg quotient (eyes closed/eyes open) about surface (RombergS), about speed (RombergSp), and about distance (RombergD). The static posturography tests performed at the beginning of the study demonstrated a good test-retest reliability. Intraclass correlation coefficients showed 0.624–0.924%, 0.571–0.912%, 0.737–0.939%, and 0.666–0.916 95% confidence intervals for XEO, XEC, YEO, and YEC, respectively.

Functional Balance (Secondary Outcome). The Berg balance scale was used to assess the balance ability of the subjects. It is a performance-based measure of balance consisting of 14 observable tasks common to daily life activities used to evaluate functional balance (5,25). The maximum score that can be achieved is 56, and each item possesses an ordinal scale of 5 alternatives, which varies from 0 to 4 points. The test is simple, easy to administer, and accompanies the evolution of elderly patients. It only requires a ruler and a watch and takes approximately 15 minutes to execute (25). A score lower than or equal to 45 is considered evidence of altered balance (42). The validity of this test for screening old adults standing balance is well established (1).

We also assessed participants' gait and balance abilities using the Tinetti scale (41). For gait evaluation, the subject stands with the examiner, walks across the room, first at "usual" pace, then back at "rapid, but safe" pace (using usual walking aids), and the following tasks are scored (0–2, indicating highest to lowest level of impairment, respectively): initiation of gait, step length and height, step symmetry, step continuity, path, trunk sway, and walking stance. For balance evaluation, the subject is seated in a hard armless chair, and the following manoeuvres are tested (score: 0, 1, or 2): sitting balance, arises, attempts to arise, immediate standing balance (first 5 seconds), standing balance, "nudged," eyes closed, turning 360° angle, and sitting down. The maximum sum-score of both gait and balance components are 28 points. Patients who score <24 are at risk for falls, and the risk of falling is high with a score <19. The validity of this test for screening old adults at risk for falling is well established (32).

Statistical Analyses

Student's *t* test and Chi-square test were used to compare anthropometric (age, weight, height, and BMI) and demographic variables (marital, occupational, and educational status and income), respectively, between both experimental and control groups. Repeated measures ANCOVA (2 group × 2 time) with age as covariate was used to assess the effects of 12 weeks training on stabilometric variables (X, Y, and Romberg quotient), Tinetti and Berg tests values, and Bonferroni's post hoc adjustment was used. The nonparametric Kruskal-Wallis test for independent samples and Wilcoxon test for dependent samples were used for the data that did not show homoscedasticity (Levene's test) and normality (Kolmogorov-Smirnov test). Pearson's correlation was performed to determine correlations between the scores of Tinetti and Berg tests. The assessment of the CoP displacement, and not the sense of this displacement [right and forward (+), left and backwards (−)], is the main goal of this study, and to erase the influence of the positive and negative signs in the significant differences analysis, the analysis of variance of the CoP was performed after multiplying X and Y negative values by −1. A *p* value <0.05 was used to identify statistical significance. Intraclass correlation analysis was used to assess the reliability of the stabilometry tests at the beginning of the study. All analyses were performed separately. Percentage of change after training (postmeasurement − premeasurement)/premeasurement × 100) was calculated. Analyses were performed using the Statistical Package for Social Sciences (SPSS, v. 19.0 for Windows; SPSS, Chicago, IL, USA).

Results

X and Y Stabilometric Variables

Figure 2 shows the results of the mean center of pressure position in the medial-lateral plane with eyes open (XEO) and eyes closed (XEC) and in the anterior-posterior plane with eyes open (YEO) and eyes closed (YEC). After 12 weeks, medial-lateral displacements with eyes open (XEO) (Figure 2A) described group main effect $F[1,41] = 5.27$, $\eta^2 = 1.114$, $p = 0.027$. More precisely, the experimental group shows a smaller oscillation displacement in the x-axis compared with the control group ($M = 0.74 \pm 1.44$ and $M = -1.74 \pm 1.28$ mm, respectively, $p = 0.012$). Intrasubject effect was not significant ($p = 0.085$ for the largest). The XEC analysis did not reveal any significant inter- or intrasubject effect ($p = 0.102$ for the largest, Figure 2B). On the other hand, anterior-posterior displacements significantly improved (decrease of the mean CoP position) in both tests: YEO $F[1,41] = 5.04$, $\eta^2 = 1.109$, $p = 0.030$ (Figure 2C) and YEC $F[1,40] = 4.12$, $\eta^2 = 0.93$, $p = 0.049$ (Figure 2D). Post hoc analysis revealed that the improvement of the experimental group in comparison with the control group control was 78% in eyes open test ($M = 0.46 \pm 4.43$ vs. $M = 2.11 \pm 1.24$ mm, respectively, $p = 0.010$) and 139% in eyes closed test ($M = 0.82 \pm 1.07$ mm vs. $M = 2.05 \pm 0.97$ mm, respectively, $p = 0.008$). No significant inter or intrasubject effects were observed in YEO and YEC analysis ($p = 0.096$ and $p = 0.390$, respectively, for the largest).

Romberg Quotient

Romberg quotient is the ratio of the variable values obtained in the condition "eyes closed" and "eyes open." We have calculated the Romberg quotient for the average surface (Figure 3A), speed (Figure 3B), and distance (Figure 3C). The analysis of the Romberg quotient about the surface (Kruskal-Wallis test) revealed significant differences between the experimental (85.37 ± 25.62) and the control (207.17 ± 44.97) groups in the postintervention measurements ($p = 0.039$). No more inter- or intrasubject differences were identified ($p > 0.05$). The results of the Romberg quotient about speed revealed a group main effect ($F[1,41] = 7.32$, $\eta^2 = 0.152$, $p = 0.010$) and a group × time interaction ($F[1,41] = 5.25$, $\eta^2 = 0.114$, $p = 0.027$). In the post hoc analysis, significant differences were observed between the experimental and the control groups (46.16 ± 27.25 vs. 108.66 ± 43.11, respectively, $p < 0.001$). After 12 weeks of proprioceptive training, significant improvement was observed in the experimental group ($p < 0.001$) but not in the control group ($p = 0.090$). No time effect or group × time interaction were observed ($p = 0.057$ for the largest). No intra- or

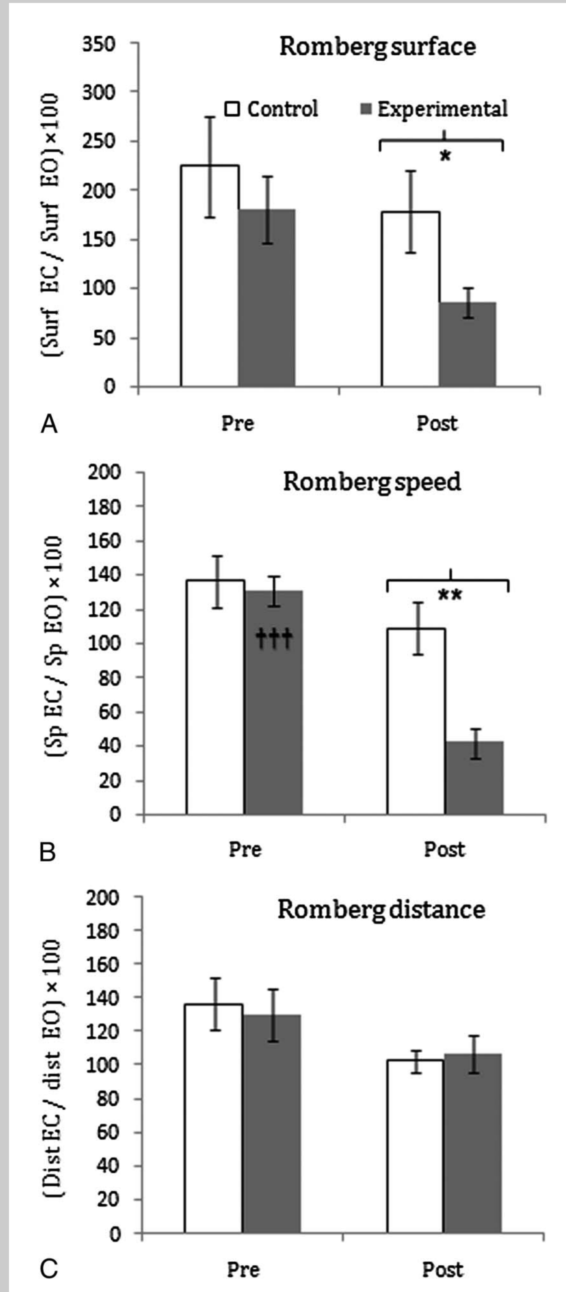

Figure 3. Romberg quotient about surface (A), speed (B), and distance (C). Pre- and postresults of the intervention in the experimental ($n = 20$) and control ($n = 24$) groups. Dist = distance; Sp = speed; Surf = surface; EO = eyes open test; EC = eyes closed test. *$p < 0.05$ and **$p < 0.01$ indicate differences between the experimental and control groups. †††$p < 0.001$ indicates differences about the same group.

intersubjects effects were observed in Romberg quotient about distance ($p = 0.061$ for the largest).

Balance and Gait Tests

The results of Tinetti and Berg balance scales are represented in Figure 4. After 12 weeks of proprioceptive treatment, we

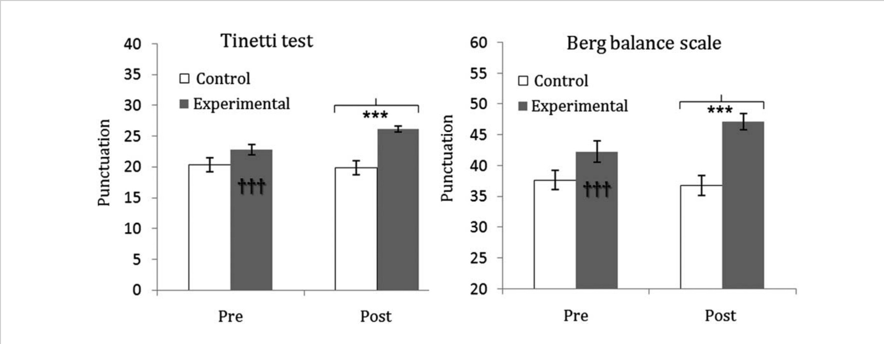

Figure 4. Average scores of gait (Tinetti test) and balance (Berg balance scale). Pre- and postresults of the intervention in the experimental ($n = 20$) and control ($n = 24$) groups. ***$p < 0.001$ indicates postmeasurement differences between the experimental and control groups. †††$p < 0.001$ indicates differences about the same group.

could observe a group main effect $F[1,41] = 10.74$, $\eta^2 = 0.208$, $p = 0.002$ and $F[1,41] = 11.69$, $\eta^2 = 0.222$, $p = 0.001$, respectively, in both tests. Post hoc analysis revealed that the experimental group obtained a significantly higher score (ps < 0.001) compared with the control group in Tinetti scale (26.2 vs. 22.9 points, respectively) and Berg balance scale (47.2 vs. 42.3 points, respectively). A group × time interaction was also observed for both Tinetti ($F[1,41] = 58.19$, $\eta^2 = 0.59$, $p < 0.001$) and Berg (F [1,41] $= 74.42$, $\eta^2 = 0.65$, $p < 0.001$) tests. After 12 weeks of proprioceptive training, the experimental group obtained significantly higher scores in Tinetti and Berg balance scales (ps < 0.001). There were no pre-post differences in the control group ($p > 0.05$). The results of the balance and gait tests after the study period were very similar in both tests, with a very high correlation coefficient ($r = 0.833$ [$p < 0.001$] and $r = 0.869$ [$p < 0.001$], in pre- and postmeasurements, respectively).

Discussion

This study was designed to evaluate the effects of 12-weeks proprioception training program in postural stability, gait, and balance in older adults (aged 65–90 years). Although our training protocol differs from those used in previous studies, our findings are consistent with these works, and our protocol seems to be effective in static and dynamic stability, leading to an improvement in gait and postural balance (8,11,25).

Falls, as mentioned above, are considered as one of the most important geriatric problems, with a high incidence, morbidity, and mortality. Several studies have described that the risk of falling can decrease with proprioceptive exercises in older adults, improving balance and preventing falls (17,26).

Balance control depends on a coordinated effort of the sensory systems (visual, vestibular, and proprioceptive systems) and many works have shown that older individuals have reduced balance control compared with young individuals (23). Stabilometric parameters, measured with force platforms, can predict falls in ≥65-year-old adults (24).

Based on our results, we can state that the experimental group improves in the medial-lateral displacements of the center of pressure with eyes open, supporting evidences from Brouwer et al. (7) who described an improvement in lateral stability after a physical activity program in older people. In eyes closed test, no significant improvements were observed in the experimental group, similar to other authors' observations, who didn't report any progression in both eyes open and closed tests, whereas we could observe this improvement in eyes open test (11).

In our analysis of anterior-posterior displacements of the center of pressure, the experimental group significantly improved in eyes open test, corroborating the results of Brouwer et al. (7), and under eyes closed condition. Contrary to our observations, Crilly et al. (11) couldn't find any improvement in both tests.

In older adult population, the ankle, hip, or mixed strategies are used to maintain upright stance (10). With eyes open, the ankle strategy (i.e., control using distal musculature) is the most frequently used strategy for maintaining balance because vision has a stronger effect on variability of sway in the anterior-posterior direction (37). Under eyes-open conditions, anterior-posterior movements are controlled by the vision and the proprioception improvement was observed in the mediolateral plane. Nevertheless, under eyes closed conditions, the subjects change to a hip strategy predominance, with an increased muscle activity in hip ab/adductors to improve mediolateral displacements, and anterior-posterior movements are more influenced by the proprioception improvement. Our findings are consistent with these observations, and after the proprioception training, we could observe significant improvements in XEO and YEC displacements.

According to our findings, the effect of proprioceptive training was also shown in Romberg quotients about surface and speed, with improvements of 58.6% and 60.3%, respectively. These results agree with some studies, which described that the improvement was produced by the increase of the speed of the motor responses (39), and the precision of movements (14); however, Romberg quotient about distance did not show any significant improvement. This may be because a different type of training should be required or some other factors may influence this variable.

Pérennou et al. (29) concluded that Tinetti test is a valid and reliable tool to evaluate the mobility and the risk of falling in older adults, and it is more effective than other tests, such as Berg scale test, but according to our results, both tests can be used to assess balance and gait, supporting evidences from Panella et al. (28) who determined that these scales provide a very good reliability about the risk of falling, balance, and gait.

Consistent with Iwamoto et al. (18) and Cakar et al. (8), our results show that proprioceptive training increases Tinetti and Berg scores (14.66% and 11.47%, ps < 0.001, respectively), and it leads to improved balance. On the other hand, Berg balance test score was the most significant result obtained by Badke et al. (1), and Pujiula et al. (31) could not describe any balance improvement after a multifactorial intervention program.

The scores obtained with the Berg balance scale seem to be appropriate, as a score of <45 was shown to be predictive of multiple falls in older adults (4). Thorbahn and Newton (40) also pointed out that this cutoff score predicted a person's use of an assistive device. Our results showed a significant increase in the Berg test score after proprioceptive training, placing the score higher than the cutoff score described in the studies mentioned above. Similar studies with exercise interventions in older people had shown improvement in balance, reaction time, strength, and flexibility (20).

Various studies have indicated that performance on combined agility/dynamic balance tasks is a predictor of recurrent falling (41), and physical exercise is an important factor in maintaining agility and balance (33). The large between-group effect size for the up and go test in our study suggested that agility and dynamic balance differed between the 2 groups after 12-weeks proprioception training program.

In conclusion, the results of this study suggest that a proprioceptive training program is associated with significant improvements in static posturography and functional balance, and it can reduce the risk of falling in people aged 65 years and older. A 12-week proprioceptive training program, with 30-minute sessions (2 days per week) leads to positive effects on lateral and anterior-posterior stability in older adults. There were also significant improvements in the surface and speed of the center of pressure (Romberg test) but not in the distance. The use of Swiss ball and BOSU as proprioceptive training tools showed highly significant improvements ($p < 0.001$) in both standing balance and fall prevention in adults older than 65 years.

Practical Applications

This study shows that, compared with a traditional training program, a 12-week proprioceptive training with Swiss ball and BOSU has positive effects on postural stability, gait, and balance in older people. This study also indicates that this proprioceptive training may be important in preventing falls and subsequent injuries in adults older than 65 years. It is recommended that this population should engage in long-term regular proprioception exercise to help them gain more health benefits in gait and balance capacity. Assessing balance may have important implications for improving the quality of rehabilitation services for older people with postural balance problems not only in home-dwelling population but also in older adults who are living in other settings. Standardized functional measures should be used to assess balance in the screening for potential fallers among older people.

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