Book Chapter

Are There Sex Differences in Balance Performance after a Short-Term Physical Intervention in Seniors 65+? A Randomized Controlled Trial

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Abstract

A systematic review and meta-analysis of studies demonstrate a relationship between sex and balance determinants in seniors, however still no study has focused on sex-related differences in static and dynamic balance performance after a physical intervention as primary interest. The aim was to investigate sex differences in the static and dynamic balance performance after a 4-week physical intervention based on yoga in seniors 65+. 500 participants (234 men, 266 women) were assessed with the Tinetti Balance Assessment Tool in pre-and post-testing. The experimental group (122 males, 140 females) underwent the intervention, while the control group (112 males, 126 females) ran their usual daily program. ANOVA model consisting of Subject factor (explaining the inter-individual variability), between subject factors Gender (men vs. women), Group (experimental vs. control), Age (< 75 years vs. ≥ 75 years of age) and within-subject factor Stage - after intervention (Stage 2) vs. before intervention (Stage 1) and a full set of between-factor interactions was used. For post hoc analysis, the least significant multiple comparisons were used. Results proved changes in static and dynamic balance scores after the intervention in experimental group compared to the control group, without any sex differences (static balance - effect size η_p^2=0.0135; dynamic balance - effect size η_p^2=0.0330). Differences were analyzed in both sexes in relation to age with a median of 75, when in men and women under 75 years of age were analyzed better performance results in static and dynamic balance compared to men and women older 75 years. But even in male and female seniors older 75 years, the performance in static and dynamic balance significantly improved after the intervention. An important result for practical application is that

the precision of movements responsible for static and dynamic balance performance can be significantly improved in both sexes of seniors 65+, in a relatively short time, in addition even in age 75+.

Keywords

Balance Improvement; Precision of Movements; Seniors 65+; Sex-Related Differences

Introduction

Balance performance represents an important prerequisite for independent activities in daily life of seniors 65+. In aging, deterioration of physical functions may slow down the movements and balance responses and generally the motor system as well [1-2]. It is very important in terms of fall prevention. In aging, 65+ falls rates are the highest among adults in all regions of the world [3-5]. Balance control changes with age, resulting in a postural instability. There are declared correlations between age and balance performance in seniors 65+. Examination of the relationship between balance and age among seniors living in senior houses proved that as age advances, the balance performance deteriorates [6-7]. Therefore, the question is to what extent of balance performance can be expected to improve after a physical intervention in correlation with increasing age [8-9].

Cross-sectional surveys suggest that some factors of balance performance may be sex-specific in the seniors over 60 years old. Men were characterized by a lower level of postural stability compared with women and worse performance when sitting down [10]. A systematic review and meta-analysis of the previous studies have demonstrated a relationship between sex and balance determinants in seniors; however, none have focused on sex-related differences in balance performance after the physical intervention as primary interest [11-12]. Other authors [13] declare that the influence of gender on balance is still controversial in seniors 65+. Using a modified Clinical Test of Sensory Interaction on Balance they declared that gender has

no effect on static balance abilities between male and female seniors.

Balance performance represents a multifactorial quality that can be probably effectively increased by exercise training means in both sexes of seniors. Therefore, it is fundamental to promote balance performance in form of physical intervention in aging, being that a negative effect on balance performance has been seen in the no-intervention control groups. The control groups of seniors which received no physical intervention, showed a decline in the ability to balance, suggesting that inactivity plays a pivotal role in seniors, in the mechanisms involved in maintaining balance [14-15]. Various studies have examined different kinds of exercise, from Pilates, stair climbing, to dancing and yoga in seniors 65+ [16-18].

A multicomponent physical intervention with yoga components seems to provide positive outcomes on the improvement of balance performance [19-20]. Yoga exercises may represent the adequate program for seniors´ balance development because they are slowly performed, with breathing improvement. Yoga exercises may counterbalance muscle imbalances and ensure adequate exercise load for the musculoskeletal system. Breathing, relaxation, and balance exercises result in movement control, soothe the nervous system, and promote flexibility [21-22].

For balance performance augmentation, there are declared results of a 4-week yoga intervention indicated that seniors' balance and range of motion on shoulder flexion and abduction improved in both sexes [23]. Similar physical intervention studies in seniors suggest positive effects on balance performance promotion after only a 4-weeks intervention [24-25].

The study is focused on sex differences of balance performance in seniors 65+. The aim was to investigate sex differences in the static and dynamic balance performance after a 4-week physical intervention based on yoga exercises. The physical intervention has been adapted so that seniors 65+ can participate safely while

still benefiting from the intervention. On the basis of the theoretical analysis, we hypothetically assume that completing the physical intervention will significantly affect the performance of static balance in both sexes of participants 65+ in the experimental group compared to the control group, and also significantly affect the performance of dynamic balance in both sexes of participants 65+ in the experimental group compared to the control group.

Materials and Methods

Material and Procedure

500 seniors aged 65+ (234 men with an average age of 74.5 SD±7.74; 266 women with an average age of 76.9 SD ± 7.23) selected by stratified randomized sampling from all the regions of the Czech Republic participated in the examination. While randomizing, equal or very similar number of participants for both groups were kept in the particular homes/centers. The participants were grouped into the Experimental group (n=162; 122 males, age average 72.8, SD±7.44, median 71 (67.0, 78.0); 140 females, age average 76.1, SD±8.03, median 76.0 (69.0, 81.0) and the Control group (n=112 males, age average 72.2, SD±6.54, median 71.0 (67.0, 74.0); 126 females, age average 72.9, SD±7.32, median 70.5 (67.0, 76.0).

Ethical approval was obtained from the Ethics Committees of the College of Physical Education and Sport PALESTRA in Prague and the Institute of Endocrinology in Prague expressing full agreement and conformity of the research with the requirements stipulated in the Declaration of Helsinki. All participants gave written informed consent. All of the participants signed up for the research voluntarily, which they also confirmed by signing the document in the medical record. An instructional interview regarding method measurements and exercise intervention was given to all the participants of the study. However, participants were not informed about the research purpose. The exclusion criteria for the involvement of participants in the experimental study were determined according to the White Book on Physical and Rehabilitation Medicine in Europe [26] and were as follows: (i) human to

human infectious diseases and bacillus carrier, (ii) all acute-stage diseases and conditions in which destabilization of health state can be reasonably expected, (iii) cachexia of various etiologies, (iv) malignant tumors, (v) active attacks or phases of psychoses and mental disorders with asocial manifestations or with reduced communication, (vi) 2nd and 3rd degree of urinary incontinence and stool incontinence. The standardized medical anamnesis protocol was performed by a physician using a standardized protocol specifically focused on the current health status of seniors, drugs, injuries, and surgeries [27]. Finally, the physician carried out the medical recommendation whether or not to include an individual into the study.

Investigation started with the assessment of body height, body weight, and body composition provided by an anthropologist with two assistants. Subsequently, a physiotherapist conducted an individual balance examination using the Tinetti Balance Assessment Tool. Each participant underwent all of the procedures in a single run. The obtained data was stored and protected according to the Regulation of the European Parliament and the Council of the EU 2016/679. After the pre-measurements, participants of the experimental group underwent the 4-week yoga based intervention, while the control group ran the standard daily routine program in their senior homes or centers. One to six days after the 4-week intervention, the post-measurements were performed in the same conditions [28].

Methods

Baseline Characteristics

Body height was measured using the Tanita Leicester Height Measure device (Invicta Plastics, Leicester, United Kingdom) with an accuracy of 0.1 cm. A tetrapolar multi-frequency bioelectrical impedance device InBody 230 (InBody, Seoul, South Korea) was used to gain basic body characteristics such as body weight, body fat percentage, and total muscle mass [29].

Tinetti Balance Assessment Tool

The Tinetti Balance Assessment Tool was used to measure the static and dynamic balance score [30]. The higher the score, the better the performance. The static balance test is assessed on the basis of observation of an individual's bodily behavior during sitting and standing positions and their changes which are defined by 9 items and the dynamic balance (gait) test is judged by 8 items that involve characteristics of gait manifested in an individual during a 4.5-m walkway, first at a usual pace, then at a rapid pace.

Intervention

The 4-week intervention in the experimental group was focused on body posture and balance control, flexibility, muscle strength, breathing, and release. The exercises were carried out according to the Yoga in Daily Life System [31], without contraindications for the seniors, whilst sitting on a chair or standing by a chair, including: Pulling arms up, Turning the shoulders, Leg stretch, Hamstring Stretch, Shoulder stretch, Fingers stretch, Toes stretch, Bottom lift, Knee bends, Forward band, the Balance exercises standing behind a chair with support, Stand on one leg, diaphragm breath, modified "cat pose" breathing, "lion grimace" breathing, exercises to relax the muscles of the face and neck, vibration exercises with vibrational effects in the diaphragm, lung and brain areas, etc. The intervention protocol always included a warm-up and cool-down phase. Each week of the provided intervention included a different motivation motto for the participants and a different package of exercises (Week 1: "You are never alone", Week 2: "Change is always possible", Week 3: "Movement is life", Week 4: "Enjoy life and every moment") [32-33]. Always once per week, the main training lesson lasting 90 minutes was conducted with 10–12 participants under the guidance of a coach and two assistants. After this main training lesson, each participant received an educational sheet with exercises overview for the concrete week. During the week participants repeated the learned exercises daily for 30 minutes under the supervision of the assistants.

Statistical Analysis

Power analysis was set as follows: power > 0.80 (beta < 0.2) for alpha < 0.05 and to test whether the analysis is not underpowered. ANOVA model consisting of Subject factor (explaining the inter-individual variability), between subject factors Gender (men vs. women), Group (experimental vs. control), Age (< 75 years vs. ≥ 75 years of age) and within-subject factor Stage (after intervention (Stage 2) vs. before intervention (Stage 1) and a full set of between-factor interactions was used. For post hoc analysis, the least significant multiple comparisons were used. To eliminate skewed data distribution and heteroscedasticity, the original data was transformed to attain symmetric distribution in dependent variables and, at the same time, to stabilize the variance (attaining homoscedasticity), by a power transformation, as described in detail previously [34]. After performing the statistical tests, the data was then retransformed into the original scale, using a recurrent formula. A robust Mann-Whitney test was used to evaluate the differences between the experimental and control groups at the beginning of the trial. The NCSS 12 statistical software from (Number Cruncher Statistical Systems, Kaysville, Utah, USA) was used for ANOVA testing and power analysis and the statistical software Statgraphics Centurion 18 from Statgraphics Technologies, Inc. (The Plains, Virginia, USA) was used for power transformations.

Results

Baseline Characteristics of Subjects

To test the effectiveness of the applied physical intervention, a randomized selection of subjects was conducted. Our aim was to create comparable groups with a high comparable compliance before the intervention. As shown in Table 1, the subjects of the experimental group (n=262) and control group (n=238) did not differ in baseline variables.

Table 1: Baseline characteristics (shown as median with quartiles) of monitored men and women (n=500; Experimental group n=262; 122 males, 140 females; Control group n=238; 112 males, 126 females)

Variable	Control group	Experimental group	p-value*
Age (years) men	71 (67.1, 74.3)	73 (68, 80)	0.186
Age (years) women	70 (67, 76)	73 (68, 80)	0.034
Height (cm) men	174 (170, 178)	174 (170, 180)	0.790
Height (cm) women	164 (160, 168)	163 (158, 166)	0.409
Weight (kg) men	82 (73.8, 94.3)	85 (77.8, 90)	0.575
Weight (kg) women	73 (64, 81.2)	71.4 (62.5, 83)	0.487
Body fat (%) men	26 (22, 35)	26 (22, 33.3)	0.838
Body fat (%) women	33.5 (30, 42)	35 (27, 45.2)	0.959
Muscle mass (kg) men	34 (29, 39)	35 (30, 40)	0.388
Muscle mass (kg) women	30 (25.3, 32.1)	30 (24, 32)	0.528
Static balance score men	14.5 (11, 16)	14 (10.8, 15)	0.394
Static balance score women	14 (11, 16)	15 (10, 16)	0.872
Dynamic balance score men	10 (9, 12)	10 (8, 12)	0.195
Dynamic balance score women	10.5 (9, 12)	11 (8, 12)	0.800
*Mann-Whitney test			

Intervention Effects on Static Balance Performance in Monitored Men and Women

The positive effect of the applied physical intervention on the static balance performance was significant in both sexes of the experimental group compared to the control group, where no significant improvement of the static balance performance was noticed in the post-measurements in both sexes of the control group.

Significant positive improvements of the static balance performance in participated men and women after the intervention were observed, as visible from the values of the statistical analysis, i.e., Group × Stage: F=5.5, p=0.02, Effect size η_p^2=0.0135, (Table 2), and from the Figure 1, part "I" Group x Stage.

Furthermore, a significant difference in the static balance performance between groups of seniors up to 75 years and over 75 years of age was observed, regardless of gender and type of group. Worse results in the static balance performance were demonstrated in the group of seniors 75+, i.e., Age: F=55, p=0.001, Effect size η_p^2=4.0353, (Table 2), as noticeable in the Figure 1, part "C", i.e., Age and part "J", i.e., Age x Stage.

Positive significant shifts in static balance performance are very similar for both men and women of the experimental group, as seen from Figure 1, part "L", i.e., Geder x Group x Stage.

Table 2: ANOVA model highlighting the dependence of the Tinetti static balance score on gender, group, age, and stage of the trial (n=500; Experimental group n=262; 122 males, 140 females; Control group n=238; 112 males, 126 females)

Dependent variable	**Tinetti static balance score**			
Factor/interaction	**F-ratio**	**p-value**	**β(p=0.05)**	**Effect size η_p^2**
Gender	0	0.871	0.947	0.0019
Group	0.7	0.396	0.865	0.0529
Gender × Group	0	0.847	0.946	0.0027
Age	**55**	**<0.001**	**<0.001**	4.0353
Gender × Age	1.8	0.181	0.733	0.1317
Group × Age	3.3	0.069	0.555	0.2445
Gender × Group × Age	0.1	0.731	0.936	0.0087
Subject	**29.9**	**<0.001**	N/A	30.1101
Stage	**26.5**	**<0.001**	**<0.001**	0.0651
Gender × Stage	0	0.946	0.949	0.0000
Group × Stage	**5.5**	**0.02**	0.353	0.0135
Gender × Group × Stage	0.1	0.825	0.944	0.0001
Age × Stage	0	0.851	0.946	0.0001
Gender × Age × Stage	3.6	0.059	0.527	0.0088
Group × Age × Stage	0.8	0.378	0.858	0.0019
Gender × Group × Age × Stage	0.3	0.593	0.917	0.0007

β(p=0.05) = 1-power, η_p^2 ~ 0.01, 0.06, and >0.14 represent small, medium and large effect size, respectively

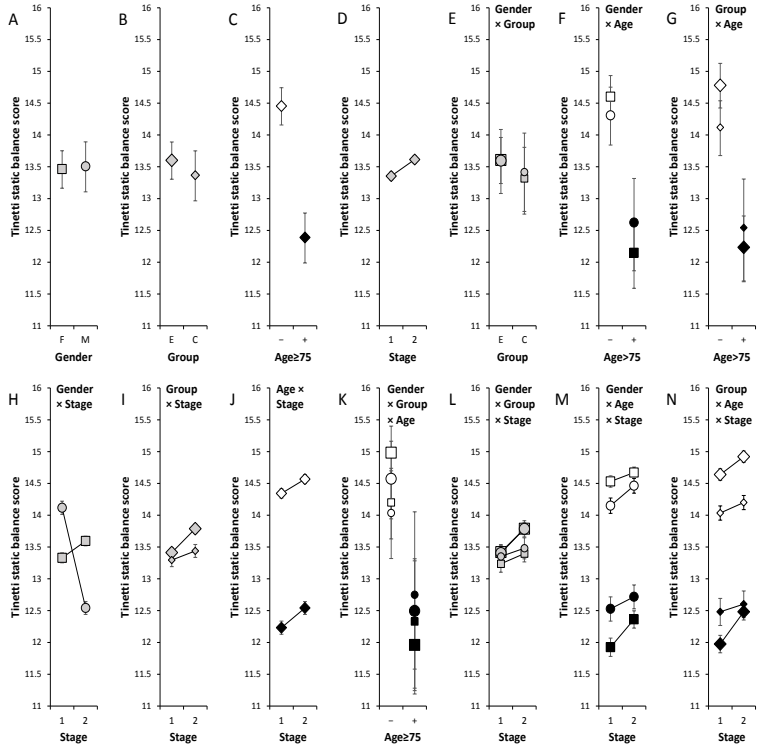

Figure 1: ANOVA model highlighting the dependence of the Tinetti static balance score on gender, group, age, and stage of the trial

The symbols with error bars represent the means with 95% confidence intervals. The male and female gender are symbolized by circles and squares, respectively, the experimental and control group was represented by greater and smaller size of symbols, respectively, the subjects with age < 75 years and those with age ≥ 75 years were signified by symbols filled by white a black color, respectively. For details please see the section Statistical analysis.

Intervention Effects on Dynamic Balance Performance in Monitored Men and Women

The positive effect of the applied physical intervention on the dynamic balance performance was also significant in both sexes

of the experimental group compared to the control group, where no significant improvement of the dynamic balance performance was noticed in the post-measurements in both sexes of the control group.

Significant positive improvements of the dynamic balance performance in participated men and women after the intervention were observed, as visible from the values of the statistical analysis, i.e., Group × Stage: F=13.4, p=0.001, Effect size η_p^2=0.0135, (Table 3), and from the Figure 2, part "I" Group x Stage.

Furthermore, a significant difference in the dynamic balance performance between groups of seniors up to 75 years and over 75 years of age was observed, regardless of gender and type of group. Worse results in the static balance performance were demonstrated in the group of seniors 75+, i.e., Age: F=38.4, p=0.001, Effect size η_p^2=2.6273, (Table 3), as clearly noticeable in the Figure 2, part "C", i.e., Age and part "J", i.e., Age x Stage.

Positive significant shifts in static balance performance are very similar for both men and women of the experimental group, as seen from Figure 2, part "L", i.e. Geder x Group x Stage, and from the part "M", i.e., Gender x Age x Stage..

Table 3: ANOVA model highlighting the dependence of the Tinetti dynamic balance score on gender, group, age, and stage of the trial (n=500; Experimental group=122 males; 140 females; Control group=112 males; 126 females)

Dependent variable	**Tinetti dynamic balance score**			
Factor/interaction	**F-ratio**	**p-value**	**β(p=0.05)**	**Effect size η_p^2**
Gender	0.8	0.36	0.85	0.0574
Group	0.2	0.696	0.932	0.0105
Gender × Group	0	0.955	0.95	0.0002
Age	**38.4**	**<0.001**	**<0.001**	2.6273
Gender × Age	0	0.937	0.949	0.0004
Group × Age	2.2	0.137	0.682	0.1518
Gender × Group × Age	0.1	0.747	0.938	0.0071
Subject	**27.8**	**<0.001**	N/A	28.0223
Stage	**13.4**	**<0.001**	**0.045**	0.0330

Gender × Stage	0.1	0.745	0.938	0.0003
Group × Stage	**13.4**	**<0.001**	**0.045**	0.0330
Gender × Group × Stage	0.4	0.554	0.909	0.0009
Age × Stage	0.1	0.711	0.934	0.0003
Gender × Age × Stage	1.6	0.204	0.755	0.0040
Group × Age × Stage	0.3	0.575	0.913	0.0008
Gender × Group × Age × Stage	1.6	0.206	0.756	0.0039

β(p=0.05) = 1-power, η_p^2 ~ 0.01, 0.06, and >0.14 represent small, medium and large effect size, respectively

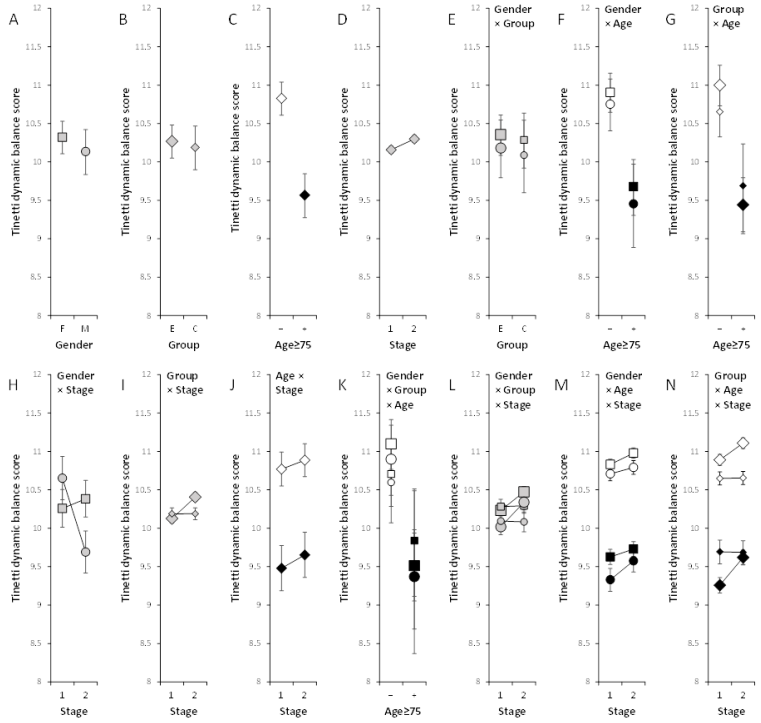

Figure 2: ANOVA model highlighting the dependence of the Tinetti dynamic balance score on gender, group, age, and stage of the trial

The symbols with error bars represent the means with 95% confidence intervals. The male and female gender are symbolized by circles and squares, respectively, the experimental and control group was represented by greater and

smaller size of symbols, respectively, the subjects with age < 75 years and those with age ≥ 75 years were signified by symbols filled by white a black color, respectively. For details see the section Statistical analysis.

Based on the results above, it can be stated that the hypothetical assumptions were confirmed, that completing the physical intervention significantly affected the performance of static balance in both sexes of participants 65+ in the experimental group compared to the control group and also significantly affected the performance of dynamic balance in both sexes of par-ticipants 65+ in the experimental group compared to the control group.

Discussion

The findings of our study show interesting results of significant changes in balance performance indicated in static balance performance and dynamic balance performance as well, after the intervention without any sex differences of monitored subjects in the age 65+. This may indicate the universality of the applied physical intervention with respect to both sexes. Furthermore, the results indicate high effectiveness of the applied physical intervention in terms of the possibility of static and dynamic balance performance optimization, in a relatively short period, although some authors [35-37] emphasize that in old age, the loss of muscle mass and thus muscle strength in women can reach a critical level earlier than in men, which can subsequently be reflected in the deterioration of postural balance and gait in women.

The main findings of the intervention effects on static balance performance in monitored men and women can be summarized as follows: (1) In both sexes of the experimental group, all measurements of static balance performance were significantly improved after the applied physical intervention; (2) In accordance with our hypothetical assumptions, it was found that already short-term physical intervention may lead to a significant increase in static balance of performance in seniors,

men and women, experimental group in comparison with the control group.

This finding corresponds with those from previous studies examining the impact of physical interventions on static balance measurements in seniors. For example, according to the studies [38-39] the authors stated that static postural balance training for both men and women 65+ must be developed in a controlled manner, under the supervision of a coach and assistants, to achieve significant progress in the static balance performance. They also mention that the question of whether performance development in static balance differs significantly between women and men has not been convincingly answered according to the fact that due to the performed physical intervention the static balance improved in both sexes, but the improvement was more pronounced in women compared to men. The aim of our study was not to primarily examine the relationship between the effectiveness of intervention with control and supervision, however, we believe that interpreted positive effects of supervised balance performance training are particularly pronounced and obvious. In accordance with that and on the basis of the realised physical intervention in our study, we may recommend to include supervised lessons in balance training programs in both sexes of the seniors 65+, in order to effectively improve balance and muscle strength in seniors, which is in line with the recommendations of experts who have dealt with this issue more deeply [40]. Of course, the biomechanical organic aspect of the analyzed result plays a significant role in male and in female balance performance. The results are also in line with the authors [41] stating that differences between women and men in terms of dynamic balance performance are increasing with age to the detriment of women.

Other authors [42-43] examined the effect of physical intervention training on static balance traits in seniors 65+ living in senior homes compared to seniors living in their own residences. In comparison, the training group in the senior homes showed a better improvement in their static balance performance (i.e. less postural swing and greater reach) than the group of seniors living in their own residences, undergoing

intervention within senior clubs. We may emphasize on the need for regular balance training in senior houses, using a short term physical intervention based on simple and safe exercises, for both sexes of seniors 65+ to maintain the optimization of the static and dynamic balance skills. Our study has shown that the applied physical intervention is feasible for seniors living in senior homes. Its application is real in the senior homes, including seniors with different types of disability as declared by the authors [44-45], when using a chair in the physical intervention focused on balance skills improvement was incorporated. The authors outlined that the motivation of seniors to absolve the intervention was high, which is in accordance with our study.

Finally, the authors [46] studied seniors who completed a 4-week physical intervention in a spa facility. They found an improvement in static and dynamic balance performance compared with physical balance development. The results of this study suggested that balance treatment may be a suitable exercise regimen to improve balance performance in healthy seniors 65+ in spa conditions. In accordance with the authors [47], therefore the interplay among the balance ability and psychosocial indices in relation to gender, age, and the individual specific of seniors should be taken into consideration.

The purpose of the presented study was fulfilled. We are aware of some limitations of the study. As a limitation may be the fact that the physical activity level of participants and story of falls were not evaluated before the intervention in the seniors 65+. Furthermore, despite all our efforts to follow the basic research methodology, it should be noted that the examined sample cannot fully reflect the general population of seniors aged 65+. Another hurdle is the lack of previous research studies on this topic with which it would be possible to compare the achieved results. We recommend further research to review the results. We also recommend for follow-up studies to monitor sustainability and stability of the results in the months following the intervention. The follow-up study should explore if the improvements are maintained in periods of 1-3-6 months after the intervention.

Conclusions

Completing the physical intervention proved changes in static and dynamic balance scores after the intervention in the experimental group compared to the control group, without any sex differences in seniors 65+. Differences were analyzed in both sexes in relation to age with a median of 75, when in men and women under 75 years of age were analyzed better performance results in static and dynamic balance compared to men and women older 75 years. But even in the age 75+, the performance in static and dynamic balance significantly improved after the intervention. The applied short term physical intervention program has proven to be safe and effective enough for seniors 65+.

An important result for practical application is that the precision of movements responsible for static and dynamic balance performance can be significantly improved in both sexes of seniors 65+, in a relatively short time, in addition even in age 75+.

To our knowledge, this is the first randomized trial to test a physical intervention based on yoga, investigating sex differences in the static and dynamic balance performance in seniors 65+. Findings indicate excellent feasibility and acceptability, although future studies, with larger sample sizes are needed to confirm the findings.

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