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BALANCE IMPROVING IN FEMALE SENIORS 65+ AFTER COMPLETING SHORT TERM INTERVENTION PROGRAM BASED ON YOGA EXERCISES

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Aim. The study is aimed to analyze the interplay among the static, dynamic and overall physical balance score with anthropometric determinants and psychosocial indices in relation to effects of the yoga intervention. **Materials and Methods.** The participants comprised 266 female seniors in age 65+ (mean: 76.9 SD ± 7.23), divided in experimental and control groups, participating voluntarily in the research procedure. For data collection diagnostic methods "Medical anamnesis", "Tinetti Balance Assessment Tool", "Health Survey SF-36" were applied. For statistics multivariate regression with reduction of dimensionality and orthogonal projection to latent structure and repeated ANOVA were used. **Results.** Before intervention the correlation analysis "Orthogonal projections to latent structures" proved that anthropometric predictors had a significantly positive impact on balance abilities in monitored female seniors, $p < 0.01$: Body height, Body weight, Length of the tibia; Length of the femur, Length of the ulna radialis, Girth of chest across mesosternale, Girth of the knee, Girth of the wrist. After the intervention significant improvement in static, dynamic and overall balance score in the experimental group was found. **Conclusions.** Optimal musculoskeletal robustness represents a positive predictor for the static, dynamic and overall balance. Completion of the yoga four-week intervention had significantly positively influence the results of the static, dynamic and overall balance in female seniors.
Keywords: *balance changes, falls prevention, female seniors, yoga in daily life.*

Introduction

Senior is defined as a person aged 65 and over, with determined rights on a pension, social security and healthcare [5–7]. Research conceptually based on a careful analysis of determinants of movement dysfunction of static and dynamic balance in senior age focused on the balance development in female seniors aged 65 is very actual. In the age after 65 the change in body composition is more significant, when lean body mass is decreasing, fat is increasing, the connective tissue becomes less elastic. Body weight and body mass index (BMI) with age usually rise to 7^{th}–8^{th} decennium. Then it occurs to the decrease. The ratio of muscle mass to fat is significantly influenced by lifestyle, especially of food intake, energy expenditure and strength training [4, 24]. From an anthropometric point of view, in both genders male and female, the shape of the chest changes, assessed by the transversal and antero-posterior diameters, and its circumference increases. Comparing the age of 20 and 65 from the view of body height, the difference represents five centimeters in males and nine centimeters in females approximately [2, 13].

Female seniors are characterized by potential susceptibility to fluctuations in hormonal levels and frailty. A risk of falling down is one of the main risks in seniors [7, 20]. Approximately 30% of seniors experience at least one fall per year, when in institutional care the percentage of such seniors is higher. One fall of ten falls ends with a fracture. One fifth of falls requires hospital medical care [7, 25]. Coping, balancing and harmonization strategies are associated with various forms of behavioral responses, particularly depending on the ability or inability to control the situation. There are some typical changes in the psychosocial area of seniors in the age of sixty five years old and over. These changes may include decreasing of cognitive function, decreasing of emotional instability, decreasing of ability to adapt to changes or new situations. Authors [5, 8] stress that negative emotions may play a role in the level of physical balance in female seniors with feelings of insecurity or fear [5, 8, 19]). The social environment is often perceived as a source of stress leading to agonist behavior. However, stress can also be alleviated by the various forms of social support available in the social environment. Successful coping strategies reduce physiological imbalance as measured by cortisol and catecholamine levels in the blood [11]. Stress does not necessarily have to come only from the outside. It can also come from within, due to the requirements to which female seniors are exposed, depending on the personality characteristics. A very significant phenomenon in female seniors is mood disorders, neurotic and anxiety disorders [11, 12]. There is a need for conceptual intervention, aimed at the psychosomatic balance habits in daily life of senior over 65 years old.

An important factor in balance management in female seniors is physical flexibility, namely the ability to bend, kneel, kneel and regain. This finding is consistent with published studies by [3, 4, 14, 15], which point to the significant positive impact of easy yoga exercises from the system Yoga in Daily Life [17] on functional balance of sympathetic and parasympathetic activity in the elderly, creating calm and maintaining adequate physical flexibility through dynamically performed exercises (sarvahita asanas) that improve the ability of muscle interaction and overall coordination in the walking and movement activities of seniors.

The intent of physical balance development in elderly is to realize experiences in psychosomatic balance training. The great impact of the yoga exercises effectiveness on the quality of overall balance and its development emphasized social factors which may interact physical balance [9, 18, 21, 23]. Yoga exercises represent an extremely wide range of different movement situations that share the common psychological and physical attributes of balance, such as synchronizing of movement with breathing, the slow movement sequences and releasing mind from fear and worry.

On the base of theoretical empirical analysis two hypotheses were established" H1: "Completion of the intervention will significantly positively influence the results of Tinneti static balance test in female seniors from the experimental group and H2 "Completion of the intervention will significantly positively influence the results of Tinneti dynamic balance test in female seniors from the experimental group.

Materials and Methods

Design and procedure, material

The research procedure included 266 female seniors in age 65 years and older (mean: 76.9 SD ± ± 7.23, median: 76.0, interval: 66.0, 84.0) of all Czech regions selected from senior homes and centers, participating voluntarily in the research procedure on the base of signed "Informed consent". By stratified random sampling, the female seniors were divided into an experimental group (140 females, mean: 76.1 SD ± 8.03; median: 76, interval: 69.0, 81.0) whose members completed the intervention and a control group (126 females, mean: 72.9 SD ± 7.32; median: 74.0, interval: 67.0, 78.0) whose members did not participate in the intervention. Research team provided measurements and intervention in constant conditions, morning time in a spacious room equipped with measuring devices. Investigation started with "Medical Anamnesis" provided by a physician, followed with "Functional anthropological examination" provided by an anthropologist with two assistants, followed by the test of balance according the "Tinetti Balance Assessment Tool" provided by a physiotherapist. After that senior had 15 minutes break and after completed the RAND 36 Short Form Health Survey (SF-36) with the possible assistance of a research team member. Obtained data were stored in a database, adequately protected, in compliance with the rules of personal data protection according to the Regulation of the European Parliament and the Council of the EU 2016/679 of 27 April 2016. In the experimental group after the PRE examination followed the four-week intervention. In the control group ran the standard routine daily program. Seniors selected in the control group lived in same senior homes as seniors from experimental group. After the four-week intervention, the POST examination was performed in all probands, in the same paradigm of methods. The Ethical committee of the research institution expressed full agreement with research aim and procedure in accordance with Helsinki Declaration principles.

Diagnostic methods

Medical Anamnesis: In cooperation with a physician each participant completed the standardized protocol focused on actual senior´s health, disability, medicaments consummation, past injuries, surgeries, etc.

Functional anthropological examination: The examination consisted of non-invasive anthropometry methods, using anthropometer, digital personal scale, Harpenden calliper, manual dynamometer type Collin. It was examined: body height, body weight, BMI, girth of chest across mesosternale, girth of waist, abdominal circumference, gluteal circumference, arm circumference relaxed, calf circumference maximal, biepicondylar width of humerus, biepicondylar width of femur, width of wrist, width of ankle, girth of thigh, girth of knee, girth of ankle; thickness of 7 selected skinfolds - calliper measurement type Harpenden (biceps, triceps, suprailiac, abdominal, subscapular, anterior thigh, calf medial). Body Composition Analysis using In-Body 230.

Tinetti Balance Assessment Tool: The tool exams static balance abilities and dynamic balance during the gait. The proband is to sit in an armless chair and will be asked to rise up and stay standing, in normal standing, then in standing with closed eyes, and then to keep standing balance while physiotherapist pushes against his sternum. The proband will then turn 360° and then sit back down. Next, the proband walks at a normal speed, followed by turning and walking back at a “safe” speed. Then the proband will sit back down. There are evaluated rise up and sitting down on the chair, keeping upright while sitting on the chair and during standing (open/close eyes, push on sternum), length and height of the steps, symmetry and continuity of the steps and straightness of the trunk during the walk [24, 26].

RAND 36 Short Form Health Survey (SF-36): The survay SF-36 is sensitive to physical, mental and social functioning in aging [28]. It consists of 36 questions grouped into categories: “Overall perception of health”; “Physical activity”; “Restrictions of physical activity”; “Restriction caused by emotional problems”; “Pain”; “Vitality, neurosis, depression”; “Social activity”; “Health change” [28].

Intervention

The intervention was focused on overall physical balance development and posture correction, the development of psychic harmony and optimizing of social interaction in senior age 65 and over on the base of yoga exercises without contraindications to the seniors (“Sarvahita Asanas”) to develop breathing, balance, flexibility and strength capacity, to move in sitting on chair or in standing, by the system “Yoga in Daily Life” of Maheshwarananda [17]. During the four-week intervention, once per week a main training lesson was carried out and trained exercises and elements were repeated then throughout the week on daily bases. Each participant received an educational sheet, which contains a simple guide and a symbolic attribute for the concrete intervention week. The week program also includes the motto: Week 1 “You are never alone”; Week 2 “Change is always possible”; Week 3 “Movement is life”; Week 4 “Enjoy life and every moment”. The main training lesson, in duration of 90 minutes, was conducted under the guidance of coach in small groups of 10–12 participants. In addition to the coach, 2–3 coach assistants were present to help to seniors complete exercises easily and correctly. The assistants after the main training lesson, during the week motivated seniors to repeat learned exercises.

Statistics

The multivariate regression with reduction of dimensionality such as the method of orthogonal projection to latent structure (OPLS) which are capable to cope with the problem of multicollinearity was used. The balance changes after the intervention were analyzed using repeated measures ANOVA. Statgraphic Centurion software, version XVI from Statpoint Inc., Warrenton, Virginia, was used for the statistical evaluation.

Results

Results of the balance predictors analyses

The results of the correlation analysis evaluated by the OPLS model are presented in Table 1. The analysis obtained significant variable influenced the performance in static, dynamic and overall balance of all monitored female seniors aged of 65 years and older before the intervention. As a significant negative predictor with respect to any type of investigated balance the age of female seniors was analyzed, when with age increasing can be predicted the increasing of risk to manage balance in different positions and movements. According [1, 10, 22] age may also predict the risk of possible falls associated with serious health complications. Correlation analysis by the OPLS showed that a total 8 anthropometric predictors have a significantly positive impact on the performance in any type of physical balance (static, dynamic, overall Tinneti balance score) in female seniors.

Probably, the frailty occurring more frequently in female than in male seniors may be a omplication in balance abilities. The followed anthropometric predictors were analyzed in female seniors at $p < 0.01$: Body height, Body weight, Length of the tibia; Length of the femur, Length of the ulna radialis, Girth of chest across mesosternale, Girth of the knee, Girth of the wrist.

Table 1

Results of correlation analysis of the interplay of anthropometric parameters and static, dynamic and overall balance score in the monitored female seniors evaluated by the OPLS model (n = 266)

	Variable	Predictive component, OPLS			
		Component loading	t-statistics	R^a	P value
	Age	–0.177	–11.58	–0.590	**
	Body Height	0.097	4.02	0.324	**
	Body Weight	0.021	0.85	0.068	
	Length of the tibia	0.113	6.37	0.329	**
	Length of the femur	0.181	7.82	0.524	**
	Length of the ulna radialis	0.079	4.92	0.239	**
	Girth of chest across mesosternale	0.082	5.70	0.263	**
	Girth of the knee	0.090	6.19	0.289	**
	Girth of the wrist	0.101	6.23	0.314	**
(matrix Y)	Tinetti Static Balance Score	0.574	29.12	0.709	**
	Tinetti Dynamic Balance Score	0.559	23.77	0.648	**
	Tinetti Overall Balance Score	0.599	27.22	0.718	**
Explained variability		47.9% (43.1% after cross-validation)			

R^a – component loadings expressed as a correlation coefficients with predictive component, *p < 0.05, **p < 0.01.

It seems that in female seniors aged 65 and over an optimal skeletal robustness represents a positive predictor for the static, dynamic and overall balance. In accordance with [2], it can be argued that a certain body robustness in good sense represents a significant advantage in maintaining the ability of static and dynamic balance in elderly and certainly plays an important role in falls prevention. It can be emphasized consistent with authors [15, 16], that appropriate regular physical activity and sport in youth and adulthood represents a long-term prevention, which positively develops athletic body type with adequate musculoskeletal development. Availability to different types of physical activities should be an important predisposition for balance ability in elderly.

Results of the intervention effects on balance

The application of the intervention proved to be effective as analyzed positive significant improving in the static balance in females of the experimental group: Group: F = 16.9, p < 0.001; Stage: F = 23.3, p < 0.001; Group × Stage: F = 0.7, p = 0.404; Subj (Group): F = 161.5, p < 0.001, Fig. 1.

In females of the experimental group there was also analyzed the significant improvement of the dynamic balance according to the Tinneti Balance Scale compared to the control group: Group: F = 0, p = 0.906; Stage: F = 11.5, p < 0.001; Group × Stage: F = 4.9, p = 0.027; Subj (Group): F = 38.4, p < 0.001, Fig. 2.

The significant improvement was analyzed also in overall Tinneti balance score in female seniors of the experimental group: Group: F = 0, p = 0.906; Stage: F = 11.5; p < 0.001; Group × Stage: F = 4.9; p = 0.027; Subj (Group): F = 38.4, p < 0.001, see Fig. 3. The Figs. 1–3 demonstrate a slight increase of the balance score also in the control group. We assume, that this phenomenon was caused by the "peer-action" of the female seniors of the experimental group. The females of the control group were selected from the same senior homes and could be influenced of experiences or examples of the females of the experimental group. However, the hypothetic possibility of a "peer-action" in the application of the new intervention method for seniors over sixty-five is an interesting by-effect of the research and should be further explored. These findings are consistent with [27].

Next, the significant improvement in the ability to perform moderate activities such as "ride a bicycle" in experimental group compared to control group was analyzed, SF-36, 3b: Group: F = 1.5, p = 0.225; Stage: F = 0.4, p = 0.556; Group × Stage: F = 0.9, p = 0.336; Subj (Group): F = 21, p < 0.001 (Fig. 4).

There was a significant improvement in the experimental group in the ability to climb the stairs one floor: Group: F = 57.3, p < 0.001; Stage: F = 1.9, p = 0.173; Group × Stage: F = 6.7, p = 0.01; Subj (Group): F = 30.3, p < 0.001, while in the control group of female seniors, this

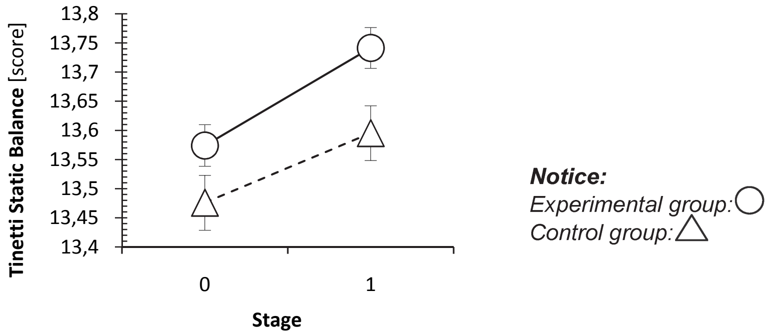

Fig. 1. Comparison of static balance changes in female seniors of the experimental group and control groups after the intervention (n = 266 females; experimental group = 140 females; control group = 126 females)

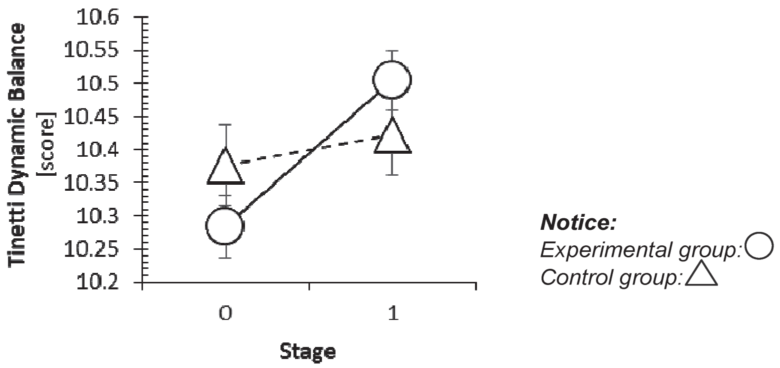

Fig. 2. Comparison of dynamic balance changes in female seniors of the experimental group and control group after the intervention (n = 266 females; experimental group = 140 females; control group = 126 females)

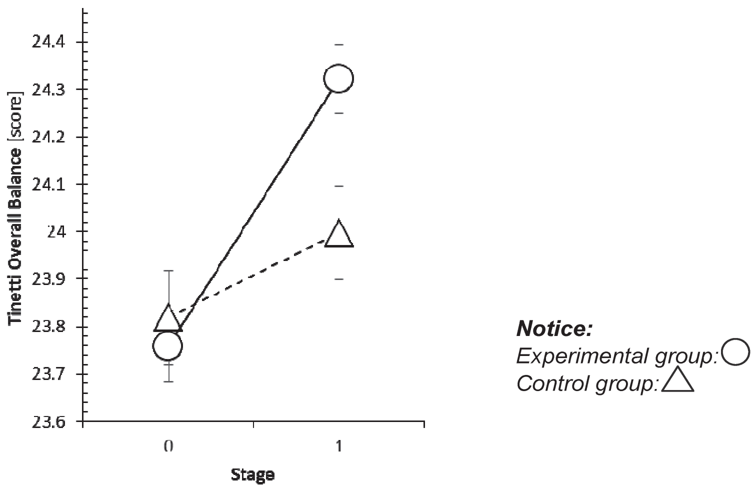

Fig. 3. Comparison of the overall balance score in female seniors of the experimental group and control group after the intervention (n = 266 females; experimental group = 140 females; control group = 126 females)

ability remained basically the same. Even females of the experimental group improved their ability to climb several floors after the intervention: Group: $F = 27.1$, $p < 0.001$; Stage: $F = 3.2$, $p = 0.073$; Group × Stage: $F = 1.8$, $p = 0.185$; Subj (Group): $F = 36.2$, $p < 0.001$.

Next significant improvements in the experimental group was found in body flexibility (forward bending, kneeling, etc.) (SF-36, 3F): Group: $F = 60.9$, $p < 0.001$; Stage: $F = 2.1$, $p = 0.153$; Group × Stage: $F = 1.2$, $p = 0.283$; Subj (Group): $F = 21.8$, $p < 0.001$, and in the improvement of walking for several hundred meters: Group: $F = 121.7$, $p < 0.001$; Stage: $F = 5.7$, $p = 0.018$; Group × Stage: $F = 0.8$, $p = 0.386$; Subj (Group): $F = 40.4$, $p < 0.001$. The results

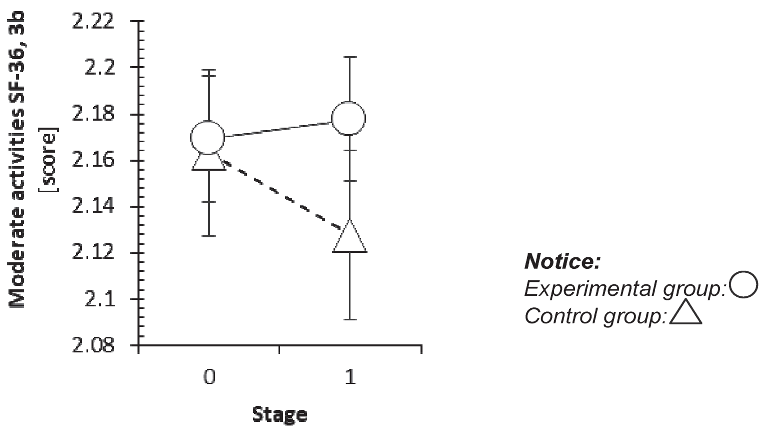

Fig. 4. Comparison of the ability to perform moderate activities in female seniors of the experimental group with the control group (n = 266 females; experimental group = 140 females; control group = 126 females)

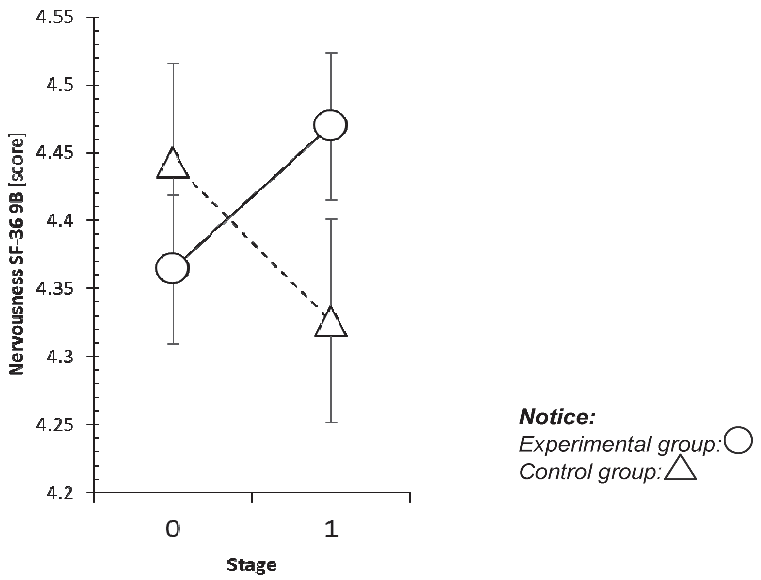

Fig. 5. Comparison of the Nervousness score in female seniors of the experimental group and control group after the intervention (n = 266 females; experimental group = 140 females; control group = 126 females)

also proved interesting *psychosocial changes* after the intervention in female seniors. Females of the experimental group experienced a decrease in subjectively perceived pessimism and sadness after intervention compared to females of the control group: Group: $F = 22.9$, $p < 0.001$; Stage: $F = 0.3$, $p = 0.596$; Group × Stage: $F = 4.3$, $p = 0.039$; Subj (Group): $F = 13.5$, $p < 0.001$. This result may be related to pain decreasing according to authors [3, 12], what represents another significant result in quality of life and health promotion of the monitored females of the experimental group after the intervention compared to females of the control group, where is analyzed a slight increase of pain, SF-36, 8b: Group: $F = 55.4$, $p < 0.001$; Stage: $F = 1$, $p = 0.326$; Group × Stage: $F = 0.4$, $p = 0.519$; Subj (Group): $F = 26.9$, $p < 0.001$.

Furthermore, there was analyzed a significant decrease of nervousness in the experimental group of female seniors, while in the control group the result was the opposite, item SF-36, 9b: Group: $F = 0.5$, $p = 0.489$; Stage: $F = 0$, $p = 0.907$; Group × Stage: $F = 5.7$, $p = 0.018$; Subj (Group): $F = 9.8$, $p < 0.001$, Fig. 5.

Conclusions

The analyzed results are valid and reliable to the aim of the research study. It is possible to conclude, that physical balance (static, dynamic, overall) of female seniors, aged 65 and over, interact with age, anthropometric factors and psychosocial factors.

On the base of presented results it is possible to declare that the hypothesis H1: "Completion of the intervention will significantly positively influence the results of Tinneti static balance test in female seniors from the experimental group" was verified, and that the hypothesis H2: "Completion of the intervention will significantly positively influence the results of Tinneti dynamic balance test in female seniors from the experimental group" was verified. Presented results show that female seniors are able to manage balance in psychosomatic consequences productively and efficiently, if an effective programing for them is given.

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УЛУЧШЕНИЕ БАЛАНСА У ЖЕНЩИН 65+ ПОСЛЕ КРАТКОСРОЧНОЙ ПРОГРАММЫ НА ОСНОВЕ ЙОГИ

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Цель. Данное исследование направлено на анализ взаимосвязи между статической, динамической и общей оценкой физического баланса с антропометрическими данными и психосоциальными индексами после занятий йогой. **Материалы и методы.** В исследовании участвовали 266 пожилых женщин в возрасте 65+ (средний возраст 76,9 SD ± 7,23), разделенных на экспериментальную и контрольную группы. Все участники выразили добровольное согласие с процедурой исследования. Для сбора данных применялись следующие диагностические методы: медицинский анамнез, тест Тинетти, опросник SF-36. Статистические расчеты осуществлялись с использованием многомерной регрессии с уменьшением размерности и ортогональной проекции скрытой структуры, а также с использованием дисперсионного анализа (ANOVA). **Результаты.** Корреляционный анализ «Ортогональные проекции скрытых структур» перед прохождением программы показал, что антропометрические предикторы имеют статистически значимое положительное влияние на способность к равновесию у наблюдаемых пожилых женщин, $p < 0,01$: рост, масса тела, длина голени; длина бедренной кости, длина лучевой кости, обхват груди (мезостернум), обхват колена, обхват запястья. После программы упражнений было обнаружено значительное улучшение показателей статического, динамического и общего баланса в экспериментальной группе. **Вывод.** Оптимальная опорно-двигательная устойчивость является предиктором статического, динамического и общего баланса. Четырехнедельный курс йоги оказал значительное положительное влияние на показатели статического, динамического и общего баланса у пожилых женщин.

Ключевые слова: *изменение баланса, профилактика падений, пожилые женщины, йога в повседневной жизни.*

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