



The effect of two different training programs on the body composition of senior women

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Abstract

Introduction: The aim of the study was to design an 8-week training program for a group of senior women ($n=33$) aged 71.03 ± 5.9 years, focusing on the development of aerobic endurance capabilities. Subsequently, we compared the results of the program with the one implemented in the same study group two years before. The study deals with the optimization of physical activity programs for elderly women and their effect on the composition of the body. **Material and Methods:** We monitored changes in the body composition of the elderly women applying the BIA method of bioelectrical impedance, using the In Body 230 device. The Jones & Rose [1] questionnaire was further used to supplement additional information about their current health condition and physical activity. **Results:** After having implemented the first training program, we observed significant improvement in certain body composition parameters, namely skeletal muscle mass ($p\leq 0.01$), body fat ($p\leq 0.01$), muscle mass of the right and left upper limbs and the trunk ($p\leq 0.05$), and body minerals ($p\leq 0.01$). We expected a similar effect after having implemented the second training program designed to develop aerobic abilities. Although in most senior women there were individual improvements in the monitored parameters, the changes did not prove statistical significance. **Conclusions:** Despite the fact that the second training program focusing on aerobic endurance elicited no statistically significant changes in body composition of the seniors, which we attribute to the regular and long-term sport activity of the study group, we consider both training programs to be optimal for the examined age group.

Keywords: senior women, training programs, body composition, bioelectrical impedance

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INTRODUCTION

There are physiological, psychological and social benefits of living an active life. It is important for the society to consider aging a natural phenomenon of life that concerns all of us. A positive attitude of the society towards the aspects of old age may have favorable influence on the quality of life of seniors [2].

A properly targetted training program may well help to slow down the process of aging by including appropriate mental and physical activity. We distinguish between physiological aging with its individual indications and aging which is manifested by pathological changes that result from illness or injury [3]. The relationship between physical activity levels and functioning during life stages have become an very important health related point [4-6]. Aging has various forms in individuals of the same age, i.e. aging in social, cultural and geographical terms, which are perceived as aspects of old age assessment [7].

Mineral loss and bone loss, resulting in osteoporosis, occur with age. It is caused by decreasing bone mineral density [8,9] Losses are primarily manifested in the bone tissue of the spine and later in the limbs. Minerals in bone tissue account for up to 65% of the overall bone mass. Of the total, 82-85% of minerals are bound in the bone tissue. In the first 50 years of life, the density of the compact bone of the spine in women decreases by 30% and the density of the spongy bone by as much as 65%. Natural bone remodeling slows down with increasing age, resulting in accumulation of bone microfractures and disturbed bone integrity [10]. As a result, fractures occur more commonly [11].

In the sixth and seventh decade of life, muscle strength decreases by about 15% and in the next decades by further 30% [9]. There are degenerative changes in articular cartilages accompanied by formation of osteophytes, and joint arthrosis that limit their mobility. The cause of decreasing body height is, inter alia, muscle atrophy and a gradual increase in imbalance between muscle groups, which may consequently lead to increased thoracic kyphosis [12, 13].

According to Máček et al. [6], after 65 years of age, the performance of the cardiovascular system is also decreasing, resulting in two-thirds of all heart attacks occurring at that period of life.

As stated in the National Program for Active Aging of the Slovak Republic by 2020, the ratio between the working age (71.5%) and the post-productive age (13.1%) citizens is favorable. By 2025, the average age is expected to increase to 42 years [14,15]. According the EU Commission's estimates, the number of elderly people will increase by 180% over the next 45 years (2005-2050) [16]. The average life expectancy both among men and women is rising. The basic principles of the National Program for the Protection of Older Persons support the rights of older people to have the conditions and opportunities to achieve physical, social and mental well-being [14,15].

For the seniors' quality of life, their functional motor skills are vital. Such can be maintained by their optimal level of regular physical activity. Physical activity designed for seniors should meet several conditions. For instance, moderate exercise intensity will help maintain the appropriate strength needed to perform basic functions necessary for life. Conversely, too much physical activity has a negative effect on bone density [17,18].

Currently, opinions on the nature, intensity, frequency and duration of physical activities in the elderly are changing fundamentally. Aerobic exercises are still considered fundamental to maintain functional aerobic fitness. In particular, cyclic movements within endurance exercises and health gymnastics are recommended to maintain the performance of the locomotive apparatus, such as joint mobility exercises, stretching, balance, rhythmic and dynamic exercises of adequate intensity [19, 20].

To achieve significant changes in body composition in seniors and consequently total body reflection, the expected duration of movement-based intervention programs is about 2 years [21].

In addition to strength training of moderate intensity, various combined programs are implemented in order to strengthen the large muscle groups, supposed to sufficiently maintain and develop active body mass and bone integrity, at a minimum frequency of 2-times per week [17], combined with the development of endurance, flexibility and balance-keeping capabilities.

Máček et al. [9] particularly recommend a combined strength and endurance program to influence the determinants of functional ability of seniors after 65 years of age, when their cardiovascular system performance is reduced.

When working with senior citizens, we must take into account the biological, social as well as psychological aspects of their lives in order to achieve a positive result in the selection of training programs that would suit them. The primary goal is to prevent causing worsening physical resp. psychological impacts on their health by implementing the exercises of our choice.

The aim of the study is to find out which of the two training programs is optimal for supporting appropriate composition of the body of senior women.

MATERIAL AND METHODS

Participants

The aim of the study was to create an 8-week exercise program for a group of senior females (n=33) aged 71.03 ± 5.9 years, focusing on the development of aerobic endurance abilities (Aerobic Training Program, hereafter ATP-2017).

Our study group comprised women actively participating in guided group exercises organized for seniors. The precondition for inclusion in the program was their good health and age over 60 years. We followed the need for a homogeneous performance set of females with adequate physical fitness, who provided prior consent to undergo the input and output measurements.

The program

The lessons, i.e. training units, within the ATP included mainly exercises aimed at developing aerobic endurance ability, further supported by exercises to develop flexibility and balance. Aerobic endurance exercise reduces the risk of mortality, caused particularly by cardiovascular disease, and improves physical fitness. Exercises supporting flexibility were included in the warm-up and in the final parts of every lesson, i.e. training unit. All participants were under medical supervision, aware of the responsibility for their own health, and they did not admit any changes to their lifestyle for the duration of the program.

The program lasted for 8 weeks, with a frequency of two 60-minute training units per week. The lessons were organized in the morning hours. Every training unit started with a 10-minute warm up, which included basic steps of an aerobics class, followed by 5-7 minutes of active stretching and balance exercises. The main part of the training unit consisted of a 20-25 minute aerobics workout including basic elements of low impact aerobics (120-130 BPM – speed of music), during which at least one foot always remains in contact with the floor. Low impact aerobics is characterized by reduced load on joints of the lower limbs, thus considered a suitable form of exercise for elderly women.

In teaching the aerobics choreography, we used the pyramid teaching method where the number of repetitions of the particular elements is gradually reduced to reach the final version of target choreography. In week 1 and 2, the participants performed one 32-count aerobics block - 8 repetitions, in weeks 3 to 5 it was two 32-count aerobics blocks - 4 repetitions, after week 5 we added a third 32-count block - 3 reps. In the following weeks we maintained performing the final number of blocks and repetitions.

In case the participants had difficulty performing the exercises, they were allowed to interrupt it at any time. The exercise unit was designed to meet several basic requirements: it had to be aerobic (heart rate maintained in the aerobic range of 60 - 70% HR_{max}). The exercise was complex but uncomplicated.

Examples of aerobics exercise blocks:

AE Block 1

- march/travel up + kick, march/travel back + kick (8 cts)
- mambo backwards (4 cts)
- reverse V – step (4 cts)
- lunge side single R-L + lunge double R-R (8 cts)
- 2x side to side (8 cts)
- the same elements opposite direction

AE Block 2

- 2x leg curl single, 1x double (8cts)
- grapevine L (16 cts)
- 2x V – step + arms (8 cts)
- the same elements opposite direction.

AE Block 3

- 2x step knee R, L (8 cts)
- 1x repeater step knee V- step (8 cts)
- 2x reverse V-step (8)
- mambo forward + pivot turn (8)

For various choreographies, following the principles of low impact aerobics, we altered the directions: walk forward, backwards, right, left, square, diagonal. We further engaged the upper limbs. We made sure that the arms were elevated above shoulders for a limited time only in order not to cause undesirable increase in blood pressure. The exercises were prepared in advance with regard to the physical fitness of the senior women.

After a 20-minute aerobics workout, a 15-minute standing strength and weight training followed. When practising the exercises, we guided the participants towards proper position and proper breathing as well as to consciously engage the deep abdominal muscles. The lesson ended with 10 - minute stretching aimed at developing flexibility and relaxation. Gradually, we added and modified the breathing exercises derived from yoga or the Pilates method. By alternating different movement patterns, we engaged as many muscle groups as possible.

We assumed that regular aerobic exercise by senior women during the period under review would improve their somatic indicators: body weight, BMI, skeletal muscle mass, body fat percentage, muscle mass of the right and left upper and lower extremities, trunk muscle mass, and the amount of body minerals measured by bioimpedance analysis.

In the next step, we compared the results of the program with Strength Endurance Training Program (hereafter SETP - 2015) [22] implemented in the same study group two years before. We also assumed that the group of senior women will achieve more significant changes in body composition after an 8 - week program based on heavy - weight strengthening exercises (using 6 kg metal bars), compared to the 8 - week aerobic endurance program. The detailed composition of strength endurance training program SETP is described in the work by Horbacz et al. [22].

In the course of designing both training programs for seniors, we referred to the standards and recommendations by several authors [23-25]. We created the programs to support skills and capabilities such as aerobic, coordination, balance, strength, stretching, proper breathing and relaxing. We adjusted the volume and intensity of load to the age and health condition of the participants.

Methods

We monitored changes in the body composition of seniors, after having participated in the training program, applying the bio-electric impedance (BIA) method using the In Body 230 device [26]. The device allows for reliable calculation of body composition. This method enables not only to determine body composition, but also to track development and changes in composition of the body.

We focused on the same selected somatic indicators as in the 2015 measurement: body weight (BW), body mass index (BMI), muscle mass (SMM), body fat mass (BFM), percentage of body fat (PBF), segmental muscle, the amount of minerals. Prior to the analysis, we instructed the senior women to follow the measurement protocol in order to get the measurement results as accurate as possible [22]. It is well-known that the accuracy of the results is greatly influenced by the observation of the measurement protocol and of the instructions for maintaining the validity of measurements using the BIA method [27]. Validity and reliability of the results of anthropometric analyses using the bioelectric impedance method (BIA), are now the subject of discussions. We often encounter conclusions recommending the use of the BIA method in applied research [28-31]. We consider the BIA method to

be reliable for the diagnosis of body fat and overall active body mass, in particular when monitoring the elderly. Measurements and questionnaires were completed in the morning hours.

Statistics

We used basic statistical characteristics (nonparametric Wilcoxon test) to process and evaluate the data. We reviewed statistical significance at $p < 0.05$ and $p < 0.01$. Processing and evaluation of the data obtained was carried out using the Statistica Version 12 statistical program and Microsoft Excel 2010. The basic statistical characteristics are shown in the tables and figures. The results obtained were subjected to logical-substantive analysis.

RESULTS

After having implemented the first SETP program, we found significant improvement in body composition parameters, namely skeletal muscle mass ($p \leq 0.01$), body fat percentage ($p \leq 0.01$), amount of muscle mass in right and left upper limbs as well as trunk muscle mass ($p \leq 0.05$), and the amount of body minerals ($p \leq 0.01$) (Table 1).

Following the implementation of the SETP program, we observed statistically significant increase in skeletal muscle mass (LBM) from an input value of 22.97 kg to 23.55 kg, which represents an increase by 0.55 kg ($p \leq 0.01$). On the contrary, in the percentage of body fat in the monitored group we found a statistically significant reduction from 36.21%, to the output value of 35.06%, representing a decrease by 1.15% ($p \leq 0.01$). When evaluating changes in muscle mass in the upper extremities and the trunk, we found a statistically significant increase, reflecting changes in the overall amount of skeletal muscle mass ($p \leq 0.005$). The amount of minerals in the experimental group increased by only 0.09 kg (Table 1).

We expected a similar trend after having implemented the second program (ATP), aimed at aerobic fitness. Although in most senior women there were individual improvements in the monitored parameters, the changes did not prove to be statistically significant (Table 2).

Table 1. Analysis of body composition SETP 2015 (In Horbacz et al. [21]).

Composition of the body (2015) (n=29)	Pre - program	Post - program	Change	p
LBM (kg)	22.97	23.55	0.58*	$p \leq 0.01$
BFP (%)	36.21	35.06	-1.15*	$p \leq 0.01$
RMM (kg)	2.19	2.27	0.08	$p \leq 0.005$
LMM (kg)	2.16	2.23	0.07	$p \leq 0.005$
TMM (kg)	19.17	19.60	0.43	$p \leq 0.005$
MRL (kg)	3.00	3.09	0.09	$p \leq 0.001$

Legend: LBM - lean body mass; BFP - body fat percentage; RMM, LMM - right/left segment muscle mass; TMM - trunk muscle mass; MRL - amount of minerals in overall body composition. *statistically significant differences

Table 2. Analysis of body composition ATP 2017

Composition of the body (2017) (n=33)	Pre - program	Post - program	Change	p
LBM (kg)	23.08	23.33	0.25	$p \leq 0.05$
BFP (%)	37.44	36.77	-0.67	$p \leq 0.05$
RMM (kg)	2.29	2.27	-0.02	$p \leq 0.05$
LMM (kg)	2.19	2.22	0.03	$p \leq 0.05$
TMM (kg)	19.63	19.69	0.06	$p \leq 0.05$
MRL (kg)	3.05	3.09	0.04	$p \leq 0.05$

Legend: LBM - lean body mass; BFP - body fat percentage; RMM, LMM - right/left segment muscle mass; TMM - trunk muscle mass; MRL - amount of minerals in overall body composition. *statistically significant differences

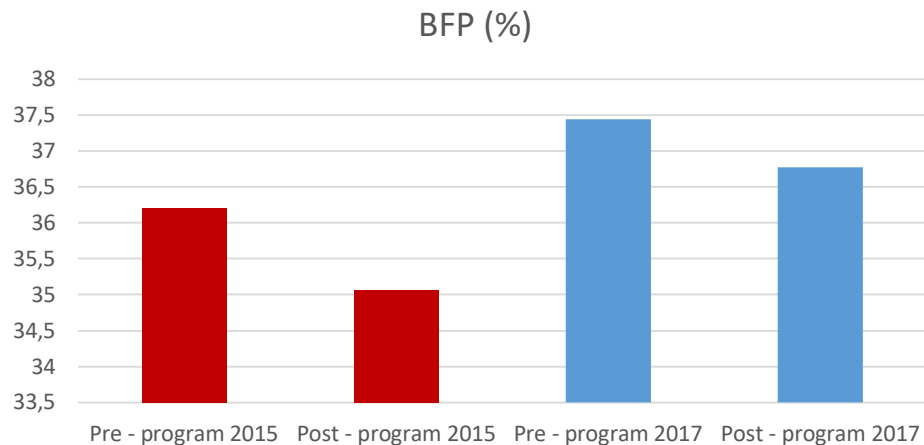


Figure 1 Percentage of body fat in seniors before and after accomplishing the training programs in years 2015 and 2017. Legend: BFP - body fat percentage (8 - week SETP, 8 - week ATP)

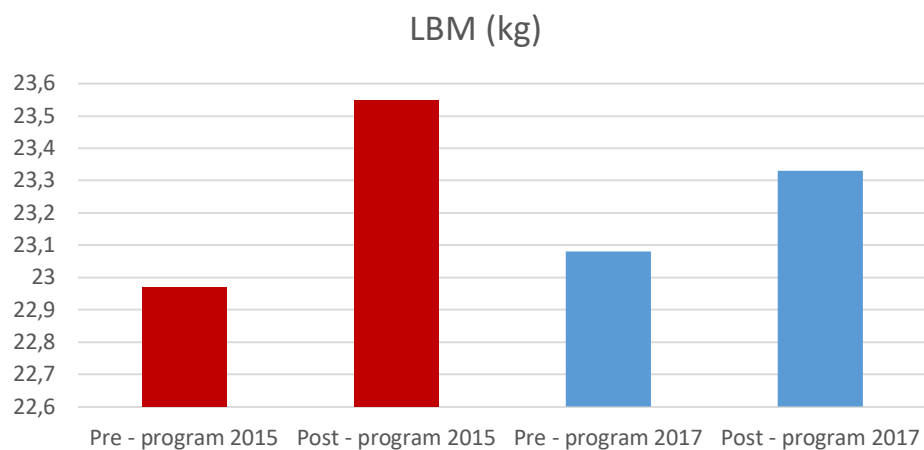


Figure 2 Body muscle weight in senior women before and after accomplishing the training programs in years 2015 and 2017. Legend: LBM - lean body mass (8 - week SETP, 8 - week ATP)

We compared the results of the seniors' body composition measurements after accomplishing the 8-week SETP (2015) with those recorded after undergoing ATP (2017) of the same length. The average SETP body weight (hereafter BW) input value was 67.08 kg and the output 67.57 kg. The average ATP input BW was 68.38 kg and the output 68.35 kg. Average BMI values in the SETP group were 26.47 kg/m² and the output 26.50 kg/m². Average BMI values in the ATP program group were 26.32 kg/m² and the output 26.33 kg/m².

At the start of SETP, 13 women fell into the normal BMI category of up to 25kg/m², while at the output measurements there were 15 women. BMI values suggested class 1 obesity in 4 women on the input side, while only 3 at the output. Only one woman fell into the category of class 3 obesity at both the input and output measurements. Out of 29 senior women in the group (2015), 14 were categorized overweight.

In ATP, out of 33 women in the group (2017) 13 seniors fell into the normal BMI (25 kg/m²) group on the input side, counting two more at the output. Regarding BMI values, 3 women were classified suffering class 1 obesity both at starting and completing the program. Of the 33 women (group 2017), similarly to the 2015 program, 14 seniors fell into the slightly overweight group.

The average input body fat percentage (BFP) at SETP, measured by InBody 230, was rated 36.21% (Figure 1), corresponding to 24.77 kg of fat in a female weighing 67.08 kg. Changes in BFP were checked both on the input and output of SETP. BFP values recommended by the InBody 230

standards (18-28%) were observed in 6 women (20.7%) at the input measurement and in 7 (24%) on the output side. Such result shows excess BFP in seniors participating in our research.

In the ATP program, BFP values recommended by InBody 230 (18-28%) standards were found in only 2 women (6%) both at the input and output. The result shows excess BFP in 94% seniors of the research group. In implementing SETP, the percentage of body fat (BFP) proved a statistically significant decrease from 36.21% to 35.06%, representing a change of 1.15% ($p \leq 0.01$) (Figure 1, Table 1). We did not find any significant differences in the other body composition parameters, which could have been caused by the small number of women in the study. In ATP, the decrease of body fat percentage (BFP) by 0.67% (Figure 1, Table 2) in the monitored group did not present a statistically significant reduction (from input 37.44% to output 36.77%). Surveys conducted among seniors have shown that the amount of body fat generally increases up to the age of 60, and in the years to come the changes are minute or none [29,30]; We observed similar tendencies in both of our training programs. The average input skeletal muscle mass (LBM) of our SETP group was 22.97 kg, and the output value 23.55 kg, representing 34.23% and 34.84% of the average body weight. The average input skeletal muscle mass (LBM) of our ATP group was 23.08 kg, and the output value 23.33 kg, which represents 33.75% and 34.13% of the average body weight.

These results underline the current scientific knowledge regarding changes in seniors elicited by strength-endurance and aerobic training programs causing changes in their body composition. Via implementing our ATP program, we achieved a reduction in body fat percentage and an increase in muscle mass in most senior females of the study group, which can be considered a positive phenomenon, although the changes were not statistically significant. When evaluating muscle mass changes in upper limbs, lower limbs and the trunk, as a result of involvement in SETP, we found a statistically significant increase reflecting changes in the total amount of skeletal muscle mass ($p \leq 0.005$). Similar results were reported by Milton et al. after a 4-week training program, improving the strength in lower and upper extremities, aerobic endurance, dynamic balance, and flexion of the upper limbs in seniors. [34].

At ATP output measurements, we found a minimum increase in the average amount of muscle mass. Upon accomplishing the 8-week SETP program, we found significant improvement in the amount of body minerals, a finding supported by another study [35] listing physical activities that burden the skeleton with overall body weight (fast walking, dancing, gymnastics, etc.), considered to be effective ways of increasing bone mass. In the ATP program, we did not see significant improvements in this respect.

As according Ozega et al. [36], increase in bone mineral density is observed at slight overweight, attributable to higher mechanical load. In elderly women after climax who are slightly overweight, a decrease in osteoporosis and a slowdown in the rate of bone mineral density are noticeable.

DISCUSSION

Within SETP performed among senior women, we observed statistically significant changes in most body composition indicators, namely in the amount of skeletal muscle mass, in body fat percentage, muscle mass of the right and left upper limbs and the trunk, and in the amount of body minerals.

In the identical experimental group of senior females researched again with a two-year delay, this time having undertaken an 8-week aerobic program (ATP), we found improvement in values of body composition; However, these did not prove statistically significant. Despite the finding that the second training program, focused on aerobic endurance, did not elicit significant changes in the body composition of the seniors, who participated in regular and long-term sporting activities, we consider both training programs to be optimal for the researched age category. Kalvach et al. [13] indicated that a more significant parameter to consider is the changing body composition, when fat decreases and muscle mass increases, as it was demonstrated also by our strength endurance training program (SETP). Maintaining muscle mass, along with a potential increase in the strength of large muscle groups, leads to improvement in motor skills and consequently also to maintaining autonomy of the

individual and his or her better quality of life [9,37]. On the other hand, as stated by Kutáč [38], the increase in body fat often occurs at the expense of decreasing muscle mass, which adversely affects the performance of the individual and reduces his physical fitness.

The duration of the 8-week program was not sufficient to induce fat reduction in all participants [17] as was the case with our two training programs for senior women. In addition, aging leads to changes in energy metabolism, resulting in excessive body fat deposition and a higher rate of significant energy savings during exercise [39,40]. These factors considerably slow down the effectiveness of regular physical exercise aimed at reducing body weight, compared to the efficiency of similar sport activity in a group of younger individuals.

CONCLUSION

We approve of the declaration by Bunc and Stilec [17], who emphasize the importance of locomotor activity in elderly women. The aforementioned authors monitored 90 to 180 minutes walk performed by senior women for a period of 12 months, after which a significant decrease in body weight and a decrease in body fat percentage were observed.

Following our 8-week aerobic program (ATP), there were no statistically significant improvements in body composition, namely in the amount of skeletal muscle mass, percentage of body fat, muscle mass of the right and left upper limbs, in muscle mass of the trunk and in the amount of body minerals.

On the contrary, according to expectations, after having accomplished a strength-endurance program (SETP) the group of senior women achieved more significant changes in body composition than undergoing an aerobic-endurance program (ATP). After SETP, we found improvements in body composition parameters: in skeletal muscle mass ($p \leq 0.01$), body fat percentage ($p \leq 0.01$), in right and left upper limbs muscle mass and trunk muscle mass ($p \leq 0.005$), and in the amount of body minerals ($p \leq 0.001$).

Based on our findings and years of experience with the implementation of training programs for seniors, we have formulated the following recommendations for practice:

1. Implementation of a physical strength-endurance training program with a frequency of twice a week is considered sufficient to improve the body composition parameters of seniors.
2. Despite the statistically insignificant changes elicited by the aerobic exercise program, we consider this type of program to be suitable and sufficient to achieve changes in body composition parameters in seniors
3. We recommend to incorporate to the seniors' training programs aerobic and strength training exercises, with or without weights, in order to engage stabilizing muscles and muscle groups of the upper limbs in particular and lower limbs.
4. We recommend both training programs as suitable complements for improvement, respectively maintaining muscle mass in elderly women over 60 years of age.
5. During training units for seniors, it is essential to adhere to basic principles: correct starting position, precise movement, cooperative action between abdominal muscles and pelvic floor muscles, and proper breathing.
6. Ensure a more frequent body composition measurement and testing the seniors' motor abilities.

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