Original Article

Does 12-Week Aerobics Training Influence Body Composition in Middle-Aged Women? -

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INTRODUCTION

In recent years, there has been a growing interest in the composition of the human body, particularly the amount of body fat, the mass of muscle and water content in the body. Attention is being paid to the correct proportions of these ingredients [1-3]. In medicine, it is very important to determine the composition and density of the body, which plays a role in the formation of many vital functions of the human. The body composition is related to the type of metabolism, the body's need for energy and various nutrients, as well as the dosage of drugs in medical therapy. Studies of body composition in combination with the analysis of hormonal balance become an important element not only in the assessment of the risk of developing diseases associated with obesity but also in their prevention and treatment (diet, exercise/workout) [4]. In competitive sports, knowledge of body tissue ingredients proportions is essential to determine the morphological characteristics of the athlete. The ability to achieve excellence in sport depends on this information [5-8].

An excessive amount of food intake and lack of physical activity will result in positive energy balance, which in turn leads to an imbalance of the basic body components (fat, lean body mass, water compartments) [9,10]. These changes are the cause of dangerous diseases of a modern man, especially for middle-aged women. Additionally, everything above shows that metabolic processes are slowing down leading to increased body fat, which in turn affects not only the mood but also increases the risk of metabolic diseases (including diabetes) [11-16]. Hence, this makes it more satisfying that women of this age are increasingly consciously choosing a physical activity in order to prevent unfavourable changes in their bodies. Especially fashionable in Poland is currently various fitness clubs offering a wide range of exercises adjusted to age and fitness. Among these offers, the most popular is "aerobics", i.e. gymnastic exercises of varying difficulty to the music accompaniment. However, in most cases, such an effort is undertaken by chance and does not cause the desired effects (e.g., no reduction of body fat). It follows that even the best knowledge of different exercise techniques without knowledge of changes in the body under the influence of the exercise will not ensure the achievement of the goal. Therefore, the ability to monitor (interpret) changes in body composition should be included in the training process not only for athletes but also for people undertaking exercises for health. Also, there is a need to examine the impact of different types of exercise, especially those undertaken by women in different activities (aerobics, jogging, Nordic walking, swimming, etc.) on their body components. Results of such analysis would allow planning the training process with the possibility of modification at each stage so that it would end with the expected outcome (e.g. reduction in weight).

The primary objective of the presented studies was to assess the impact of the 12-week aerobics training (including 3 sessions per week, 60 minutes each) on body components in women aged 35-50 years. It was assumed that the primary goal of the work will be achieved by answering the following questions: 1) Will the 12-week aerobics training cause changes in the composition of the body in the examined women? and 2) What is the direction and significance of changes caused by the 12-week aerobics training?

MATERIALS AND METHODS

Participants

The experiment included 23 females aged 35-50. The examined women did not actively practice any sports. They only participated in recreational "aerobics" and did not use any diet which can cause reduced body mass. The same procedure has often been used for work on similar topics [17-19]. The experiments were approved by the Ethics Committee at the University of Physical Education in Warsaw (SKE 001-37-1/2007).

Information (sex, age and health requirements) about the planned experiment was published in social media and local newspapers about 1.5 months before it began. During this time, 50 applications were received. 2 weeks before the start of the study, at a meeting with potential participants, detailed assumptions of the experiment were presented and participants were given a questionnaire to complete. A week before the start of the experiment, a meeting was organized with women who decided to take part in it (n = 48). The participants were informed about the purpose and methods of the experiment and about the right to withdraw at any time during the experiment. Participants agreed to participate in the experiment in writing. Based on the received data, women were disqualified from the groups if they reported the use of any drugs (even vitamins in large transactions), alcohol (ethanol) consumption above 2 drinks per day, smoking and disturbances in the menstrual cycle. Finally, there were 42 women who could be qualified for the experiment.

Recruited women were randomly assigned (the participants were drawing lots) to an exercising group (EG, n = 13) or a non-exercising
group (NEG, n = 10). EG and NEG groups were divided into the following groups: EP – exercising women with proper weight (n = 9), EO – exercising overweight women (n = 4), NEP – non-exercising women with proper weight (n = 5) and NEO – non-exercising overweight women (n = 5). BMI ≥ 25 kg/m² was used to define overweight. Participants’ characteristic was shown in table 1.

It is worth noting that at the beginning of the experiment the EG group consisted of 21 women, but the principle was adopted that only those women who attended at least 95% of all 36 training sessions would eventually become EGs (n = 13). The 8 women missed more than 5% of training sessions for various reasons (health problems, work, personal reasons etc.). Additionally, 11 women from the control group (NEG) were excluded in the course of the experiment due to some participants taking up some physical activity or because of significant changes in their daily diet.

METHODS

Body height was measured by a generally accepted method (accuracy - 0.1 cm). Body mass was determined using an electronic balance (Tanita BF-666, Japan, accuracy - 0.05 kg). Body mass index - BMI [kg/m²] has been calculated based on the following formula: 

\[ BMI = \frac{m}{h^2}, \]

where \( m \) – body mass [kg] and \( h \) – body height [m].

Waist/Hips Ratio – WHR = \( \frac{w}{h} \), where \( w \) – waist circumference [cm] and \( h \) – hips circumference [cm]. Body compartments: Total Body Water (TBW), Extracellular Water (ECW) and Intracellular Water (ICW), Fat Mass (FM), Fat-Free Mass (FFM) and Muscle Mass (MM), and Basal Metabolic Rate (BMR) were measured. Bioelectrical Impedance Analysis (BIA) was used (body composition analyser with proper software, Akern BIA-101, Florence, Italy). The examination was drawn after 12 hours overnight fast. Participants were informed about proper preparation before the examination (without any alcohol drinks 48 hours and any drinks (even tea or coffee) 2 hours before analysis). That kind of preparation is recommended as a routine standardization technique before BIA measurements [19].

Assessment of the physiological cost of the effort was based on Heart Rate (HR) registration using sport-testers (S610, Polar Electro Oy, Finland). Blood samples collected from fingertips before and after the effort were used to determine the concentration of lactic acid (LA), following the Lange approach (Germany).

Exercise protocol

The examined women took part in the 12-week aerobics training (training session 3x per week, for 60 min.) conducted by a person qualified (a coach) to do the program prepared for untrained persons. The program of the 60-minute session consisted of warm-up - 10 minutes, aerobic part - 35 minutes, strengthening part - 10 minutes and the closing part - 5 minutes. A single training session was conducted according to the scheme, which has been described in detail in our previous work [20].

The intensity of effort in the main part ("aerobics" - Figure 1) of each session was 145 bpm on average. The intensity in the same part of each session was an average of 160 bpm after 6 weeks of training.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EG, n = 13</th>
<th>NEG, n = 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>39.8 ± 6.6</td>
<td>43.5 ± 8.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.6 ± 5.0</td>
<td>163.9 ± 7.7</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>65.7 ± 9.2</td>
<td>67.2 ± 9.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.3 ± 3.5</td>
<td>25.1 ± 3.7</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>76.2 ± 8.7</td>
<td>79.9 ± 6.7</td>
</tr>
<tr>
<td>Hips (cm)</td>
<td>99.5 ± 5.1</td>
<td>101.3 ± 6.5</td>
</tr>
<tr>
<td>WHR</td>
<td>0.76 ± 0.05</td>
<td>0.79 ± 0.05</td>
</tr>
</tbody>
</table>

Figure 1: Heart Rate (HR) during 60-minute exercise of single session of “aerobics”; test 1 – at the beginning of experiment (1st week), test 2 – at the end of the experiment (12th week); I – warm-up part, II – the main part – aerobics, III – strengthening part and IV – closing part.
The trainer monitored the correctness of the exercises performed (number of repetitions, duration of exercise). Additionally, the women checked their own hear rate in every part of the session by the palpation method. Checking the heart rate allowed us to monitor the efficiency of exercises performed at each stage of the session.

Statistical analysis
The obtained results were statistically analyzed using Statistica, version 6.0. For the studied parameters, the average values were calculated as results ($\bar{x}$) with Standard Deviations (SD) and expressed in the form $\bar{x} \pm SD$. As statistically significant the changes at the level of $p < 0.05$ were assumed. The fulfillment of the principle of randomization was met on the eligibility of studied women to the experimental and control groups using one-way ANOVA analysis of variance, with which there were no statistically significant differences between parameters such as body mass ($F = 0.22$, $p < 0.05$) and parameter BMI ($F = 0.22; p < 0.05$). After checking the coefficient of variation (%CV) the log10 data transformation was performed for the checked parameters in order to normalize their distribution. Mann-Whitney U test analysis was conducted within groups: EP and NEP, EO and NEO, EO and EP to investigate the significance of differences between the averages of 1-2 test terms described within the experiment. To determine the effect of 12 weeks of the experiment in all groups, we analysed the significance of changes in the average values of the parameters using Wilcoxon's test. To analyse the interactions between post-training changes in the parameters, Pearson's linear correlation analysis was performed.

RESULTS
Table 1 shows the anthropometric characteristic of the women in both groups: the Exercising (EG) and the Non-Exercising Group (NEG). Table 2 presents the values of the body structure and composition parameters in both groups before the start of the experiment (1) and after its completion, i.e. after 12 weeks of the experiment (2). All values are presented in the form of $\bar{x} \pm SD$. Additionally, Table 2 shows the changes expressed in percentage terms ($\Delta\%$) of the parameters induced by the described training.

It was noted that the average value of pulse in exercise (the main part) in test 1 was 145 bpm, and in test 2-160 bpm which represents approximately 40-60 and 60-75 % of maximum heart rate for this age group, respectively. This also means that the effort was performed at approximately 40-60 and 60-75 % of maximum heart rate for this age group, respectively. The recorded HR values at the beginning and end of the experiment, allowed us to evaluate the exercise as a submaximal, because the heart rate, in any case, did not reach the maximum values, and the average increase in the concentration of Lactic Acid (LA), this parameter did not exceed the lactate threshold (4 mmol/l) in most of the examined women. Although, both after test 1 and 2 the applied effort caused an increase in the concentration of Lactic Acid (LA), this parameter did not exceed the lactate threshold (4 mmol/l) in most of the examined women (85% of the group). Therefore, you can assume that the main source of energy in the effort performed processes came from aerobic processes.

The recorded HR values at the beginning and end of the experiment, allowed us to evaluate the exercise as a submaximal, because the heart rate, in any case, did not reach the maximum values, and the average in 1 period at approximately 65% and 2 - approximately 70% of the maximum heart rate, which roughly corresponds to the oxygen consumption at respectively 55 and 60% VO2max in the examined women. Although, both after test 1 and 2 the applied effort caused an increase in the concentration of Lactic Acid (LA), this parameter did not exceed the lactate threshold (4 mmol/l) in most of the examined women (85% of the group). Therefore, you can assume that the main source of energy in the effort performed processes came from aerobic processes. The primary purpose of the research was to assess the effect of the 12-week aerobics training (including 3 sessions per week, 60 minutes each) on components of the body in women aged 35-50 years.

The 12-week aerobics training resulted in statistically insignificant weight gain in the EG group (0.6 ± 1.51 kg). The Pearson correlation analysis revealed a strong ($p < 0.05$) correlation between the following changes: body weight vs FFM ($r = 0.64$), body mass vs TBW ($r = 0.69$) and body weight vs ECW ($r = 0.66$). Changes in TBW content strongly ($p < 0.05$) correlated with changes in FM ($r = -0.69$) and FFM ($r = 0.69$). There was strong ($p < 0.05$) correlation between changes in the content of MM and ICW ($r = 0.97$) and BCM ($r = 0.97$).

Within the NEG group a statistically significant increase in body mass was observed (1.65 ± 1.17 kg, $p < 0.01$), which was reflected in a significant increase in the BMI parameter. There was an increase in both waist circumference (1.10 ± 2.64 cm) and hips circumference (2.40 ± 1.71 cm). The change in hip circumference was statistically significant ($p < 0.01$). The 12-week physical inactivity caused both an increase in the amount of fat as well as its percentage (Table 2). There was a slight increase in FM with a percentage decline in this parameter. A similar trend was observed for MM (Table 2). 12 weeks of the experiment caused a slight increase in TBW with a decrease in the percentage of this parameter. There was a slight increase in ECW and ICW, with ICW percentage was slightly lowered (Table 2).

DISCUSSION
The primary purpose of the research was to assess the effect of the 12-week aerobics training (including 3 sessions per week, 60 minutes each) on components of the body in women aged 35-50 years.
Table 2: Rest values of body structure and components in the Exercising Group (EG) and the Non-Exercising Group (NEG) at the beginning of the experiment (1) and after 12 weeks (2). The values are given as mean ± SD. ∆% - percentage change.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EG, n = 13</th>
<th>NEG, n = 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>65.1 ± 9.1</td>
<td>65.7 ± 9.2</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>24.1 ± 3.4</td>
<td>24.3 ± 3.5</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>76.4 ± 8.0</td>
<td>76.2 ± 8.7</td>
</tr>
<tr>
<td>Hips (cm)</td>
<td>100.8 ± 5.0</td>
<td>99.5 ± 5.1</td>
</tr>
<tr>
<td>WHR</td>
<td>0.75 ± 0.05</td>
<td>0.76 ± 0.05</td>
</tr>
<tr>
<td>BCM (kg)</td>
<td>21.62 ± 1.88</td>
<td>22.02 ± 2.03</td>
</tr>
<tr>
<td>TBW (L)</td>
<td>35.06 ± 3.09</td>
<td>35.62 ± 3.30</td>
</tr>
<tr>
<td>TBW (%)</td>
<td>53.98 ± 4.64</td>
<td>54.65 ± 4.52</td>
</tr>
<tr>
<td>BCM (kg)</td>
<td>15.16 ± 1.56</td>
<td>15.52 ± 1.81</td>
</tr>
</tbody>
</table>

Table 3: Changes of body structure and composition parameters in groups of the exercising Overweight Women (EO), the exercising women with proper weight (EP) and the non-exercising overweight women (NEO), the non-exercising women with proper weight (NEP).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EP, n = 9</th>
<th>NEP, n = 5</th>
<th>EO, n = 4</th>
<th>NEO, n = 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass (kg)</td>
<td>+ 0.20 ± 1.26</td>
<td>+ 2.12 ± 1.52</td>
<td>+ 1.60 ± 1.71</td>
<td>+ 1.18 ± 0.45</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>+ 0.10 ± 0.46</td>
<td>+ 0.77 ± 0.56</td>
<td>+ 0.60 ± 0.65</td>
<td>+ 0.46 ± 0.20</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>-</td>
<td>+ 1.80 ± 3.49</td>
<td>- 0.50 ± 2.65</td>
<td>+ 0.40 ± 1.52</td>
</tr>
<tr>
<td>Hips (cm)</td>
<td>-1.60 ± 1.88</td>
<td>+ 1.60 ± 1.95</td>
<td>- 0.80 ± 2.22</td>
<td>+ 3.20 ± 1.10</td>
</tr>
<tr>
<td>WHR</td>
<td>+ 0.01 ± 0.02</td>
<td>+ 0.01 ± 0.03</td>
<td>-</td>
<td>- 0.02 ± 0.01</td>
</tr>
<tr>
<td>BCM (kg)</td>
<td>+ 0.33 ± 0.58</td>
<td>- 0.10 ± 0.46</td>
<td>+ 0.58 ± 0.29</td>
<td>+ 0.76 ± 0.38</td>
</tr>
<tr>
<td>TBW (L)</td>
<td>+ 0.33 ± 0.49</td>
<td>+ 0.34 ± 1.06</td>
<td>+ 1.08 ± 0.99</td>
<td>+ 1.04 ± 1.09</td>
</tr>
<tr>
<td>TBW (%)</td>
<td>+ 0.19 ± 0.99</td>
<td>- 1.30 ± 0.79</td>
<td>+ 1.75 ± 0.76</td>
<td>+ 0.58 ± 1.42</td>
</tr>
<tr>
<td>ECW (L)</td>
<td>+ 0.40 ± 0.72</td>
<td>+ 0.44 ± 0.77</td>
<td>+ 1.10 ± 0.69</td>
<td>+ 0.34 ± 1.16</td>
</tr>
<tr>
<td>ICW (L)</td>
<td>+ 0.29 ± 1.77</td>
<td>+ 0.82 ± 0.90</td>
<td>+ 1.03 ± 0.90</td>
<td>- 0.38 ± 1.92</td>
</tr>
<tr>
<td>ICW (%)</td>
<td>+ 0.29 ± 1.77</td>
<td>- 0.82 ± 0.90</td>
<td>- 1.03 ± 0.90</td>
<td>+ 0.38 ± 1.92</td>
</tr>
<tr>
<td>FM (kg)</td>
<td>+ 0.12 ± 0.91</td>
<td>+ 1.84 ± 0.75</td>
<td>- 1.25 ± 1.02</td>
<td>-</td>
</tr>
<tr>
<td>FM (%)</td>
<td>+ 0.10 ± 1.36</td>
<td>+ 2.08 ± 1.02</td>
<td>- 2.08 ± 0.97</td>
<td>- 0.54 ± 1.74</td>
</tr>
<tr>
<td>FFM (kg)</td>
<td>+ 0.40 ± 0.65</td>
<td>+ 0.22 ± 1.20</td>
<td>+ 1.98 ± 0.85</td>
<td>+ 1.18 ± 1.36</td>
</tr>
<tr>
<td>FFM (%)</td>
<td>+ 0.10 ± 1.36</td>
<td>- 2.08 ± 1.02</td>
<td>+ 2.08 ± 0.97</td>
<td>+ 0.52 ± 1.75</td>
</tr>
<tr>
<td>MM (kg)</td>
<td>+ 0.42 ± 0.60</td>
<td>- 0.04 ± 0.63</td>
<td>+ 0.85 ± 0.39</td>
<td>+ 0.90 ± 0.39</td>
</tr>
<tr>
<td>MM (%)</td>
<td>+ 0.34 ± 1.12</td>
<td>- 1.48 ± 0.31</td>
<td>+ 0.73 ± 0.24</td>
<td>+ 0.62 ± 0.60</td>
</tr>
<tr>
<td>BMR (kcal)</td>
<td>+ 22.69 ± 42.37</td>
<td>- 11.26 ± 26.38</td>
<td>+ 39.10 ± 13.82</td>
<td>+ 51.30 ± 26.76</td>
</tr>
</tbody>
</table>


* Change is significant, p < 0.05. ** Change is significant, p < 0.01. - no changes.
Healthy women (30 ± 12 years, BMI = 22.7 ± 2.3 kg/m²) participating in the lack of physical activity revealed a tendency to an accumulation of fat around the hips and waist. This was particularly visible in obese women in the case of non-exercising obese women (group NEO), in whom a statistically significant increase in hip circumference was observed. The changes in anthropometric characteristics confirm that the described physical activity prevents the depositing of fat in the upper body, which in turn prevents many diseases, especially those associated with cardiovascular disease [11,21]. The reduction of fat in the visceral was also confirmed in other researchers’ experiments [18,22-24].

It is well known that the maintenance of an appropriate amount of fat (FM) concerning Free Fat Mass (FFM) is important to the maintenance of the proper menstrual cycle [4,25,26]. Appropriate body fat content allows for the preservation of energy homeostasis through the production of leptin - a molecule that ensures the communication between the resource centre of fat and appetite in the hypothalamus, which in turn provides effective control of appetite [27,28]. Fat content in the Experimental Group of women (EG) deviates from generally accepted standards (22-25%) towards increased fat cover (29.37 ± 7.25%) at the expense of FFM (70.63 ± 7.25%, norm: 76-78%). A similar trend was observed in the control group of women (NEG). A modest weight gain in women participating in the aerobic training (EG) was probably the result of the lower content of FM and a significant increase in FFM, including MM (p < 0.01), which in turn is reflected in a significant increase in Basal Metabolic Rate (BMR) (p < 0.05). A similar trend was observed by Kersick et al. [29] who subjected healthy obese women to 14-week strength training and noticed weight loss with an increase in FFM and lower FM. A similar effect was observed in the study of Sillanpaa et al. [19] where they evaluated the effects of 21-week endurance training in healthy women aged 39-64 years. Also, Sedenkova et al. [30] noticed a statistically significant increase in ICW. The increase of ICW in the EG group deviates from generally accepted standards (22-25%) towards 33%. The 12-week aerobics training caused a statistically significant increase in the volume of TBW for all exercising women, with a simultaneous increase in its percentage. Similar results were obtained by Quietro et al. [38] in young female athletes (13 years) taking part in the training of different duration (<4.5 h/week, 4.5 - 8.9 h/week and 9 h/week). The 12-week aerobics training resulted in negligible growth in ECW content and a statistically significant increase in ICW. The increase of ICW in the EG group is strongly associated with the increase in MM. In the case of the non-exercising women (NEG), 12 weeks of inactivity caused a significant decrease in the percentage of TBW in the women with proper weight (NEP), which is strongly correlated with the decrease in FM (r = 1.00). However, in the case of non-exercising obese women (NEO), we observed a significant decrease in the volume of ICW. The disorder of water homeostasis in these women – due to the significant decrease in ICW with a concurrent increase in the volume of ECW (Table 3) – can lead to edema dangerous for the body [20,38]. It can be assumed that such a condition would exacerbate due to the lack of enough physical activity.

LIMITATIONS

In the presented study an attempt was made to assess the influence of 12-week aerobic training on the body composition of young women. We are aware that the limitation of this study is that laboratory conditions were not fully observed (lack of energy analysis of meals). We have only received assurances from the participants that they will not make any changes to their diet, especially regarding reducing calorie intake. Moreover, the measurements were made regardless of the menstrual cycle of each participant. Only women who did not show any abnormalities of their menstrual cycle were qualified to take the measurements.

There is no doubt that for the exercises to bring the expected results, they should be supported by an appropriately selected diet, especially with regard to age and health status. The control of training effectiveness and its influence on the body composition of participants of such training combined with a healthy diet will be the subject of our research in the future.

CONCLUSIONS

Aerobic training has improved the hydration of the body, causing water to move into the intracellular space. In the case of exercising women, an improvement in body composition was observed, manifested by a decrease in the circumference of the hips and waist.

The ‘beneficial’ effects of physical activity are particularly evident in the case of women who do not exercise and in whom inactivity
has resulted in a significant increase in body weight, an increase in body fat and, at the same time, a decrease in the percentage of lean body weight, including muscle mass. Also, 12 weeks of physical inactivity showed a tendency for water to move from intracellular to extracellular space, which is dangerous for health. Such a trend of water management parameters was particularly visible in obese non-exercising women. Lack of physical activity caused a significant increase in hip circumference and a slight increase in waist circumference.

AUTHOR CONTRIBUTIONS

M.C. contributed to the conception, design of the experiment, analysis, and interpretation of data, and wrote this manuscript. D.R. conducted described 12-weeks training. M.C. and D.R. edited this manuscript.

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