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Body Composition Changes Under the Influence of Aerobic Physical Activity

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Abstract
Determining body composition can be the way to estimate health risk, as well as the sports results of a person. Physical activity alters body composition, and the biggest impact on the components of body composition has aerobic exercise. The parameters of the body composition are body mass, percentage of fat mass (FM), amount of fat-free body mass (FFM), Waist-to-Hip Ratio (WHR), and Body Mass Index (BMI).
Determine all parameters of body composition before and after aerobic exercise and compare them.
64 healthy young female (19-25) subjects has been recruited. These were divided in two groups: control (n=32) and intervention (n=32). In the intervention group subjects followed a six week aerobic phisical activity protocol. The measurements of body composition (by bioelectrical impedance analysis) in this group have been collected three times: at the baseline, after six weeks, and finally 4 weeks after the activity protocol has ended.
Subjects in the control group have not been though any physical acivity protocol.
Body mass, percentage of fat in the body, and BMI were the lowest at the measurement 4 week post-activity. Amount of fat-free mass had its lowest value at the second measurement in the intervention group, while it increased during the third, post-acitivy, measurement.
Body composition of the intervention group has changed significantly in comparison to the control group (body mass, percent of fat-free mass and BMI were significanlty lower 4 week post-activity protocol).

Key words: **body composition, aerobic physical activity**

Introduction

Aerobic exercise is an important component of total daily energy expenditure. The amount of energy consumed during any of the aerobic exercise activities depends on the needs of the muscle mass that participates in the execution of these activities, as well as of the intensity with which aerobic exercise activity is carried out. Physical activity can increase the level of basal metabolism by means of two mechanisms: 1) increasing lean body weight and 2) changing physiological processes that affect basal metabolism rate (BMR). Both of these mechanisms are of long duration and occur in cases where a person is exercising for a long time (Miles, 2007). Assessment of body composition is important in medicine, anthropology, sports medicine and child development as it provides insights into the amount of fat in the body and can be used to assess health risk of a person as well as persons' athletic performance. The body composition can be observed using chemical and anatomical model. The *chemical model* of body composition divides a human body in different molecular entities, and the simplest form of this model is a two-component model which separates the human body fat mass (FM) and fat-free mass (FFM) component. *Anatomical model* consists of adipose tissue, muscle, and bone. Top athletes have the same body fat (6-12%), regardless of the sport, but the assessing body composition by anatomical model and measurement of muscle mass can be the way we can estimate what kind of sport the person is involved in (Eston and Reilly, 2009). There are several factors that determine a person's body composition, such as genetic predisposition, age, gender, type and extent of physical activity and nutrition. Genetic predisposition and gender are the only non-modifiable factors. Women have a greater amount of body fat than men because of their physiological characteristics. After 30 years old the human body accumulates more fat mass. Although this change with age is normal, it can be avoided with proper diet and regular exercise. The gold standard for reducing the percentage of body fat is aerobic exercise (Benardot, 2006).

Determining body composition is a challenge as it is complex. Several parameters (BMI-body mass index, WHR-waist to hip ratio, FFF-fat free mass, FM-fat mass) are normally used to determine body composition. Each of these parameters and its trend in an adult person is indicative of health status and development of health risks. For example, BMI is associated with increase risk of osteoporosis. Body fat (FM) consists of subcutaneous fat (under the skin of the abdomen) and visceral fat(which is located between the internal organs). A percentage of fat in the body indicates person's health status. WHR is the ratio of waist and hip circumference. This parameter shows the best distribution of body weight and body fat. The distribution of fat in the body is an important predictor of health risk for obesity. For women, body composition is of additional importance (compared to men) due to the risk of developing osteoporosis. Low BMI is associated with increased risk of osteoporosis (Aghaei Mayboli i saradnici, 2011). Body fat mass (FM) consists of subcutaneous fat and visceral fat (which is located between the body organs). A percentage of body fat directly affects a person's health. WHR is the ratio of waist and hips circumference, indicating the distribution of body fat, so WHR represents a very important risk factor for the development of obesity. Determination of body composition is particularly important for women because of the risk of osteoporosis.

The aim of the research is to determine the effects of the six week aerobic exercise on the body composition, and assess whether these effects are sustained 4 weeks after the completion of activities.

Methods

The only direct way to assess body composition is by dissection and analysis of human cadaver. All other methods are indirect (Hills, 2001). For the purposes of this study we used one the most frequently used indirect methods is bioelectrical impedance analysis (BIA). GAIA 359 PLUS was used to assess body composition, the apparatus that uses tetra-polar electrode to measure bioelectrical impedance. The estimation of body compositions based on measurements of impedance, the input data (gender, age, height) and body weight. From this we obtain data on body weight (kg), percent body fat (%), fat free mass (kg), waist-to-hip ratio (WHR) and body mass index (BMI - kg/m^2). Of 69 study participants, 64 of them have satisfied the conditions for participation. The exclusion criteria of the study were: a) actively engage in some form of physical activity and b) hormonal disorders. The study began with 64 healthy young women, aged 19 to 25 years, divided into two groups: intervention (n = 32) and control(n = 32). All participants were informed about the study and gave their informed consent. Both groups underwent body composition analysis at the beginning of the study (baseline), and then after 6 weeks (second measurement). During that time, the intervention group (IG) was subjected to a structured aerobic training, whereas control group (CG) did not. Aerobic training consisted of the following activities:

- step aerobics (10 minutes),
- jogging with jumping (5 minutes),
- exercises for the shoulder region and lower extremity (squats) - 10 minutes,
- the floor exercise for the abdominal muscles and gluteus (10 minutes), and
- relaxation exercises (10 minutes).

The third body composition analysis was performed only in intervention group 4 weeks after finishing the aerobic exercise program. Statistical analysis was performed with the program SPSS 17.0.1 (SPSS Inc., Chicago, IL, USA).

Results

Statistical analysis indicates that the women in the intervention and control group are not significantly different according to key indicators in the initial part of the test (age and body composition indicators) (Table 1).

Table 1. Baseline characteristics of all participants (n=64)

	Intervention (n=32)		Control (n=32)		P
	Median	(IQR)	Median	(IQR)	
Age	20	(20-21)	20	(20-21)	0,338
Body height	169	(164-171)	168	(161-171)	0,673
Body weight (kg)	59	(57-67)	60	(55-60)	0,655
FM (%)	26	(23-28)	26	(23-28)	0,832
FFM (kg)	41	(40-43)	41	(39-43)	0,779
WHR	0.75	(0.72-0.78)	0.75	(0.72-0.78)	0,725
BMI (kg/m^2)	21	(20-23)	21	(20-23)	0,868

P - Mann – Whitney test; the level of statistical significance and probability of type I error (alpha)
IQR - interquartile range
n - number of participants

Change of body weight, FM fat and FFM in the intervention group before and after aerobic physical activity (baseline and second measurement), and 4 weeks after the completion of exercise (third measurement) are shown in Table 2. The control group only participated in the first two measurements, so we compared body composition parameters in intervention group and control group only in the first two measurements.

In the control group, *bodyweight* was significantly different between baseline and third measurement ($t_{df=31}$=3.869, P = 0.001), as well as between the second and third measurement ($t_{df=31}$= 5119, P = 0.000). Between these measurements, the body weight has decreased. .No statistically significant differences were found for body weight between the baseline and the second measurement ($t_{df=31}$= 1621, P = 0.115).

FM in the body is significantly different in the baseline and the third measurement ($t_{df=31}$= 9508, P = 0.000), as well as the second and third measurement ($t_{df=31}$= 15 749, P = 0.000). In both cases the FM decreased in the third measurement. Percentage of FM does not differ at baseline and second measurement ($t_{df=31}$= -0188, P = 0852).

FFM was statistically different between the baseline and the second measurement ($t_{df=31}$= 2594, P = 0.014), as well as between the second and third measurement ($t_{df=31}$= -3865, P = 0.001), with the smallest amount of FFM at the second measurement. Between baseline and the third measurement there was no statistically significant difference in the amount of FFM ($t_{df=31}$= -1654, P = 0108). Given that all women in the study (i.e. in both intervention and control group) participated only in the baseline and second measuring, analysis of for the differences in selected parameters between the two groups were done only for the first two measurements. Mixed analysis of variance (within groups and between groups) showed that there was no significant interaction between control and intervention groups and time of measurement on body weight ($F_{1.000,61.000}$= 0.998, P = 0322). Thus, there no statistically significant difference is observed in body weight between the groups. Also, there was no statistically significant difference between the intervention and control group in the percentage of FM ($F_{1.000,61.000}$= 0499, P = 0482, η2 = 0.008), as well as the amount of FFM ($F_{1.000,61.000}$= 3923, P = 0.052), although the value is on the threshold of statistical significance (Table 2). Table 3 shows the changes in WHR and BMI in the intervention (three measurements) and control group (two measurements).

Table 2. Body weight, FM and FFM in intervention (three measurements) and in control group (two measurements)

	Body weight (kg)		FM (%)		FFM (kg)	
	Intervention n=32 M(SD)	Control n=32 M(SD)	Intervention n=32 M(SD)	Control n=32 M(SD)	Intervention n=32 M(SD)	Control n=32 M(SD)
Baseline	62,1(8,86)	60.1(6.60)	26,4(4,68)	25.8(3.18)	41,8(4,03)	41.1(4.14)
Second measurement	61,7(8,24) ***	60.1(6.25)	26,4(4,37) ***	26.3(4.92)	41,5(4,03) †	41.1(4.06)
Third measurement	60,7(7,84)*		24,4(4,62)*		42,0(3,86)**	

M - the arithmetic mean
SD - standard deviation
* p <0.001 compared to the baseline measurement
** p ≤ 0.001 compared to second measurement
*** p <0.001 compared to the third measurement
† p <0.05 compared to the baseline measurement
n - number of participants

Table 3. WHR and BMI in the intervention (three measurements) and the control group (two measurements)

	WHR		BMI (kg/m²)	
	Intervention n=32 M(SD)	Control n=32 M(SD)	Intervention n=32 M(SD)	Control n=32 M(SD)
Baseline	0.754(0.042)	0.8(0.03)	21.9(2.84)	21.5(1.88)
Second measurement	0.753(0.037) ***	0.8(0.03)	21.8(2.62) ***	21.6(1.91)
Third measurement	0,737(0,040)*		21,5(2,54)*	

** p <0.001 compared to baseline measurement
*** p <0.001 compared to the third measurement
n - number of participants

There was a statistically significant difference between *WHR* in the baseline and third measurement ($t_{df=31}$ = 5861, P <0.001) and the second and third measurement ($t_{df=31}$ = 6459, P <0.001), whereas WHR was the lowest in the third measurement. Between the baseline and second measurements there is no statistically significant difference in the WHR ($t_{df=31}$ = 0507, P = 0616).

BMI was significant different in the baseline and third measurement ($t_{df=31}$ = 3887, P = 0.001), and the second and third measurement ($t_{df=31}$ = 5222, P <0.001), with a BMI being the lowest in the third measurement. Between the first and the second measurement there was no statistically significant difference in the BMI ($t_{df=31}$ = 1563, P = 0128).

Discussion

In the scientific and practical purposes, the most commonly used indicators of body composition are the body height, body weight, percentage of FM, the amount of FFM, WHR and BMI. There is no doubt that there is connection between physical activity and body composition, but a number of studies done in this field showed a diverse connection between these two factors. There is evidence that young people who are involved in physical activity have better body composition and improved physical performance during the execution of the activity (Ara et al, 2006). Even active video games have a positive effect on the body composition (Meddison et al, 2012). During the development of the child, there are two waves of increasing body weight. Rapid growth occurs in the first year, when the birth body weight triples, while the second one occurs between the ages of 10 and 12 years in girls and 12 to 14.5 years in boys (Ondrak and Morgan, 2007). In our study participants were adolescent women aged 19 to 25 years that have passed through these two waves of increasing body weight, and in which we do not expect major physiological change in body weight. Despite this our study showed that intervention group had a variation in body weight with an increase in second and a decrease (below the baseline) in the third measurement. The biggest drop in body weight occurred after a break of four weeks after the completion of the structured exercise program. This is in contrast to Roger's study that showed no statistically significant changes in body weight in a period after exercise program (Rogers et al, 2009). Our results were not consistent with either a three-year study conducted on young people of which has been shown to extracurricular physical activity leads to an increase in body weight (Gutin, Yin, Johnson and Barbeau, 2008). This difference can be explained by the fact that the study subjects were younger, and they are expected to eventually increase body weight according to their physiological development. Another study found that the body weight of women who exercised for four weeks significantly reduced (Guillemant, Accarie, Peres and Guillemant, 2004), which was not consistent with our study. We could not find the reason why significant changes in body weight did not occur immediately after exercise.

Average value of the FM in the baseline measurement of the intervention and control group ranged within normal values (26.4% and 25.8%, respectively). Change the value of FM in intervention group had the same trend as of the body weight: there was an increase in second measurement, but in the third measurement value falls below the baseline value. Many studies indicate that physical activity leads to a reduction in FM (Gutin, 2008; Mullins and Sinning, 2005; Obradovic et al, 2009). It has been shown that athletes have a lower fat content compared to non-athletes. Adolescent girls involved in athletics have less FM, a greater amount of FFM compared to adolescents who were not involved in sports (Lucas et al, 2003). Different types of sport lead to different changes in the body composition. For example, women who are professional boxers have lower body weight and lower FM than women of the same age who are not involved in physical activity (Trutschnigg et al, 2008). Some studies have shown that the percentage of body fat does not change after exercise (Van Langendonck et al, 2004). Our results showed that the amount of FFM in the intervention group was significantly different in all three measurements. At the second measurement, which was carried out immediately after completion of the training session, showed the biggest decrease in the amount of FFM. This is in contrast to the results of a state of the research, where most studies demonstrated an increase in FFM (Gutin, Yin, Johnson and Barbeau, 2008; Nickols-Richardson et al, 2007; Trutschnigg et al, 2008; Mullins and Sinning, 2005; Wallace and Ballard 2002; Mojtahed, Snook, Motl and Evans, 2008). Our results showed that there was an increase in FFM only after four weeks after completing the training session, but increase was slightly above baseline value. Flann and colleagues conducted a study in which they compared the effects of exercise in trained and untrained persons. They found that after 3 weeks of resistance exercise on the ergometer Eccentron there has been an increase in quadriceps muscle mass in both groups, and that the biggest increase was in the untrained group (Flann et al, 2011). The results of Ogawa et al. showed that after 12 weeks of exercise program a woman's muscle mass increased, specifically the muscle groups involved in the exercises (Ogawa et al, 2010). WHR is calculated by the formula: WHR = waist circumference / hip circumference. Increased health risk in young population is associated with an increased WHR; WHR greater than 0.95 in young men and in young women WHR greater than 0.86 (ACSM's Health-Related Physical Fitness Assessment Manual, 2008). Our results showed that in the intervention group there was a statistically significant difference in WHR in all three measurements (baseline 0.754, second 0.753, and third 0.737), with the lowest rate in the third measurement. The third measurement showed lower WHR, body weight, FM and BMI in the intervention group. One Finnish study examined the effect of physical activity during military service for a period of 6 months. In that study, it was determined waist circumference, not WHR, but it is also one of the parameters of body composition, which is as important as WHR. It is shown that in participants after 6 months of exercise decreased waist circumference, and that the reduction was greater in those with higher BMI compared to those with normal BMI (Mikkola et al, 2012). A British study has also shown that with increasing physical activity waist circumference reduces (Stewart-Knox et al, 2012).

BMI value is calculated according to the formula: BMI = body weight / body height^2 (kg/m^2) Increased BMI indicates an increased health risk (Salinari et al, 2003). BMI subjects in the intervention group differed significantly between the baseline (21.9) and the third measurement (21.5), and between the second (21.8) and third measurement, where the index was at its lowest in the third measurement. Positive effect of physical activity in BMI is not visible immediately after the exercise. Many studies showed that the BMI increases in physical activity (Gutin, Yin, Johnson and Barbeau, 2008; Trutschnigg et al, 2008; Ondrak and Morgan, 2007). In our study there were no significant changes in BMI after six weeks of physical activity, but its value decreased four weeks later (after a period of relative rest). At the same time, the body weight of our participants, too, was at its lowest value. Because it is directly proportional to this index, it is understandable why BMI value reduces. Our results are consistent with the results of the study conducted by Rogers et al. In that study, the BMI and FM did not significantly change 3 months after the completion of the exercise program (Rogers et al, 2009). Our study also showed a positive correlation between the amount of FFM and BMI. Similar results were shown in other studies (Liou, 2007; Luuk and Pihl, 2003).

Conclusion

In this study we have shown that physical activity had no positive effect on body composition immediately after completing the training session, but the body composition parameters improved after 4 weeks after completion of aerobic physical activity. Hence, aerobic physical activity has a beneficial effects on body composition, but it takes more than four weeks for them to become evident.

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