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# The impact of strength training on the changes in one's physique and resting energy expenditure

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**Abbreviations:**
BW – body weight
WHR – waist to hip ratio
PBF – percent of body fat
BMR – basal metabolic rate

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## Abstract

***Background and Purpose**: The aim of this research is to determine the way in which the strength training affects the changes in one's physique and resting energy expenditure.*

***Materials and Methods**: 16 sedentary subjects completed strength training for seven weeks, 3 training/week. The examinee's physique has been analyzed through bioelectrical impedance method (BIA) before and after the seven-week cycle. The variables compared are BW (body weight), WHR (waist-hip ratio), PBF (percent of body fat) and BMR (basal metabolic rate). The differences between the initial and final values have been tested by paired t-test. The correlations between those differences have been expressed by the Pearson correlation coefficient. The level of statistical significance is p=0, 05.*

***Results**: The results indicate that the strength training, even in relatively restricted time period, influences the changes in person's physique, as well as the changes in resting energy expenditure. The mean difference for BMR (p=0.0036), WHR (p=0,022), PBF(p=0,0184) and BW (p=0.0275) have been established for the entire sample. For the males differences were found for BMR (p=0,002), PBF (p=0,0417) and BW (p=0.0280), but no significant change in WHR. No statistically significant changes were found in female group. Correlation was found for differences in results for BMR vs BW r=0.698 (p=0.003), BMR vs WHR r=-0.578 (p=0.019), and PBF vs WHR r=0,671 (p=0,004).*

***Conclusions**: The overall changes in one's physique and energy expenditure indicate that the strength training needs to be one of the crucial factors in physical activity, aimed at the improvement of person's health.*

## INTRODUCTION

The strength as a motor skill is usually divided on maximum, explosive, repetitive, and static. Some of the activities have specific aims, i.e. the final aim determines the development of a specific strength, and based on that the entire training process is planned *(1)*. The first thought that comes to mind when the strength training is mentioned is a muscular hypertrophy, the examinees' previous activities, and their initial state which will significantly influence the training results *(2, 3)*.

The strength training is a confirmed method for the increase of fat-free mass *(4, 5)*. It is also a good choice for the prevention of the increase

in the total body fat percentage *(6)*, and an efficient method for the decrease of subcutaneous adipose tissue *(7)*. For that precise reason, it is very popular method of intervention in the case of obese people. With strength training the fat-free mass is increased and, at the same time, the percentage of adipose tissue is reduced *(8, 9)*. There is also an increase in daily energy requirements and resting energy expenditure *(10)*, therefore the intensity of the training should be kept in mind *(11)*.

The strength training is recommended for people suffering from type 2 diabetes, also for the prevention of the cardiovascular diseases *(12, 13)*, and it lowers the tumor mortality risk among men *(14)*. It is the only training method which can slow down sarcopenia *(13)*, and it has a great role in osteoporosis prevention *(15)*.

The objective of this research is to determine the way in which the strength training influences the changes in one's physique and resting energy expenditure.

## MATERIALS AND METHODS

This experimental longitudinal research has been conducted on the sample of sixteen sedentary examinees (8 males and 8 females), aged 20±1. All the examinees volunteered for the experiment. The physique has been analyzed through bioelectrical impedance method (BIA), with the help of the GAIA 359 device. Measurements were performed at the beginning of the study, before the start of training sessions, and at the end, in the 8. week from the start. Before the analysis of their physique, the examinees were given the following instructions:

- no food or drink 4 hours before the test
- no physical activity 12 hours before the test
- no alcohol consumption 48 hours before the test
- empty bladder 30 minutes before the test
- no diuretic intake 7 days before the test

The variables compared are: BW (body weight), WHR (waist-hip ratio), PBF (percent of body fat), and estimation of BMR (basal metabolic rate).

The strength training was conducted in the period of seven weeks, 21 training sessions all together (three training sessions a week).

The training sessions were conducted in the gym at University of Applied Sciences Lavoslav Ružička in Vukovar, under supervision of an expert. Exercising method divided by stations. First 2 weeks 10 stations, 2 sets, 15 repetitions, 60% exercise load. The following 2 weeks 10 stations, 3 sets, 12 repetitions, 70% exercise load. Last 3 weeks 6 stations, for two muscle groups, 3 sets, 10-12 repetitions, and 80-85% exercise load.

Statistical analysis was performed using MedCalc 10.2.2.0 statistical software. The normal distribution has been confirmed by the Kolmogorov-Smirnov test. The differences between the initial and final values have been tested by paired t-test. The correlations between those differences have been expressed by the Pearson correlation coefficient. The level of statistical significance was set at p=0, 05.

## RESULTS

Sample consisted of 16 sedentary subjects, 8 males and 8 females aged 19- 21, with average age 20 years. Average height was 175,4 cm ± 8,6 cm, and average weight 70,3 kg ± 12,4 kg. Men had mean height of 181,6 cm ± 4,9 cm, and weight 79,5 kg ± 9,2 kg, while female group had average height 169,1 cm ±6,8 cm, and average weight 61 kg ± 7,1 kg. At the beginning of study WHR for the whole sample was 0,762 ± 0,04, when differenced by sexes: male subjects had average WHR 0,779 ±0,04, female`s average WHR was 0,745 ± 0,03. PBF was 21,25% ± 5,62% in the whole sample, in the male group PBF was 17,47% ± 4,61%, and among females 25,02% ± 3,72%. BIA measurements also gave an estimation of BMR, and it was average 1535,93 kcal ± 239,49 kcal, for males 1755,75 kcal ± 98,96 kcal, and for females 1316,12 kcal ± 51,78 kcal. Kolmogorov-Smirnov test confirmed normal distribution of data in all measured variables, so all the results are presented as arithmetic mean ± standard deviation. Differences in values of variables at the beginning and at the end of the study, as well as the results of statistical analysis are presented in tables 1-3. In Table 1 differences in values of variables at the beginning and at the end of study for the whole sample are presented, while Table 2 and table 3 present results differenced by sex. In Table 2 are presented results of male subjects, while in Table 3 are the results of female group. Differences in values of measured variables were correlated, and results of these correlations are in Table 4.

## DISCUSSION

The results provided by this research, as a consequence of the strength training, show statistically significant increase of the mean value for BMR with difference of 17,187 (p=0,0036), and BW showed differences of 0,86 (p=0,0275), while the values for WHR decreased, with mean difference WHR -0,01 (p=0,0220) considering all examinees. As for the male examinees, statistically significant change is evident in BMR variable on p = 0.0020 level, mean difference 31,375, and for the BW variable p=0.0280, mean difference 1, 47, on the other hand the difference of the WHR values is not statistically significant (p = 0.0548). Table 3 shows that, considering female examinees, none of the variables have shown statistical significance. Considering the BMR changes, which have expressed statistically significant difference in male population (and none in female population), one must bear in mind that the BMR in male population is usually higher *(16, 17)*. Based on that, one can presume that the chang-

**TABLE 1**

The differences between final and initial values for BMR, WHR, and BW for the entire sample.

| | BW | WHR | PBF | BMR |
|---|---|---|---|---|
| Mean difference | 0.8687 | -0.01437 | -0,9375 | 17.1875 |
| t-test | 2.442 | -2.556 | -2,643 | 3.453 |
| Statistical significance | p = 0.0275 | p = 0.0220 | p=0,0184 | p = 0.0036 |

**TABLE 2**

The differences between final and initial values for BMR, WHR, and BW for male examinees.

| | BW | WHR | PBF | BMR |
|---|---|---|---|---|
| Mean difference | 1.4750 | -0.0225 | -1,4250 | 31.3750 |
| t-test | 2.762 | -2.302 | -2,488 | 4.803 |
| Statistical significance | p = 0.0280 | p = 0.0548 | p = 0,0417 | p = 0.0020 |

**TABLE 3**

The differences between final and initial values for BMR, WHR, and BW for female examinees.

| | BW | WHR | PBF | BMR |
|---|---|---|---|---|
| Mean difference | 0.2625 | -0.00625 | -0,4500 | 3.0000 |
| t-test | 0.673 | -1.357 | -1,189 | 1.225 |
| Statistical significance | p = 0.5225 | p = 0.2168 | p = 0,2732 | p = 0.2603 |

**TABLE 4**

Correlation coefficients among the differences between final and initial values on the level of the entire group for variables: BMR, BW, WHR, and PBF.

| | | BW DIFFERENCE | WHR DIFFERENCE |
|---|---|---|---|
| BMR DIFFERENCE | Correlation Coefficient | 0.698 | -0.578 |
| | Significance Level P | 0.003 | 0.019 |
| | n | 16 | 16 |
| PBF DIFFERENCE | Correlation Coefficient | -0,230 | 0,671 |
| | Significance Level P | 0,392 | 0,004 |
| | n | 16 | 16 |
| BW DIFFERENCE | Correlation Coefficient | | -0.097 |
| | Significance Level P | | 0.720 |
| | n | | 16 |

es in BMR (which are the result of the strength training) will be more significant as well. As for the body weight (BW), there is also a difference between the sexes; there is a significant increase in body weight in male population, while the results among female population did not express any statistical significance. We obtained similar results for PBF, with statistically significant decrease in male subjects (p=0,0417), and with no significant differences among females (p=0,2732). Strength training led to a weight gain among male examinees – 1, 47 kg on average. The increase in body mass is most likely the consequence of the increase of the muscle mass and consequentially decrease in percentage of body fat *(18, 19, 20, 21)* There are evidences in literature of hypertrophy of

muscles after 8 weeks of strenght training *(22)*. The reason why statistically significant differences were not evident in female examinees is most likely the fact that there is a difference in adjustment to strength training between male and female body. It was shown by Martel *et al. (22)* that differences in response of body to strength training are highly influenced by sex and age, and that muscle fibre response is different in young males and young females. Body weight changes are connected to the resting energy expenditure, the consequence of the decrease in body weight is lower BMR *(23)*, in this case there is an increase in body weight in male population, as well as the BMR increase. Strength training allows BMR to stay on the same level, while reducing body mass, the training maintains the level of fat-free mass *(10, 24)*. Considering the entire test group, there is a notable reduction in WHR. Based on that, and the decrease of PBF that was found, one can presume that strength straining has a positive effect on the reduction of the visceral fat *(25)*.

That is highly important considering that visceral fat increases the risk of developing type 2 diabetes *(26)* and dyslipidemia *(27)*.

Table 4 shows statistically significant connection between BMR and BW on for the entire group, i.e. weight gain (as a result of the strength training) led to increase in resting energy expenditure. Also, one can observe the negative correlation between resting energy expenditure and WHR. The connection between body weight and WHR is not statistically significant; on the other hand positive correlation of change in PBF results and change in WHR results was found, which serves as another proof that strength training has led to the increase in total body weight through the increase of fat-free mass.

Based on the results of this research, whose objective was to determine the ways in which strength training influences the changes in one's physique and resting energy expenditure, conducted on the sample of 16 examinees (8M) and (8F) aged 20±1, one may claim that the strength training leads to the changes in morphological characteristics of an individual, as well as the metabolic ones. On the level of the entire group, the strength training led to positive BMR changes, i.e. there was an increase in resting energy expenditure. Also, there was a decrease in WHR values, and PBF values, i.e. the visceral fat. The weight gain is, most likely, the consequence of the growth of the fat-free mass. This is evident in the reduction of WHR values. Based on that, the strength training can be recommended as an efficient method for the health improvement and the regulation of body composition. One must always consider the age and the sex of the examinees because equal training intensity will not produce the same effects within different groups. This research was restricted by the relatively small number of examinees; therefore the interpretation of the differences between male and female examinees must be taken into consideration. It is important to emphasize that the body weight was taken as a variable in this research due to the fact that it is easily measurable in an everyday context.

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