

HIGH INTENSITY INTERVAL TRAINING (HIIT) EFFECTS ON PHYSICAL ABILITIES AND MORPHOLOGY IN FEMALES

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Original research

Abstract

The basic aim of this research was to determine the magnitude of the effect of short-term high intensity interval training (HIIT) on transformation of morphological characteristics and motor abilities in physically inactive women. Based former studies, one can assume that aerobic training of high intensity will probably affect the improvement of motor abilities and reduction of body mass in bodily inactive women. Subject of this research were 30 examinees of an average aged 32.2 ± 1.83 , who were physically inactive in the past year, but they have previous training experience necessary for realization of predicted training content. Examinees did not have conspicuous health problems or injuries in the past year. Morphological status (body height: 171.1 ± 7.82 cm and body mass: 76.17 ± 11.74 kg) shows increased body mass index 26.67 ± 3.62 and excess of body fat in total body mass. Morphological characteristics are evaluated with battery of 8 tests, while muscular endurance and explosive strength are evaluated with 5 variables which cover all topological regions of the body. Experimental training treatment lasted for 4 weeks with frequency of 4 trainings per week, which is in total 16 training units. An average duration of the training lasted between 45-50 minutes, and training principles of high intensity interval training are applied (HIIT). Analysis of pre-post differences in the group of morphological variables, we can conclude that all variables except for circumference of the waist/hip which statistically and significantly differ ($p < 0.05$) in final compared to initial measurement in range of 0.73% to 5.32% with an average effect of 3.53%. Analysing the results acquired in motor tests, we can conclude that there is a statistic difference ($p < 0.05$) between all results recorded in final when compared to initial testing, in range of 15.1% to 148.9% with average effect of 67.2%. By comprehensive analysis of effects conducted during the training program, the conclusion is imposed that changed experimental protocol when observed quantitatively, has triggered positive transformational effects in all researchable variables.

Key words: HIIT, body fat, physical fitness

Introduction

Obesity is defined by *World Health Organization – WHO*, as a disease in which excess of adipose tissue is accumulated to that extent that it jeopardizes health (Poirier et al., 2011). This is probably reason for great number of scientific and expert work on obesity, morphological features and training methods for reduction of subcutaneous fat in physically inactive female population. Body composition presents important indicator of health and can be presented based on presence of volume of muscle, fat, bone tissue and other anatomic components, which contribute to body mass of human (Solway, 2013). Very often, overall morphological status and body composition and presents three indicators: body mass index, sum of five points of subcutaneous fat and waist volume (Duggan, Mercier, & Canadian Society for Exercise, 2007). Apart from morphological variables, an important indicator of general form of body are

functional and motor abilities, which are subjected to transformation under the influence of training operators. Therefore, it is necessary to draft training program which will affect key indicators of health status and body condition. In order for training process to cause significant reduction of subcutaneous fat it is necessary, with adequate diet, to apply those activities that will stimulate metabolism of fat and carbohydrate, during the longer period of training (ACSM, 2009). It is believed, for a long time, that training with low to mediate intensity in longer period (more than 30 minutes) as continues training method, is the only method for reduction of subcutaneous fat and body mass. Later studies revealed that training of high intensity, as interval method can be used for these purposes. According to results of great number of former studies (Gormley et al., 2008; Perry et al., 2008; Tabata et al., 1996; Aksović et al 2017), aerobic

training of high intensity should improve motor skills and reduction of body as in physically active women. The fundamental aim of this study is to determine the amount of effects of short-term high intensity interval (HIIT) on transformation of morphological features and motor abilities in physically inactive females.

Methods

Sample subjects

Sample subjects of this research were 30 female subjects aged $32,2 \pm 1,83$ who are physically inactive in the past year without significant health problems or injuries but with increased values of body mass index and body fat in total mass. They all have training experience, necessary for performance of anticipated training activities especially in work with heavy athlete technology, and they all have similar experience. All female subjects needed to have confirmation of their physician that they are healthy and that they can be subjected to high training loadings i.e. HIIT. Also, female subjects are informed, before testing, with Helsinki declaration, and they voluntarily consented on testing with possibility of dropping out in any given moment.

Sample variables

Anthropometric tests

Basic anthropometric tests are determined according to standard procedure which is recommended by International biological program (Misigoj-Durakovic,

2008), and it is used in 8 variables. Description and protocol of performance of tests (except ITM) is taken from Kazazovic (2013).

- Body height (BH);
- Body mass (BM);
- Body mass index (BMI); standard procedure described by Lohman et al. (1992) is used for calculation of ITM
- Waist volume (WV);
- Hips volume (HV);
- Relation- proportion of waist and hips (RPWH);
- Forearm volume (FV);
- Upper leg volume (ULV);
- Tibia volume (TV).

Tests for assessment of motor skills

- Squats in 30 sec (SQ 30). Procedure of performance of test by Reiman and Manske (2009) modified and adjusted to performance with time limitation;
- Lifting torso in 30 sec – (LT 30);
- Push ups in 30 sec; description and procedure of performance of tests (LT30 I PU30) are taken from and adjusted for performance by Kazazovic (2013)
- Standing Long jump – (SLJ) The protocol for both jumping tests was taken from Marković et al. (2004);
- Plank endurance (PLK) Protocol of performing test is described by Jernstedt et al. (2015).

Experimental procedure

Table 1 Global plan and program of conducted experiment

Initial testing (1 week)	Experimental program (4 weeks)	Final testing (1 week)
Anthropometric testing: <i>Body height</i> <i>Body mass</i> <i>Forearm volume</i> <i>Waist volume</i> <i>Hips volume</i> <i>Upper leg volume</i> <i>Tibia volume</i>	High intensity „Hard body“training with frequency 4 x a week Duration 45-50 min Main part of training includes 7 sets- rounds each with 2 to 3 exercises Total 14-18 exercises per training Interval of work 15-40 sec x 6-8 intervals per exercise Series pause (between intervals) 10-20 sec with 1 min pause between exercise and 2- 3 minutes between sets	Anthropometric testing: <i>Body mass</i> <i>Forearm volume</i> <i>Waist volume</i> <i>Hips volume</i> <i>Upper leg volume</i> <i>Tibia volume</i>
Testing of motor skills: <i>Squats in 30 sec</i> <i>Push-ups in 30 sec.</i> <i>Lifting torso off the floor in 30 sec.</i> <i>Standing long jump</i> <i>Plank endurance</i>		Testing of motor skills: <i>Squats in 30 sec</i> <i>Push-ups in 30 sec.</i> <i>Lifting torso off the floor in 30 sec.</i> <i>Standing long jump</i> <i>Plank endurance</i>

Table 1 shows global plan with basic elements from the experimental program. The main part of the training is conceptualized in the way that it includes 7 independent sets – “rounds” as they are called in training process, during which 2 to 3 exercises are performed. Exercises with one’s own mass-„BODYWEIGHT COMPLEX“ are applied, and exercises with one’s own mass performed on TRX2 (which is not different from low gymnastic rings) „SUSPENSION TRX2“ and exercise with external loading such as kettlebell or „Russian bell“-„KETTLEBELL TRAINING“. Kettlebell training is performed in a way so that parameters of technical demands of exercises are increased progressively, but also the weight of the equipment is increased, in range between 4-8 kg. Results of 25 female subjects from experimental group

are included in the analysis because the preformed initial and final testing and they did minimal 13 out of 16 planned training units.

Methods of data processing

Standard descriptive parameters and measures of normality of distribution are calculated for all dependent variables. Normality of distribution is checked by Kolmogorov - Smirnov test (KS test). Differences between initial and final condition are determined by T-test for dependent samples. All statistical analysis were conducted by SPSS 25 program package for Windows operative system.

Results

Table 2 Descriptive parameters of sample in initial testing

	Minimum	Maximum	Mean	Std. Deviation
Age	29	35	32.20	1.826
Body height	151	185	171.20	7.82
Body mass	57.00	108.10	78.17	11.74
Body Mass Index	20.69	37.85	26.67	3.62

Descriptive parameters which describe sample in initial testing are presented in table 2. Average age of female subjects was 32.2 while age range was between 29 and 35. Morphological status (body height $171,1 \pm 7,82$ cm and body mass $78,17 \pm 11,74$ kg) point to increased means of Body Mass Index $26,67 \pm 3,62$ and increased body fat in overall body mass.

Table 3 Arithmetic means recorded in all variables in initial and final testing, differences and belonging t and p means (t-test)

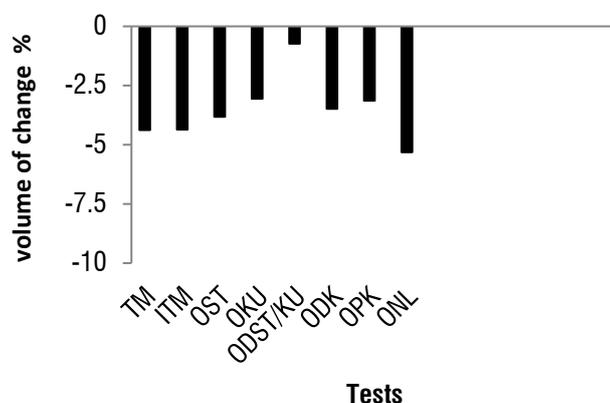
	Initial	Final	Differences	Differences (%)	t means	p means
Body mass	78.17	74.74	-3.42	-4.38	-10.01	.000
Body Index Mass	26.67	25.50	-1.16	-4.36	-11.38	.000
Waist volume	94.77	91.15	-3.62	-3.82	-11.84	.000
Hips volume	109.27	105.92	-3.35	-3.06	-6.59	.000
Proportion waist-hip	.86	.86	-.01	-0.73	-1.63	.115
Upper leg volume	61.65	59.50	-2.15	-3.48	-11.13	.000
Tibia volume	40.18	38.92	-1.26	-3.14	-7.61	.000
Forearm volume	32.70	30.96	-1.74	-5.32	-8.59	.000
Squats 30s	16.96	26.48	9.5	56.13	20.43	.000
Sit-ups 30s	14.36	22.96	8.60	59.89	14.61	.000
Push-ups 30s	10.64	16.64	6.00	56.39	15.67	.000
Plank endurance	46.28	115.20	68.92	148.92	10.73	.000
Long jump	151.80	174.72	22.92	15.10	9.26	.000

Table 3 presents arithmetic means of initial and final testing and absolute and relative differences with belonging level of statistical significance. Obtained results show that pre-post differences in all applied variables occur in final measurement in relation to initial measurement, apart from variables waist/hips.

In percentage, differences between initial and final measurement in group of morphological variables were

-0,73% (proportion of waist/hips) to -5,32% (forearm volume). More detailed overview of table 3 shows that after experimental program, body mass was reduced for 3,42kg and 4,38%, respectively. Body mass index was reduced for 1,16kg/m² and 4,36%, respectively, waist volume for 3,62cm, 3,82%, respectively, hips volume for 3,35cm and 3,06, respectively, and waist/hips volume for 0,01, and 0,73%, respectively.

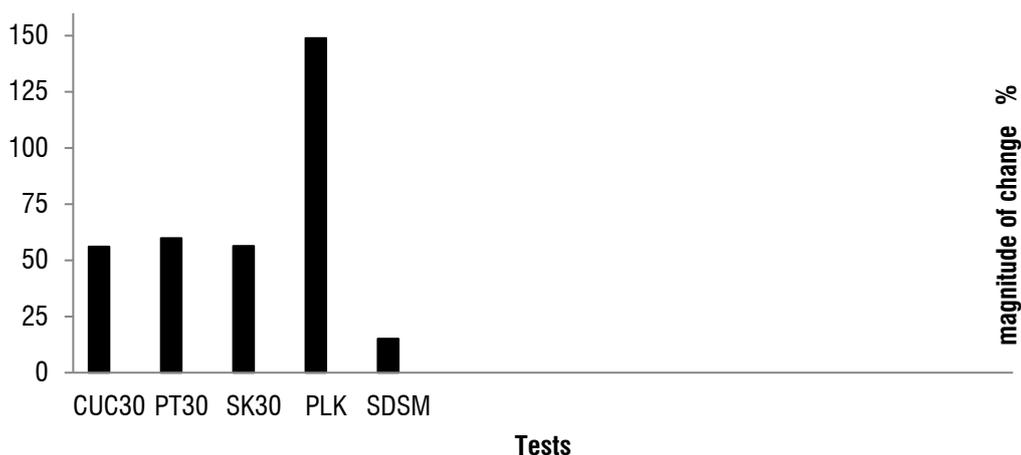
Graph 1 Percentage magnitude of achieved results in morphological variables



Percentage of differences between initial and final measurements in group of motor variables was +15,1% in variable Long jump +148,9% in variable Plank endurance. More detailed overview on table 3 and graph 2 shows that after experimental program, number of squats is increased for 9,5 and 56,13%, respectively, number of sit-ups for 8,6 and 59,89%, respectively, and push-ups for 6 and 56,39%, respectively, all three tests during 30 sec. Improvement in long jump in final measurement in

relation to initial measurement was 22,92cm, and 15,1%, respectively, while time of plank endurance is increased up to 1 minute, (68,9 sec.), and 148,9%, respectively. Great percentage differences between two points of measurement are obtained due to very small means of results of motor tests in initial measurements, which points to the bad shape of female subjects at the beginning of this experimental procedure.

Graph 2 Percentage magnitude of obtained results on motor variables



Discussion

The aim of this research is to determine the magnitude of effects of short-term HIIT on transformation of morphological features and motor skills in physically inactive women, with the special

emphasis to determination of magnitude of effects of applied training on reducing body mass, body volume and Body Mass Index means as fundamental indicator of morphological status.

Also, the focus of this research was improvement of motor skills with the emphasis on general and local muscle endurance. Obtained results suggest that short-term HIIT caused expected (from 0,73% do 5,32% with average effect to 3,53%) changes in morphological status and motor abilities in physically inactive women. Obtained results in group of morphological variables show there are positive transformation effects, which are in accordance to most of recent studies on similar topic (Aktas et al. 2016; Ahmadizad et al. 2015; Rossi et al. 2015; Cokorilo et al 2012). Opposite to these results, small number of studies (Ziemann et al 2011) did not record reduce of body mass and volume after appliance HIIT. Namely, in their study they noticed increase of body mass for 0.6kg in amateur athletes after 6 weeks (3x a week) of HIIT training. These results are like this maybe because of different protocol of performance of HIIT training, which included overall loading from 6x90 sec at 80% VO₂max, with previous 5-minute warm-up at 30% VO₂max.

Detailed analysis of pre-post differences in group of morphological variables, showed that all variables except for variable of proportion of waist/hip are statistically and significantly different ($p \leq 0.05$) in final measurement in relation to the initial measurement. Reason for this can be found in differences which appeared in these two variables, separately, in final measurement in relation to the initial measurement. Namely, in terms of reduction of waist volume, result of -3,62cm or 3,82% is achieved, while hips volume is reduced for -3,35cm or 3,06%. It is perceived that individual progress differentiate for 0.76% in these measurements. Therefore, with proportional reduction, which is recorded, proportion remained almost the same and in this case changed (-0.73), but not statistically significant. It is important to mention that some other studies haven't recorded statistically significant changes in relation of waist/hip changes in relation as in Camacho-Cardenosa et al. (2016) where samples included 35 adolescents (19 men and 16 women), who were included in HIIT, 3x a week, in 8 week training. In this study, proportion of waist/hip maintained unchanged (0.84) in final measurement in relation to initial measurement.

Opposite to these results Murawska-Cialowicz et al. (2015) noticed significant reduction of proportion of weight/hip (0.72 in initial and 0.70 in final measurement) after three-month training of high intensity of 15 men and 15 women. Taghian and Zolfaghari (2014) found statistical significant reduction of proportion of waist/hip in final in relation to the initial testing (with 1.04 on 1.03).

Although differences in other variables are in accordance to the results recorded in this study, it is inevitable fact that average means of ITM in this

study was 26,67 in initial and 25,50 in final testing, while in mentioned study initial means were 37,21 and final 35,6 which points to significant difference in sample subjects. Obtained results of motor skills, which were evaluated in this paper, show that HIIT experimental program, has better results in all measured motor variables. Detailed analysis of results obtained in motor testing shows statistically significant difference ($p \leq 0.05$) between results recorded in final testing in relation to initial testing, in range from 15.1% to 148.9% average result of 67.2%. Improvement of results recorded in tests of motor skills is in accordance with recent studies (Sekulic et al; 2003; Whyte, Gill, & Cathcart, 2010; Ziemann et al., 2011; Shepherd et al., 2015; Ahmadizad et al., 2015; Zhang et al., 2015; and Murawska-Cialowicz et al. 2015) which evaluated results of HIIT training. All studies recorded positive effects of HIIT training on motor skills and physical shape.

Since effects of HIIT training on development of motor skills during HIIT and reduction of body mass and fat are well recorded, it is likely that the core of these changes lays in physical loading during HIIT. Aksovic et al. 2017. state that, due to features of high intense exercises and their influence on physical shape, its efficiency is determined on body system of women. The core of that influence is physical loading of body, which is specific for work-training of high intensity, which includes metabolic consumption and "oxygen debts". Consequence of "payment" of oxygen debt is increased level of metabolic in period after activities till so called after-burn effect" (EPOC level of me – eng. excess post-exercise oxygen consumption) which results in increased calories consumption. Studies Perry, Heigenhauser, Bonen, & Spriet, 2008, support this theory. They showed that oxidation of body fat or burning fat and oxidation of carbohydrates.

Improvement of general shape, which includes increase of aerobic and anaerobic abilities, muscle strength and endurance under the influence of HIIT, can be explained by physical adaptation of body on this type of training program. Better results in tests of muscle strength and endurance were shown due to increase of muscle mass in overall body mass. Study of Paolilo et al. (2011) confirms this theory, which indicates that experimental HIIT group has increased muscle mass in relation to control group which had running on treadmill. Talanian et al (2007) determined that after only 2 weeks of HIIT mitochondrial volume was increased for 31%. One of the key reasons is increase of mitochondrial capacity of muscles during high intensity activities, which influence increase of aerobic and anaerobic abilities of female subjects (Gillen et al., 2013).

Conclusion

Obtained results of this research show that experimental program, in duration of 4 weeks with frequency of 4 trainings a week (total 16 training units) with average duration of training between 45-50 minutes, caused positive effects, statistically significant (except in relation of waist and hip) transformational effects in all variables of morphological status and motor skills in body inactive women. This study confirmed hypothesis based on former studies, which indicates that short-term HIIT in duration of 4 weeks, significantly influence physically inactive women, especially in the area of physical mass and composition of body and improvement of motor potential and basic shape.

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