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Walking at Speeds Close to the Preferred Transition Speed as an Approach to Obesity Treatment

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SUMMARY

Introduction Increasing energy expenditure through certain exercise is an important component of effective interventions to enhance initial weight loss and prevent weight regain.

Objective The purpose of this study was to determine the effect of a 16-week weight loss exercise programme on morpho-functional changes in female adults and to examine the programme effects on two subpopulations with different levels of obesity.

Methods Fifty-six middle-aged women were divided into 2 groups according to their body mass index (BMI): 25-29.9 kg/m^2 – overweight (OW) and ≥30 kg/m^2 – obese (OB). The exercise protocol included a walking technique based on hip rotation at horizontal plane at speeds close to the preferred transition speed (PTS). At the initiation of the study and after 16 weeks of the programme, anthropometric, morphological and cardiovascular parameters of all subjects were assessed. The main effects of Group (OW and OB) and Time and the interaction effect of Group by Time were tested by time repeated measures General Linear Model (mixed between-within subjects ANOVA).

Results Mean weight loss during the programme was 10.3 kg and 20.1 kg in OW and OB, respectively. The average fat mass (FM) loss was 9.4 kg in OW and 16.9 kg in OB. The Mixed ANOVA revealed a significant Group by Time interaction effects for waist circumference, body weight, body water, fat free mass, FM, %FM and BMI ($p<0.05$).

Conclusion The applied exercise protocol has proved as beneficial in the treatment of obesity, since it resulted in a significant weight loss and body composition changes. The reduction in body weight was achieved mainly on account of the loss of fat mass.

Keywords: weight reduction; fat loss; preferred transition speed

INTRODUCTION

Key challenges in the treatment of obesity are to reduce body weight and maintain such lowered body weight over a long time. Typically, that can be achieved by increasing energy expenditure (EE) through physical activity and restricting calorie intake over a period of time. For overweight people, who are at a heightened risk of injury during exercise, walking is the most suitable and comfortable form of physical activity. Overweight adults, similarly to normal-weight adults, realize minimum EE by walking at preferred walking speed of about 1.4 m/s (5 km/h) [1, 2, 3]. Energy is primarily obtained from fat oxidation at walking speeds ranging between 4.8 and 6.8 km/h. Carbohydrate oxidation rate increases sharply above 4.8 km/h, while carbohydrate oxidation becomes the primary source of energy at the walking speeds of 6.8 to 7.2 km/h [4]. Human gait at this speed range reaches a critical value as walking requires more muscle fibre work [5] and consumes twice the energy compared to walking at preferred walking speed [4]. To reduce energy consumption, person spontaneously starts running rather than to continue walking. This is energy saving mechanism commonly known as walk-to-run preferred transition speed (PTS). Gait transition is triggered by mesencephalic locomotor region and based on decreased body mass inertia on account of decreased gait frequency [6]. PTS depends of age, gender, anthropometric dimensions and training status [7, 8, 9], and is typically reported to be around 2.0 m/s (7.2 km/h) for most human subjects [9].

Higher-intensity physical activities have additional benefits on body composition, cardiorespiratory fitness, lipids and insulinemia [10, 11]. Exercising at higher intensities will reduce the time required to spend a given amount of energy, and may help promote weight loss and maintenance. Higher-intensity exercises are associated with a greater increase in postexercise EE, the potential to use lipids for energy production, and a decrease in postexercise energy intake when compared to lower intensity exercise [1, 4, 10].

Venables et al. [12] showed that fat-free mass (FFM), level of physical activity, VO_2 max, gender and fat mass (FM) are significant predictors of maximum fat oxidation. Compared to men, women have higher maximum rates of fat oxidation, and lipids remain the dominant fuel at higher exercise intensities. Fat oxidation during walking is by 11% to 33% greater in overweight than in normal-weight adults. However, the difference in energy consumption during walking can reach up to 95% in favour of overweight persons [1, 2, 3, 13, 14]. It should be noted that EE depends not only on speed but also on a particular combination of stride

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length and frequency at a given speed [15]. Additionally, EE depends on vertical displacement of the centre of mass (COM) while walking [16, 17]. According to Saunders et al. [17], walking technique involving small vertical displacement of the COM reduces the metabolic cost of locomotion, as it reduces the muscular work required to lift the body. On the contrary, Ortega and Farley [16] have shown that minimizing the vertical displacement of the COM increases metabolic cost of walking. This assertion was based on the fact that muscles must generate force to maintain a stiff stance of the limb and prevent the COM from collapsing. Accordingly, we hypothesized that a weight loss programme including a walking technique that minimizes vertical displacement of the COM at speeds close to PTS would have favourable effect on improving body composition in overweight and obese subjects.

OBJECTIVE

The purpose of this study was 1) to determine the effect of 16-week weight loss exercises programme on morphological and functional changes in female adults; 2) to examine these programme effects on two subpopulations with different levels of obesity.

METHODS

Fifty-six middle-aged women (aged 31-49 years) who participated in a 4-month weight loss intervention programme were divided into 2 groups according to their body mass index (BMI): 25-29.9 kg/m^2 – OW, and ≥30 kg/m^2 – OB (30 OW and 26 OB). There were 5 dropouts or 9% (2 in OW and 3 in OB). The reasons for dropout were mainly lack of time or motivation, while none dropped out due to intervention programme-related illness or injury.

All subjects were normotensive (with arterial blood pressure of <140/90 mm Hg) and free of disease as determined by a health history questionnaire and medical examination. The subjects were sedentary to moderately physically active (<90 min/wk), with stable body mass (<3 kg change) over the previous 3 months. Subjects with diabetes mellitus or those treated for heart or blood pressure irregularities within the previous 5 years were excluded from the study. All subjects were fully informed about the nature of the study and were required to sign an informed consent statement before the baseline testing. The study procedures were approved by the Ethical Committee for Human Studies of the Faculty of Sports and Physical Education, University of Belgrade, Serbia. The study included three phases: 1) a baseline testing phase; 2) a 16-week diet and exercise programme; and 3) a post-testing phase.

Baseline testing phase

At the start of the study, the anthropometric, body composition and cardiovascular parameters of all subjects were assessed. All anthropometric data were measured using a portable stadiometer (Seca 214 Road Rod, Seca Corporation, Germany) and a non-extensible 2-metre measuring tape, and recorded to the nearest 0.1 cm. Body weight was measured using a portable platform digital scale and recorded to the nearest 0.1 kg. BMI was calculated as weight (kg) divided by squared height (m^2). Body composition was measured using an arm-to-leg bioimpedance apparatus (BIA) (Nutriguard-M, Data Input, Germany) and calculated using the NUTRI3 software (Data Input, Germany). Before testing, the subjects were required to adhere to the following BIA testing guidelines [18]. Heart rate and blood pressure variability were determined while the subjects were at rest in a sitting position. Heart rate was measured by a pulsometer (Polar Electro, Finland). The subject's resting systolic and diastolic blood pressures were measured in duplicates on their right arm to the nearest 5 mm Hg, using a mercury sphygmomanometer. The average value was used in the analysis.

Weight-loss diet

The diet was identical for all groups in order to isolate the effects of physical activity. To qualify for participation in the study, all subjects were required to keep 2-week baseline eating accounts, which promoted adherence to the diet. All subjects were instructed to follow a weight maintenance diet during 4-months intervention period (energy intake in the range of 1200-1500 kcal/day, where 55% to 60% was provided from carbohydrates, 15% to 20% from proteins and 20% to 25% from fat), in line with current recommendations for weight loss in obese adults given by the National Institute of Health [19]. Dietary intake was recorded using a daily exchange checklist, while compliance with the diet was measured by weekly dietary recalls (16 per subject during the study).

Exercise protocols

At the end of each month, walk-to-run PTS was determined for each subject in the group, using the Hreljac's protocol [9]. Before training sessions, each subject had 20 minutes familiarization with a new walking technique on treadmill (Technogym Runrace, Gambettola, Italy) explained below. All subjects exercised 4 times a week (2 days of exercise, 1 day of rest, 2 days of exercise and 2 days of rest). Every exercise session was structured as follows: 1. warming up; 2. treadmill 1; 3. exercise session 1; 4. treadmill 2; 5. exercise session 2; 6. overall relaxation (proprioceptive neuromuscular facilitation method of stretching, controlled by a sport physiologist).

Treadmill 1: Subjects were instructed to walk 0.4-0.8 km/h below the PTS for three 8-minute sessions, with the speed altering every 2 minutes to walk at the PTS for 20 seconds.

Treadmill 2: Subjects were instructed to walk 0.4-0.8 km/h below the PTS for two 8-minute sessions, with the speed altering every 2 minutes to walk at the PTS for 20 seconds. Between the sessions, subjects were instructed to walk for 5 minutes at the speed of 5 km/h.

The above walking combination was expected to increase the generated mechanical work. Learning walking technique was based on the hip rotation at horizontal plane, partially using adduction from the backward stance position (braking thigh abduction) and decreasing flexor activity within the range of movement from backward to forward leg position. In terms of tendency to minimize vertical displacement of the COM, this technique was expected to increase EE by not allowing foot to land sharply on the hill but on almost entire foot, which extends backward swing. Consequently, overweight subjects were expected to be able to increase the PTS as a result of their ability to extend stride length at the same stride frequency. To minimise the vertical displacement of the COM, subjects were instructed to lower COM by a few centimetres and to maintain it at that height [16]. The objective of the exercise sessions was to strengthen posture muscles so as to maintain stability and protect the locomotor system, especially when reproducing the gait at speeds close to the PTS.

Exercise session 1: Exercises for strengthening abdomen (on account of muscle strength) and limbs (on account of muscle speed) and flexibility exercises for lower limb muscles.

Exercise session 2: Exercises for strengthening postural, limb and chest muscles, and breathing exercises.

The choice of muscle strength exercises depended on the phase of the weight loss programme. The following are three phases of the weight loss programme:

- Phase I (Month One)

Exercises were used to improve ability of muscle groups neutralizing movement in the sagittal plane, with the aim of producing dynamic balance under high intensity walking.

- Phase II (Month Two)

The exercises strengthened abdominal muscles – m. transversus abdominis and lower parts of m. rectus abdominis, and medial parts of m. gluteus maximus – with the aim of achieving hip joints decompression, decrease of pelvis inclination and increase of intra-abdominal pressure. In each exercise, muscle contraction lasted between 4 and 6 seconds.

Exercises for stretching m. iliopsoas, m. vastus lateralis and m. gastrocnemii were performed. The stretching resulted in an increased muscle length and, consequently, in an increased stride length. This enabled more efficient synchronization of the hip flexion and knee extension in the course of the forward leg movement.

- Phase III (Months Three and Four)

The purpose of the exercises was to improve the muscle power output in m. gluteus maximus and m. iliopsoas in order to produce high frequency movement and, as a result, achieve gradual increase of PTS. It was expected that the PTS should increased due to increased stride length and stride frequency [15].

Abdominal muscles were treated under different muscle contraction regimes throughout all phases of the exercise programme in line with the muscle function and the muscle ability to adapt.

Post-testing phase

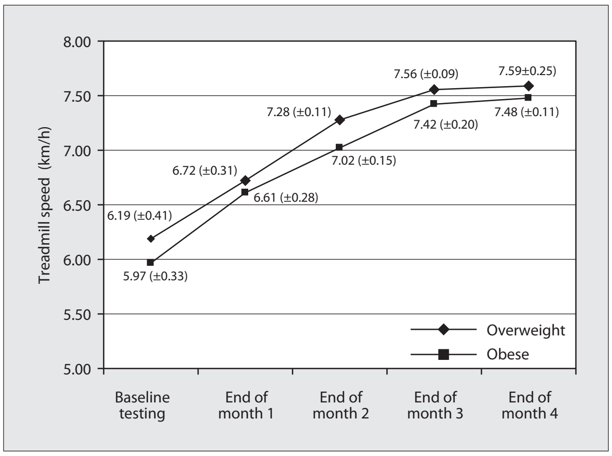
In the post-testing phase measurements were repeated in the same order as during the initial testing. Statistical analyses of all measured variables were made after the post-testing.

Statistical analysis

Mean and standard deviation (SD) values for all dependent variables were calculated to describe the initial and final characteristics of the subjects. The main effects of Group and Time and the interaction effect of Group by Time were tested by time repeated measures General Linear Model (mixed between-within subjects ANOVA). The effect of Time represented applied exercise protocol over a 4-months period, while the effect of Group related to the subjects divided into 2 groups (obese and overweight). A significant Group by Time interaction indicated that the change from baseline to post-testing was different depending upon the treatment groups. If there was a significant Group by Time interaction, individual effects of Group and Time were considered as insignificant and therefore were not analysed. Additionally, in those variables showing a significant interaction, paired-samples Student's t-tests were examined to determine significant baseline to post-test changes within each group. In those variables which did not show a significant Group by Time interaction, separate effects of Group and Time were tested. All statistical tests were considered significant at a $p<0.05$ level. Data were analyzed using SPSS (version 17.0).

RESULTS

Average walk-to-run PTS found at the beginning of the study for OW and OB was 6.19±0.15 km/h and 5.97±0.18



Graph 1. Changes in walk-to-run PTS over 16-week weight reduction programme

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km/h, respectively. After two months, the subjects in both groups reached PTS previously published for normal-weight human subjects [7, 9], continuing to increase their PTSs throughout the study (Graph 1). On average, the increase amounted to 1.40 km/h in OW and 1.51 km/h in OB. For initial and final PTS values, mixed between-within subjects ANOVA did not show a significant Group by Time interaction ($p=0.501$, $e^2=0.122$). However, significant effects of Time was observed ($p=0.023$, $e^2=0.081$).

Effects of exercise programme on anthropometric characteristics

Mixed between-within subjects ANOVA revealed significant Group by Time interaction effects only for waist circumference ($p=0.001$) (Table 1). A paired Student's t-test however showed significant reduction ($p<0.01$) in waist circumference for both study groups. No significant Group by Time interaction effects was found for thigh and upper arm circumferences ($p=0.148$ and $p=0.076$, respectively), while significant main effects of Time was noted ($p<0.01$) (Table 2).

Effects of exercise programme on body composition

Mean weight loss during the 4-month programme as a percentage of initial body weight was -12.1% and -18.4% in OW and OB, respectively. As expected, the greatest decrease in BMI was found in OB (from 35.8±6.3 to 29.0±5.9 kg/m²). The same group had the highest FM loss,

Table 1. Anthropometrics characteristics, body composition and cardiovascular response at baseline and after the 16-week weight reduction period for variables with significant Group by Time interaction

Parameter		Obese (BMI≥30kg/m²)		Overweight (BMI=25–29.9 kg/m²)		Group time[b]		
		Mean±SD	p[a]	Mean±SD	p[a]	p	F	e²
Age (years)		36.4±8.2	-	38.2±7.1	-	-	-	-
Body weight (kg)	Initial	106.79±21.39	0.000	86.44±14.96	0.000	0.000	29.3	0.374
	Final	86.73±19.16		76.11±13.82				
Body water (l)	Initial	47.45±10.48	0.006	44.72±9.23	0.074	0.047	4.145	0.078
	Final	45.09±8.69		44.02±9.18				
Fat free mass (kg)	Initial	64.83±14.31	0.006	61.09±12.64	0.073	0.050	4.053	0.076
	Final	61.62±11.88		60.13±12.55				
Fat mass (kg)	Initial	41.96±12.88	0.000	25.37±5.62	0.000	0.000	32.638	0.400
	Final	25.11±12.50		15.98±4.67				
Fat mass (%)	Initial	39.12±7.36	0.000	29.60±5.59	0.000	0.018	6.021	0.109
	Final	28.08±8.67		21.20 ±5.90				
BMI (kg/m²)	Initial	35.83±6.30	0.000	27.12±2.81	0.000	0.000	38.701	0.441
	Final	29.03±5.90		23.80 ±2.58				
Abdomen – waist (cm)	Initial	110.31±13.16	0.000	94.91±9.59	0.000	0.001	13.315	0.259
	Final	92.78±9.77		86.21± 9.14				

[a] Paired-samples Student's t-tests (p values). Differences are statistically significant for $p<0.05$.
[b] Mixed between-within subjects ANOVA – Group by Time interaction

Table 2. Anthropometrics characteristics, body composition and cardiovascular response at baseline and after the 16-week weight reduction period for variables without significant Group by Time interaction

Parameter		Obese (BMI≥30kg/m²)	Overweight (BMI=25–29.9 kg/m²)	Group time[a]			Time[b]			Group[c]		
		Mean±SD	Mean±SD	p	F	e²	p	F	e²	p	F	e²
Cell amount (%)	Initial	53.27±2.70	54.20±3.77	0.428	0.638	0.013	0.092	2.951	0.057	0.226	1.504	0.226
	Final	52.45±3.61	53.90±4.16									
Extracellular mass (kg)	Initial	30.16±6.25	27.69±4.88	0.166	1.977	0.039	0.048	4.130	0.078	0.167	1.972	0.167
	Final	29.05±4.51	27.49±5.21									
Body cell mass (kg)	Initial	34.65±8.38	33.38±8.25	0.059	3.739	0.071	0.000	15.888	0.245	0.796	0.067	0.001
	Final	32.56±7.98	32.65 ±8.08									
Upper arm (cm)	Initial	36.31±3.72	34.11±2.51	0.076	3.326	0.080	0.000	66.472	0.636	0.141	2.259	0.056
	Final	32.47±4.08	31.68 ±3.09									
Thigh (cm)	Initial	67.89±5.81	62.82±4.36	0.148	2.180	0.054	0.000	19.581	0.340	0.101	2.827	0.069
	Final	61.61±5.36	58.59±3.96									
Heart rate (beats/min)	Initial	83.00±9.90	82.00±7.13	0.642	0.223	0.013	0.000	76.821	0.819	0.480	0.521	0.030
	Final	66.50±2.71	63.50±4.37									
TA systolic (mm Hg)	Initial	128.00±21.21	126.00±19.11	0.458	0.577	0.033	0.000	65.718	0.794	0.356	0.907	0.051
	Final	110.00±14.14	111.00±13.24									
TA diastolic (mm Hg)	Initial	79.00±7.07	76.00±7.12	0.212	1.681	0.090	0.000	30.298	0.641	0.479	0.525	0.030
	Final	70.00±7.11	70.00±7.10									

[a] Mixed between-within subjects ANOVA – Effects of Group by Time interaction
[b] Mixed between-within subjects ANOVA – Time effect
[c] Mixed between-within subjects ANOVA – Group effect
Statistically significant effects for $p<0.05$.

with an average loss of body fat amounting to 16.9±5.8 kg and body fat percentage decreasing from 39.1±7.7% to 28.1±7.2%.

Mixed between-within subjects ANOVA revealed significant Group by Time interaction effects for body weight, body water, FFM, FM, %FM and BMI ($p<0.05$). A paired Student's t-test however showed a significant reduction ($p<0.01$) in body weight, BMI, FM and %FM for both study groups. There was no significant decrease in the amount of FFM (-0.96 kg, $p=0.073$) and body water (-0.70 kg, $p=0.074$) in OW (Table 1).

A significant Group by Time interaction was not found for cell amount, extra cellular mass and body cell mass ($p>0.05$), where significant main effects of Time was noted for extra cellular mass and body cell mass ($p<0.05$). No significant main effect for Group was found for any measured variable ($p>0.05$) (Table 2).

Effects of exercise programme on cardiovascular response

Cardiovascular parameters were significantly influenced by the Time effect ($p<0.01$). Both groups experienced a reduction in resting heart rate and resting systolic and diastolic blood pressures after the experimental period. The decrease in systolic and diastolic pressures were similar among OW and OB (ranging from 15 to 18 mm Hg for systolic, and 6 to 9 mm Hg for diastolic). An average decrease in resting heart rate after 4-months exercise programme was 18.5±8.9 and 16.5±9.2 beats/min for OW and OB, respectively (Table 2).

DISCUSSION

The main findings of this study are 1) weight-loss programme based on walking close to PTS and minimal vertical displacement of the COM had a significant favourable effect on body composition in female adults; 2) for certain observed body composition variables, effects of training programme depended on the levels of obesity (obese and overweight).

Thr applied statistical procedures showed a high level of interaction between the training programme and groups for variables waist circumference, body weight, BMI, body water, FFM, FM and %FM, which indicated that the change from baseline to post-testing was different depending upon the treatment groups. Consequently, a post-testing analysis (paired-samples Student's t-tests) was performed to determine the significant baseline to post-test changes within each group for these variables. T-test showed statistically significant changes in both groups ($p<0.05$). Mixed ANOVA a showed significant interaction due to various changes in absolute values of these variables in two groups (subjects from OB group lost more in absolute values compared to OW group), but the Student's t-test showed that the exercise programme had significant effects on both groups.

Unlike variables mentioned above, FFM and body water showed statistically significant declines in OB vs. OW. Since obese subjects had a greater amount of FFM on account of accumulated fluids, it is assumed that the decrease in the amount of FFM in OB was created because of the loss in body water. Also, a significant loss of the FFM across the OB may have been explained by the decrease in the size of body organs typically enlarged by obesity [20].

A few cross-section studies examined the effects of high intensity treadmill walking on fuel selection, indicating that such walking predominantly used up fat as a fuel [4, 10, 13, 14, 21]. Overweight individuals find it relatively difficult to maintain synchronized gait circles at speeds close to PTS, as these speeds imply high-intensity walking. Doing strength exercises, the subjects successfully adapted their muscle-joint system so as to reach PTSs previously published for normal-weight human subjects [7, 9]. Accordingly, the relevance of the results presented herein lies in the fact that they describe the effect of high intensity walking on body composition over a protracted period of time.

Since abdominal fat is more closely associated with health risk than fat stored in other regions of the body [22], waist circumference is a clinically feasible measurement that may be used independently or in addition to the BMI [22, 23]. Four months into the weight loss programme, both groups showed a highly significant reduction in waist circumferences. Also, the subjects from both groups decreased their BMI by one classification category of the World Health Organization [24] (obese from 35.8 to 29.0 kg/m^2 and overweight from 27.1 to 23.8 kg/m^2).

In the present study, the average FM loss was found to be 9.4 kg in OW and 16.9 kg in OB. These results corroborate our hypothesis that walking technique and walking intensity have a significant effect on the amount of fat loss. As the target walking speed (0.4-0.8 km/h below PTS) increased throughout the study as a result of increased PTSs (Graph 1), we cannot say with certainty which of the walking techniques and walking intensity had more impact on fat loss. Using indirect calorimetry, further studies should reveal impact of these two factors on fat oxidation. A number of reports have shown that low-intensity walking burns the greatest proportion of fat, whereas high-intensity walking uses more total fat as a fuel [4, 12, 21]. Walking intensity should also have impact on the total amount of energy expanded in physical activity, with the high intensity exercise expending more relative and absolute energy [2, 3, 4, 21]. The increase in total EE is a result of an increase in the metabolic cost of activity at high-intensity walking and in the post-exercise oxygen consumption, which is not seen in the low-intensity exercise [10, 25]. Walking speed producing high EE does not follow speed that provides high fat oxidation [4, 10, 13, 14, 21]. Walking speeds of 0.4–0.8 km/h below the PTS were assumed to be the speeds at which a compromise between high EE and high fat oxidation could be achieved [21]. Also, it was important for subjects to learn the adequate walking technique, minimizing vertical displacement of the COM in order to engage more muscles and to reduce foot impact on the treadmill, thus ensuring a low level of

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joint stress [16]. It is important to note that both groups achieved significant progress in term of increasing transition speeds and thus, increased EE and fat oxidation during the training [21].

Maintaining FFM might be very important during periods of weight loss as previous studies revealed that maximum fat oxidation is positively correlated with the FFM [11]. There is an ongoing debate whether exercises, as a part of weight loss programmes, can prevent the FFM loss [26, 27, 28]. Adding „low-cost" strength exercises to intensive and long lasting aerobic exercises that ensure greater metabolic cost and utilization of fat stores might be beneficial for preserving the FFM [28], which in turn prevents joint injury in heavier individuals and improves walking technique during walking exercise. Other studies have reported that weight loss through the combination of diet and aerobic exercise results in a significant loss of both body fat and the FFM [26, 27, 28]. However, the FFM was rather difficult to estimate accurately by the BIA. Another challenge was to make as accurate estimate of the FFM (consisting of body cell mass and extra cellular mass) as possible. Individual variability has previously been reported to be high, as the accuracy of the BIA may be compromised in the conditions of altered hydration status [29] and obesity [30]. The results showed that the exercise programme significantly affected the amount of body cell mass and extra cellular mass in both groups (-0.73 kg, -0.20 kg in OW and -2.09 kg, -1.11 kg in OB, respectively). Since obese subjects in this study showed a significant decrease in FFM and body water, this seems to be the most likely explanation for the significant decrease in the amount of body cell mass and extra cellular mass. However, the percentage of the body cell amount, i.e. the share of body cell mass in the FFM, did not show significant change during training period. Since training protocol that included strength exercises in order to preserve body cell mass, and body cell amount was not influenced by the programme, we can assume that this variable is perhaps more accurate assessment of body active tissue.

Strong evidence exists that weight loss reduces blood pressure in both overweight hypertensive and nonhypertensive individuals [19, 28, 31, 32]. Weight loss is associated with a reduction in vascular resistance, total blood volume and cardiac output, and suppression in sympathetic nervous system activity [31, 32]. There is also a direct association between aerobic training and better oxygen consumption of cardiac muscle, contributing in increasing cardiovascular fitness and reducing of resting heart rate and blood pressure [33]. Yoshioka et al. [10] have recommended high intensity exercises, since this kind of exercises have additional benefits on improving the body composition and cardiovascular fitness. Data from the present study suggesting that walking at speeds close to PTS, as a form of high intensity aerobic training, is effective in lowering resting heart rate and blood pressure during diet-induced weight loss. These results were directly dependent of the exercise programme ($p \leq 0.01$, $e^2=0.641-0.821$) and out-of-obesity level ($p \geq 0.05$). This has important public health implications since obesity and hypertension are direct, strong and independent co-morbid risk factors for the development of chronic cardiovascular disease and stroke [32].

CONCLUSION

This study demonstrated that walking technique based on hip rotation at horizontal plane in order to minimize the displacement of the centre of mass at speeds close to preferred transition speed resulted in a significant weight loss and changes in body composition. This reduction in body weight was achieved mainly on account of the loss of fat mass. We cannot say with certainty which of the walking techniques and walking intensity had more impact on fat loss. Further studies should be conducted to reveal which of these two factors has more influence on fat loss. Although in this study we were not able to separate these factors, it is important to note that both groups through this training programme and walking technique significantly increased transition speed. Beside improved body composition, beneficial effects of the weight loss programme on cardiovascular parameters were observed.

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Ходање брзинама приближним оптималној транзитној брзини као терапијски приступ гојазности

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КРАТАК САДРЖАЈ
Увод Повећање потрошње енергије кроз одређено вежбање важна је компонента ефикасне интервенције, како би се побољшао почетни губитак телесне масе и спречило враћање килограма.
Циљ рада Циљ рада био је да се утврди утицај шеснаестонедељног тренажног програма на смањење телесне масе и морфофункционалне промене код одраслих гојазних жена.
Методе рада Испитано је 56 жена средње животне доби које су сврстане у две групе према индексу телесне масе (енгл. *Body Mass Index – BMI*): у умерено гојазне (*BMI=25–29,9* kg/m^2) и екстремно гојазне (*BMI≥ 30* kg/m^2). Тренажни протокол обухватио је технику ходања засновану на ротацији кукова у хоризонталној равни при брзинама приближним оптималној транзитној брзини. На почетку истраживања и после 16 недеља примене програма измерене су вредности антропометријских, морфолошких и кардиоваскуларних варијабли. Главни ефекти групе (умерено гојазне и екстремно гојазне) и времена (тренажни протокол) и ефекти интеракције групе и времена испитани су општим линеарним моделом (*mixed between-within subjects ANOVA*).
Резултати Просечан губитак телесне масе током програма био је 10,3 *kg* код умерено гојазних и 20,1 *kg* код екстремно гојазних жена. Просечан губитак масног ткива био је 9,4 *kg* у првој и 16,9 *kg* у другој групи испитаница. Анализом су утврђени значајни ефекти интеракције групе и времена за обим струка, телесну масу, телесну течност, безмасну масу, количину и проценат масног ткива и *BMI* ($p<0,05$).
Закључак Примењени тренажни протокол показао се корисним у терапији гојазности, будући да је имао значајан утицај на смањење телесне масе и промене у телесном саставу. Смањење телесне масе постигнуто је углавном на рачун губитка масног ткива.

Кључне речи: смањење телесне масе; губитак масног ткива; транзитна брзина ходања

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