Original Article

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Effect of Physical Exercise on Adiposity and Physical Fitness in Middle Age Men with Different Body Mass

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Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation

Abstract

Purpose: Overweight and/or obesity is a growing problem over the world. Alongside a range of health problems associated with increased body mass (BM) – adiposity and reducing of fitness level it is an important limiting factor for realization of regular physical exercise and quality of life. Therefore, the aim of our study was to verify the effect of physical intervention based on walking in men of middle age with different weight status with minimal changes in their eating habits. *Material and Methods:* Study was carried out in 25 middle age men with normal BM (mean age=43.7±3.6 years; BM=78.3±3.9 kg; height=177.5±4.6 cm; %BF=22.1±2.1 %, VO_{2peak}=33.2±3.1 ml/kg.min), 26 overweight men (42.0 ±2.9; 89.9±3.1; 178.1±4.0; 27.9±2.2; 30.2±3.9) and 18 obese men (43.8±3.0; 97.4±4.6; 178.3±3.2; 33.1±3.4; 24.1±4.2). All these subjects were without regularly movement training before the starting of intervention. Body composition was assessed by bioimpedance method using prediction equations that are valid for the Czech men population, functional variables were assessed on a treadmill. *Results:* The energy content per kg BM of weekly exercise for subjects with normal BM was 20.40±4.51 kcal/kg (13.4 – 20.4 kcal/kg), in overweight 20.36±3.00 kcal/kg (15.4 – 24.5), and in obese 20.33±3.39 kcal/kg (17.6 – 24.0). Reduction in %BF ranged from 9.4±2.7 % in obese to 8.6±2.1 % in normal BM of starting value, ECM/BCM relationship was decreased from 11.0±1.4 % in subjects with normal BM to 12.2±1.9 % in obese, and in VO_{2peak} increased from 10.3±2.2 % in normal BM to 12.7±2.6 % in obese. In men differing in BM are absolute changes in adiposity and aerobic fitness like a result of imposed movement intervention substantively and statistically significant ($p<0.05$, $d\geq0.05$). On the contrary, differences in percentages of pre-intervention values are non-significant. *Conclusion:* Exercise program with a similar energy content, form and intensity causes the similar changes in adiposity and in functional performance in middle age men, differing in BM. Movement intervention based on walking reduces body weight and at the same time improves the morphological preconditions for physical activity.

Keywords: middle age men, walking, body mass, body composition, movement predispositions

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INTRODUCTION

In recent decades, the prevalence of obesity has continued to increase across the world [1], representing a considerable global public health issue [2]. Obesity is defined as an excessive or abnormal fat accumulation, presenting health risks related to multiple chronic conditions. Physical activity is a modifiable factor for obesity, which was reported to be correlated with the built environment.

The obesity has doubled worldwide and is considered the fifth risk factor for mortality. Future projections estimates a 33% increase in obesity and 130% increase in severe obesity prevalence in 2030 [3]. Obesity is associated with a reduction in individual mobility, aggravating previous sedentary lifestyle [4, 5]. Activities of daily living (ADL) are impaired due not only to excessive body fat accumulation but also to mechanical factors that might reduce walking capacity.

Adipose tissue represents the largest energy depot in the human body. More and more people exhibit excessive fat deposition in adipose tissue, which leads to obesity, a multifactorial disease with both adverse health effects and economic implications. Although obesity has troubled humanity since ancient times, it has reached epidemic proportions only in recent years [6-9]. Since its primary cause is a chronic imbalance between energy intake and energy expenditure in favor of the former, the road to fighting obesity (excluding pharmaceutical interventions) necessarily passes through creating a negative energy balance [10].

Since many obese people have reduced physical fitness, are not familiar with exercise, and are at increased risk for musculoskeletal injuries due to excess body weight, it is important to prescribe exercise that is safe and makes them feel comfortable, thus ensuring adherence to the exercise training program. Walking on flat terrain, which is the basic locomotor activity of a person and is maximally adapted to it, meets these criteria. Such a program should be defined by the appropriate parameters of frequency, duration, intensity, type, and progressivity, which, in turn, should be determined according to individual abilities, preferences, and responses. It is also recommended that exercise be supervised by a specialized trainer, at least during an initial period. Despite the proven health benefits of aerobic exercise training, traditional modes, such as land walking and running, are often associated with an increased risk of musculoskeletal injury due to accumulated stress on the lower extremities [11], particularly in the obese. Furthermore, pain and injury from exercise are often cited as reasons for discontinuing exercise training. The recommendations apply to both women and men, as there seem to be no differences between sexes in the weight loss caused by equivalent exercise [7].

Regular physical activity (PA) is an important component of overall health. PA is well known to improve cardiorespiratory fitness, blood pressure, and body composition, which are all negatively correlated with the risks of chronic disease [12]. PA also plays a role in body weight regulation through its effects on energy expenditure and energy intake, providing a potential disruption to the energy balance equation [13]. Because exercise creates an energy deficit that may perturb homeostasis and hormone levels, the effects of exercise on energy intake are of interest.

Evidence summarized mainly in many medical staff supports the view that exercise constitutes an indispensable tool in the management of obesity. Yet, in our experience, this tool is often underestimated, and preference is given to other means such as dieting, medication, and surgery. People who are overweight or obese often claim that they are not able to implement an exercise program as individuals of normal body mass, and if they complete the program, its results will be significantly worse than that of people of normal weight [11,14].

Therefore, the aim of our study was to verify the effect of physical intervention based on walking in men of middle age with different weight status with minimal changes in their eating habits.

MATERIALS AND METHODS

Participants

Physically inactive, normal body mass, overweight, and obese men were recruited from the Prague and surroundings communities to participate in the study. Potential volunteers were recruited through informational flyers, through e-mail announcements, and by word of mouth. Volunteers were

Table 1. Demographic and selected functional data of subjects and practical and statistical significance upon entry to the study.

Variables	NBM (1)	OV (2)	OB (3)	1-2	1-3	2-3
Number	25	26	18			
Age (years)	43.7±3.6	42.0±2.9	43.8±3.0	NS	NS	NS
Body mass (kg)	78.3±3.9	89.9.7±3.1	97.4±4.6	* α	** αα	** αα
Body height (cm)	177.5±4.6	178.1±4.0	178.3±3.2	NS	NS	NS
%BF (%)	22.1±2.1	27.9±2.2	33.1±3.4	** α	** α	** α
BCM/ECM	0.85±0.03	0.93±0.04	1.01±0.04	NS	** α	NS
$VO_{2peak}.kg^{-1}$ ($ml.kg^{-1}.min^{-1}$) - BM	32.2±2.64	29.1±2.9	26.1±3.2	NS	** α	NS
$VO_{2peak}.kg^{-1}$ ($ml.kg^{-1}.min^{-1}$) - FFM	41.3±2.7	40.4±2.8	39.1±3.1	NS	NS	NS

NBM – normal body mass, OV – overweight, OB – obesity, BCM – body cell mass, ECM – extracellular mass, *p<0.05, **p<0.05, $^{\alpha}$ d=0.5, $^{\alpha\alpha}$ d=0.6

screened to ensure that they had not participated in regular aerobic activity for the previous 3 months (physically inactive) and were classified as normal body mass, overweight or obese by either body mass index (BMI) or percent body fat as measured by whole body bioimpedance analysis. Subjects were stratified according to the Czech standards for risk of cardiovascular disease, and those for whom it was required underwent a physical examination by a cardiologist before participation in the experiment. Preliminary anthropometrical and physiological characteristics of the all subjects who completed the study are presented in Table 1.

The study protocol was reviewed and approved by the local Ethics Committee Faculty of P.E. and Sports and followed the guidelines of the World Medical Assembly Declara-tion of Helsinki. Written informed consent to participate was provided by guardians and verbal assessment was provided by the participants.

Methods

Subjects were instructed to maintain their accustomed dietary and physical activity habits throughout the course of the study. No attempt was made to modify diet or activity outside of the exercise training protocol. To verify compliance with these instructions, dietary and activity habits were assessed on two occasions by questionnaire coinciding with the beginning and end of exercise training.

The walking exercise used in this study is one of the most widely known cardiovascular exercises [15]. Walking is the most fundamental physical activity of humans to which the individual is maximally adapted. It is the easiest and the most familiar form of exercise, both physically and mentally. Most people enjoy walking as a type of exercise regardless of age, fitness level, or technique, and it is associated with very little risk of injury. It is therefore well suited for individuals who have minimal experience with movement training.

In order to achieve the greatest possible effect of physical intervention and especially to maintain adherence to PA, a physical program was designed for a duration of 15 weeks. Each session included approximately 10 minutes of warm-up and cool-down, during which participants focused on range of motion and active stretching. The main portion of the walking exercise program, which consisted of 3 walking sessions per week, was designed following the ACSM physical activity guidelines for adults between the ages of 18–64 years [16]. In order to reap greater health benefits from the exercise program, a minimum of 300 minutes per week. 100 minutes per session was ensured with mean intensity of exercise on the level HR ranged from 80 to 90% of age-recommended values. Intensity - walking speed in field conditions was controlled using Sportesters (Polar Oy, Finland) or Smart mobile phones. The outside temperatue during walking was in the range of 15 - 20 degrees Celsius. Body composition was determined by the whole-body bioimpedance in the lying position.

The electrodes were in tetrapolar configuration in the places recommended by the manufacturer (BIA 2000, Datainput, Germany). Predictive equations for calculation of body composition variables (BC, BCM – body cell mass, ECM – extracellular mas) were modified for the Czech population according to verification by DEXA method. We use the ECM/BCM ratio to assess the exercise load assumptions, where ECM is the extracellular mass and BCM is the body cell mass. It holds that FFM = ECM + BCM. The lower this value, the better the movement preconditions the subject has. For trained athletes, we find values of this coefficient lower than 0.7, on the contrary, the values of untrained individuals are close to 1.00 [17,18].

The body cell mass is calculated using the FFM and phase angle between whole impedance vector and resistance [19]. The FFM was calculated according to modified formula of Deurenberg et al. [20]. An incremental maximal graded exercise test was conducted by walking on a motor-driven treadmill for VO_{2peak} determination. Oxygen consumption during exercise was assessed using an automated gas analysis system The maximal functional variables determined on a treadmill with slope of 5% during a progressive walking test until subjective exhaustion. After two familiar walking speeds of 3 and 5 km / h with zero treadmill, the initial walking intensity of 3 km / h on the treadmill with a slope of 5% was increased every minute by 1 km / h until the subject subjectively exhausted. The cardiorespiratory variables were measured in an open system using an on line method by TEEM 100 (Aerosport, USA) and/or Metalyzer 3b (CORTEX, Germany). All analyzers were checked before and after each exercise test series by a calibration gas of known concentration. The ventilation was controlled before and after test series by mechanical pump. Each subject was tested using the same metabolic equipment at pretraining and posttraining assessment periods. VO_{2peak} was taken as the highest 20-s average oxygen uptake achieved during the exercise test. HR was monitored continuously by Sportester Polar.

The subjects were verbally encouraged to continue the exercise to the point of exhaustion. To acknowledge that the subjects had achieved VO_{2peak}, at least two of the following three criteria were met: (a) a plateau of VO_2 (change <150 $ml \cdot kg^{-1} \cdot min^{-1}$); (b) respiratory exchange ratio (RER) ≥1.10; and (c) heart rate (HR) within 10 $beats \cdot min^{-1}$ of the maximum level expected for age of the maximum level expected for age. Energy when walking on flat terrain was calculated for walking speeds lower than 7 $km.h^{-1}$ from the linear relationship between movement speed and oxygen consumption, which applies to walking speeds in the range of 3 - 7 $km \cdot h^{-1}$ [20]. $VO_2.kg^{-1}$ ($mL \cdot kg^{-1} \cdot min^{-1}$) = 2.957*v ($km \cdot h^{-1}$) + 2.777. We used the relation 1 l VO_2 = 4.8 kcal for load intensity with predominantly aerobic payment of energy requirements [21,22].

Data analysis

The normality of distribution was verified by the Shapiro-Wilk test. The parametric paired t-test was used for the assessment of statistical significance of the differences pre-intervention and post-intervention data. The level of statistical significance for all the used tests was set at $p<0.05$. Practical significance was assessed using the effect size by Cohen (Cohen's d). The d value at the level of 0.2 indicates a minor change, 0.5 an intermediate change and 0.8 a major change. The value of Cohen's $d \geq 0.5$ is considered practically significant. The practical significance between the groups independent of the sample size was assessed using the Cohen effect of size. The results were statistically processed using IBM SPSS Statistics (Version 21 for Windows; IBM, Armonk, NY, USA).

RESULTS

The time spent at the prescribed exercise intensity per week ranged between 90-250 min (mean 156.8±48.9 min). Walking time ranged between 82 and 233 min (mean 142.8±45.7 min). In relative description of total exercise time walking ranged from 90.0 % to 93.2 %. The time spent at the described exercise intensity per week ranged between 90-250 min (mean 156.8±48.9 min).

The weekly exercise energy content per kg BM was in subjects with:

- normal BM 20.40 ± 4.51 $kcal \cdot kg^{-1}$ (13.4–25.3 $kcal \cdot kg^{-1}$),
- overweight 20.36 ± 3.00 $kcal \cdot kg^{-1}$ (15.4–24.5 $kcal \cdot kg^{-1}$)
- obese 20.33 ± 3.39 $kcal \cdot kg^{-1}$ (17.6–24.0 $kcal \cdot kg^{-1}$).

Table 2. Values of demographic and selected functional after intervention and their changes in % of starting value of subjects practical and statistical significance of changes upon entry to the study.

Variables	NBM (1)	OV (2)	OB (3)	1-2	1-3	2-3
BM (kg)	73.6±2.0	83.7±2.1	89.6±2.3	* α	** αα	* α
ΔBM (%)	- 6.0±1.9	- 6.9±2.1	- 8.0±2.2	NS	NS	NS
BF (%)	20.2±2.1	25.4±2.4	29.8±2.6	NS	** αα	NS
ΔBF (%)	- 8.6±2.1	- 9.0±2.4	- 9.9±2.7	NS	NS	NS
ECM/BCM	0.80±0.02	0.87±0.02	0.94±0.03	* α	** αα	** αα
ΔBCM/ECM (%)	- 6.2±1.7	- 6.6±1.9	- 7.4±2.0	NS	** αα	NS
$VO_{2peak}.kg^{-1}$ ($ml.kg^{-1}.min^{-1}$) - BM	36.5±2.4	33.8±2.4	29.4±2.7	NS	* α	NS
$\Delta VO_{2peak}.kg^{-1}$ (%)	+ 10.3±2.2	+ 11.9±2.4	+ 12.7±2.6	NS	NS	NS
$VO_{2peak}.kg^{-1}$ ($ml.kg^{-1}.min^{-1}$) - FFM	45.4±2.6	44.8±2.3	43.9±2.7	NS	NS	NS
$\Delta VO_{2peak}.kg^{-1}$ (%)	+ 10.0±2.4	+ 11.1±2.3	+ 12.2±2.7	NS	NS	NS

NBM – normal body mass, OV – overweight, OB – obesity, BCM – body cell mass, ECM – extracellular mas *p<0.05, **p<0.05, $^{\alpha}$ d=0.5, $^{\alpha\alpha}$ d=0.6

The differences in the energy intensity of the implemented walking-based exercise program are independent of the weight status of the followed men. The values of functional and anthropometric parameters in individuals with normal weight are practically identical to the values of untrained Czech men [23,24]. The values in overweight or obese men are fundamentally affected by their body mass and differ significantly from the values of individuals with normal body mass. If we convert the values of oxygen consumption to kg FFM, then we find insignificant differences between the monitored groups. Changes in demographic and selected functional data in % of starting value of subjects upon entry to the study are presented in Table 2.

The mean differences in the values of the ECM/BCM coefficient signal different movement assumptions in men with different body mass§ which reflects their movement regime before the start of the movement intervention. On the other hand, the changes in these ECM/BCM assumptions are the same in relative terms due to exercise intervention and are independent of individual weights.

The mean differences between the monitored anthropometric parameters and oxygen consumption related to kg BM or FFM in our groups of men differ insignificantly ($p<0.05$, d = 0.6) if the changes are expressed in % of pre-intervention values. When comparing extreme individuals in weight groups, the differences may be significant ($p<0.05$, d = 0.5). The differences in the monitored variables due to the implemented movement intervention in absolute values are practically the same as in the pre-intervention parameters.

DISCUSSION

Worse results of anthropometric and functional parameters in individuals with increased weight are largely due to their weight status, which is a consequence of their inadequate exercise regime. Diminished daily physical activity explains, in part, why obesity have become worldwide epidemics. In particular, chair use has replaced ambulation, so that obese individuals tend to sit for approximately 2.5 h/day more than lean counterparts [9,25].

From activities carried out by overweight or obese individuals walking was the most preferred/enjoyed activity for both men and women [14]. Otherwise, the other preferred PA were cycling, swimming and rowing in the Baillot et al. study [26], and dance or Zumba, cycling, water activities, and martial arts in the Joseph et al. [14] study which was performed among women with obesity. The preference for physical activities in these individuals is also determined by what physical activities they have personal experience with, or which PAs they implemented at a time when they were not overweight or obese. Resistance training was less often identified as a preferred type of PA in women but more in men [14].

Walking exercise appears to be an effective exercise, and an active walking program had positive effect on the level of obesity, and significantly reduced body weight, body fat and waist circumference [27]. Also, walking exercise contributed to reductions in body weight and body fat by increasing muscle tissue, maintaining muscular strength and increasing flexibility [28].

The largest changes in preintervention values of VO_{2peak} due to applied movement training are found in obese individuals (12.7 ± 2.6%). This is consistent with the original results of Dempsey et al. [29], which reported in a cross-sectional study that as the workload increased, oxygen consumption increased more rapidly in obese than in lean subjects, leading to the decreased efficiency in obese subjects. Although the activity type and measurement methodology are different from our study.

These reports support our present findings, which suggest that walking serves as an effective exercise for overweight and obese individuals with low movement experience. Therefore, continuous and systematic implementation of such an exercise program is needed.

Increased abdominal fat, among the various criteria used to evaluate obesity, is known to result in decreased balance as it negatively affects flexibility while shifting the musculoskeletal structure [28]. Obesity tends to cause arching of the affected individual's back, and increased stress on the muscles surrounding the spine can result in back pain). Subsequent postural instability can also lead to low back pain and diminished flexibility, and the resulting limited range of motion can lead to secondary inactivity and obesity [9]. The main goal of obesity management is to decrease the size of the fat tissues while minimizing the effects on FFM. Cardiovascular exercise is known to be the very effective at decreasing the amount of accumulated fat by utilizing fat as fuel to produce energy. Walking exercise, like many other cardio exercises, improves cardio-respiratory endurance and increases secretion of growth hormones (epinephrine and nor-epinephrine), which are known to promote loss of accumulated fat.

Assumption changes for PA assessed using the ECM/BCM coefficient are greatest in absolute terms for overweight individuals. This is probably due to the lower volume of spontaneous PA in obese individuals compared to individuals with better weight status. These individuals usually solve the necessary daily activities more often by using a car, for example, than individuals with lower body mass status. It turns out that a sedentary lifestyle is directly proportional to weight and an active lifestyle is very rare in these people [23,26,27].

On the other hand, the current fitness assessed using the VO_{2peak} kg of FFM is practically independent of the weight status of the person, although there is evidence of lower muscle mass in the literature as a result of lower PA. At the same time, it should be recalled that the necessary physical activities performed represent a greater burden on the muscular system of overweight or obese individuals, which is probably reflected by a larger volume of muscle mass compensating for insufficient physical activity, as represented by oxygen consumption values per kg FFM.

Changes in the ECM/BCM coefficient depending on the applied exercise mode show that walking is not only a means of weight reduction, but that at the same time the predispositions for exercise load are also improving - ECM/BCM is moving significantly lower. Our obese patients presented a functional performance similar to healthy individuals. In previous studies, morbid obese individuals presented functional capacity similar to elderly population [29] or to patients with cardiac and pulmonary diseases [30-32].

Brisk walking is a recommended form of exercise for obese individuals. However, lower-extremity joint loads and the associated risk of musculoskeletal injury or pathological disease increase with walking speed. Walking uphill at a slower speed is an alternative form of moderate intensity exercise that may reduce joint loading. These results suggest that walking at a relatively slow speed up a moderate incline is a potential exercise strategy that may reduce the risk of musculoskeletal injury/pathological disease while providing proper cardiovascular stimulus in obese adults.

Walking on an incline at a relatively slow speed is not a common exercise recommendation for obese adults and this may be due to the lack of research on the effects of slow walking speeds and inclines on the biomechanics of walking in this population. In fact, there has only been limited research on the biomechanics of incline walking in non-obese adults, and no studies have examined the combined effects of speed and grade.

Walking is the simplest, most accessible, and preferred method of physical activity prescribed for the treatment and prevention of obesity [27,33]. Additionally, it is important to make walking part of a lifestyle change and incorporate it into daily activities, such as using it as a form of commuting. Exercising in groups also is the preferred method of support to increase physical activity among inactive adults [14]. Though participation rate for our initial pilot project was low, 98% of participants stated that they would use the walking buses again, suggesting that these types of programs may be a viable way to increase physical activity among overweight and obese individuals.

Walking is a popular and comfortable form of physical activity and is part of an effective weight management strategy for obese individuals [14] that increases energy expenditure associated with daily leisure activities. However, the higher energy costs for walking (energy expenditure per unit of distance associated with walking movements) reported in obese individuals compared to lean individuals [31] may contribute to impaired mobility due to fatigue, and thus reduce the energy expenditure of free movements. Experiencing daily activities [ie thermogenesis of untrained activities] and reducing the effectiveness of walking weight management programs.

When recommending exercise for adults with overweight or obesity, it is important to balance any positive with potential negative effects on health. In the general population, exercise is associated with an increased risk of musculoskeletal injuries and adverse cardiac events, but there is evidence from non-randomized trials and observational studies that the benefits of exercise far outweigh the risks in most adults [34]. Musculoskeletal injuries are the most frequent negative side effects of exercise. There is however very little information on musculoskeletal injuries in adults with overweight or obesity during exercise interventions.

To reduce the risk of muscle injuries, it is necessary to provide quality footwear for physical training of individuals with higher body mass. At the same time, it is necessary to pay attention to the walking technique, which is usually not good [35,36] especially for individuals with physical deficits and weight gain, and contributes to faster onset of fatigue, which leads to premature termination of physical intervention and demotivation of individuals for regular physical training.

It is likely that a larger percentage of adults with overweight or obesity falls in physically inactive group compared to lean subjects. On the other hand, the largest benefits on all-cause mortality are attained when this group is moved to an at least “moderately active” level [6,37]. By analogy with the general population, overall it seems prudent to advise habitually inactive adults with obesity to become more active by a gradual progression of exercise volume by adjusting exercise duration, frequency, and/or intensity [35,36,38].

Body mass management, lack of motivation and pain are important PA motives and barriers in people with obesity. PA motives and barriers are both weight and non-weight related in people with obesity. For this reason, weight loss cannot be the only solution to remove PA barriers, and these should be addressed in PA interventions with the support of health professionals to facilitate PA initiation and maintenance. Further research is needed to investigate the PA preferences of people with obesity. Although, one size intervention does not fit all, the improvement of knowledge on PA barriers, motives and preferences would help health professionals to better address them, and develop intervention to reach the larger number of people with obesity in order to decrease physical inactivity in this population.

Study limits

The limits of the study include a limited number of subjects, which makes it impossible to generalize the conclusions. Another limit is that not all men completed the intervention on the same date, some in the spring and others in the fall. The information on the overall exercise regime was evaluated only by questioning and could be inaccurately interpreted. They were all tested by the same instruments on the same day of the week and in the morning.

CONCLUSIONS

We may conclude that, although the groups showed different exercise intensities, but similar overall energy intensity, which regulate fat oxidation, the changes in all parameters monitored were similar between the groups. We can conclude that an exercise program with a similar energy content, form and intensity causes the similar changes in adiposity and in motor and functional performance in middle age men, differing in BM. Movement intervention based on walking reduces body weight and at the same time improves the morphological preconditions for physical activity. The study was supported by grant of Charles University Progress Q 41.

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