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An effect of 12-week Nordic walking training on the body structure and composition in young women

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: The main aim was to analyse the structure and body composition in untrained women after 12-week Nordic walking training.

Material and methods: 26 women were divided into two groups: an EG-experimental group (n = 13) and a CG-control group (n = 13). The EG took part in 12-week Nordic walking training. All participants were examined twice: at the beginning and after the experiment. Body mass, waist and hips circumference; analysis of body composition (BIA method): BMI, body cell mass (BCM), total body (TBW), extracellular (ECW) and intracellular water (ICW); fat (FM), free fat (FFM) and muscle (MM) mass were recorded. The heart rate and lactate concentration were recorded to assess the exercise intensity.

Results: The body composition analysis revealed significant changes: a decrease in ECW and an increase in ICW in the EG group. Insignificant changes were noticed: a decrease in ECW and FM, and an increase in TBW and ICW, FFM, MM and BMR were recorded in the CG.

Conclusions: 12-week Nordic walking training affected the adipose tissue deposition, which prevented fat accumulation in lower body part. The used training was recognised to be a good way to maintain the basal body composition. An increase in ICW and a decrease in ECW at the same time were beneficial for intracellular mechanisms efficiency and prevented swellings.

Key words: Nordic walking training, BIA method, moderate physical exercise/training.

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INTRODUCTION

Human body is composed of many very complex substances and components which interact with each other and form cells, tissues and body organs. Awareness of the complexity of human body leads to the conclusion that its internal structure should be analysed in more detail.

Weighing a person or computing their BMI is not always accurate in indicating overweight, underweight or normal body mass. It is not rare that even athletes can be found overweight if they are evaluated based on BMI only. This is caused by the fact that athletes are characterized by high levels of muscle mass compared to body fat. The mistake in this case would be to encourage athletes to reduce body mass. The opposite pattern can be observed when a person is not involved in any physical activity and is characterized by a low level of muscle mass compared to body fat. However, total body mass may be within standard values. Difference in the appearance of these two people would not be difficult to notice [1, 2, 3].

Higher calorie intake and a low level of physical activity leads to an increase in excess energy stored in body fat, which consequently leads to disturbed balance of body composition components (fat mass and fat free mass, body water) [4]. If continued for many years, such lifestyles may lead to not only general fatigue at middle and older age due to the slowdown of metabolic processes, but also to the risk of various metabolic disorders, including diabetes [5].

Increasing tendencies for greater physical activity have recently been observed in people at different ages, aimed to maintain health and to slow down ageing processes. Nordic walking clubs are also becoming popular among a broad range of various fitness clubs. As Nordic walking started to gain popularity, attempts were made to document health benefits of this type of physical activity. Experiments, experimental results and conclusions show that Nordic walking improves physical capacity more than walking without poles. This is caused by the fact that Nordic walking involves more muscles during the exercise. Experimental results show that around 90% of muscles are activated during Nordic walking with the correct technique. In the case of normal gait, this number is lower by 20% [6]. Oxygen consumption and energy expenditure is also higher, without perceived higher exercise. It is estimated that "burning calories" during technically correct Nordic walking is higher by 30% compared to normal walking. Pulmonary ventilation is also facilitated when a person practices this sport [7–13]. However, it is worth noting that, especially in women, measurable outcomes of the exercise include improved appearance, with particular emphasis on the reduction of excessive body fat. Furthermore, without knowledge of the body structure and body response to physical exercise, even the most perfect technique of motor activity does not guarantee achievement of the set goals. Therefore, the need for learning the abilities of monitoring and interpreting changes in body composition following exercising/training in order to achieve the expected results leads to taking measures towards the analysis of the effects of various forms of so-called healthy physical activity on human body. The results of such analyses would allow for planning (and modifying) the training process so that the effectiveness of such exercise can be predicted with high likelihood (e.g. body fat reduction).

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The main goal of this study was to evaluate the effect of a 12-week Nordic walking training program on the body structure and composition in women aged 19 to 21 years. It was assumed that the goal would be achieved by answering to the following questions: (1) Will a 12-week Nordic walking training program change the structure and selected components of body composition in the examined women? (2) What will be the direction and magnitude of changes in body composition parameters in the studied women as induced by a 12-week Nordic walking training program?

MATERIAL AND METHODS

PARTICIPANTS

The participants were women who were university students of the first year of the university course in cosmetology at the Faculty of Tourism and Health of the Biała Podlaska branch of the University of Physical Education in Warsaw, divided into two groups. The exercise group (EG, n = 13) comprised participants who were not actively involved in any sport but followed only the physical education curriculum for their university course (45 minutes of physical education classes every week at all levels). The control group (CG, n = 13) composed of women with characteristics similar to the exercise group was also examined. The anthropometric characteristics of both groups are presented in Table 1. The study design was approved by the Ethical Commission in the University of Physical Education in Warsaw. All the students were informed about the experimental protocol and the option of leaving the experiment at any time and signed written consent to participate in the experiment. Furthermore, each participant in both groups recorded everyday vaginal temperature over the menstrual cycle. No menstrual disturbances were found based on the analysis of changes in the temperature. Furthermore, each study participant was asked not to modify everyday diets e.g. not to start diets that reduce body mass.

ANALYSIS OF LACTIC ACID (LA) CONCENTRATION

Analysis of lactic acid (LA) levels was also performed using a Lange Plus LP20 analyser to monitor the intensity of physical exercise during certain training sessions. Blood samples of 10 µl were obtained from fingertips for LA measurements.

TRAINING PROTOCOL

Women from the exercise group (EG) participated in a 12-week Nordic walking training program (training sessions twice a week, on Tuesdays and Thursdays, duration of each session: 60 minutes, from 5 p.m. to 6 p.m.). Training sessions were performed in the facilities of the Faculty of Physical Education and Sport in Biala Podlaska, Poland, and supervised by a qualified coach according to a program prepared for non-athletes. Training structure was based on a teaching methodology adopted by the Polish Nordic Walking Federation. Intensity of exercise ranged from 60% to 80% HR_{max}. The heart rate was monitored at selected training sessions in the 1st and 12th week (Polar Electro Oy, Finland). Table 1 illustrates the training structure.

The simultaneous examinations of female non-athletes were also performed with this group (CG, n = 13) characterized by a similar structure compared to EG in terms of body mass, BMI, group size, age and level of fitness.

Table 1. Training structure

Duration	Exercise characteristics	Aim
2 weeks	Nordic walking, general fitness level	- learning the movement and correct technique, i.e. digging the pole into the ground, pushing outside the hip line, arm extension, opening the palm in the final phase of the movement and rhythmic walking with an extended stride
4 weeks	continuous Nordic walking, general fitness level	- improving skills learnt during the first stage of training, - maintaining exercise intensity during the stage of continuous walking at a level of 60-70% HR_{max}
6 weeks	continuous Nordic walking, general fitness level	- maintaining exercise intensity during the stage of continuous walking at a level of 70-80% HR_{max}

Anthropometric measurements and body composition

Body height (accuracy: 0.1 cm), hip circumference (accuracy: 0.1 cm) and waist circumference (accuracy: 0.1 cm) of each studied woman from both groups was measured using generally accepted methods, i.e. waist circumference was measured in the shortest waist measurement position (above the navel) in the upright body position, after exhalation and before the subsequent inhalation. Furthermore, hip circumference was measured in the widest location in the standing position with relaxed gluteal muscles. Both waist circumference and hip circumference were measured three times. Two the same values of measurements were assumed as correct. Body mass was evaluated using electronic scales (Tanita BF-666, Japan, accuracy: 0.05 kg). The body mass index (BMI [kg/m^2]) was computed from the formula:

$$BMI = \frac{m}{h^2}$$

where m denotes body mass [kg] and h is body height [m]. Body composition metrics such as total body water (TBW, [%]), extracellular water (ECW, [%]) and intracellular water (ICW, [%]), fat mass (FM) expressed in [kg] and [%], fat free mass (FFM, [%]), muscle mass (MM, [%]) and basal metabolic rate (BMR, [kcal]) were measured using bioelectrical impedance analysis (BIA) by means of a body composition analyser with dedicated software (Akern BIA-101, Florence, Italy). The participants from both groups were informed about the restrictions connected with correct body component analysis. All the participants were instructed to prepare before measurements, i.e. refrain from alcohol consumption for at least 48 hours before the measurement, empty the bladder and refrain from consumption of fluids for at least 2 hours before the measurement. The menstrual period and consumption of drugs were also among the exclusion criteria. The measurements were performed twice for both groups, in the beginning of the experiment and after its completion i.e. after 12 weeks.

Statistical analysis

Statistical analysis was performed for the results obtained using software for statistical computations (Statistica, v. 6.0). Mean results were computed for all parameters ($\bar{x}$), with standard deviations (SD), expressed in the form of ($\bar{x}$ ±SD). The statistical significance of the results was set at $p < 0.05$. The principle of randomization was met at qualification of the women studied for the experimental and control group using a one-way analysis of variance ANOVA. After verification of the coefficient of variation (%CV) for the studied parameters, the data were log10 transformed in order to normalize their distribution. A one-way analysis of variance ANOVA was performed for EG and CG in order to examine differences between means in individual series of examinations. The relationships between the parameters were established using Pearson's linear correlation analysis.

MATERIAL AND METHODS

Anthropometric characterization of participants is presented in Table 2. A preliminary statistical analysis of the measurements obtained during qualification of the participants for the study found no statistically significant differences between body mass ($p < 0.05$) and BMI ($p < 0.05$).

Figure 1 shows a profile of mean values of heart rate (HR) and changes in lactic acid levels. Heart rate (HR) during 1-hour Nordic walking sessions lead to the conclusion that the exercise was submaximal since heart rate did not reach maximal values in any case, whereas its mean value accounted for ca. 70% of maximal heart rate (HR_{max}=220-age). Furthermore, the exercise induced the increases in lactic acid levels (LA) on each examination day but the value of this parameter did not exceed the anaerobic threshold (4 mmol/l, Fig. 1b) in most women studied (85%).

Table 2. Comparative analysis of changes in selected anthropometric characteristics in women with division into the groups (values were given in the form of $\bar{x}$ ±SD)

	EG, n = 13			CG, n = 13		
	1	2	Δ%	1	2	Δ%
age [years]		19.1 ±0.3			19.6 ±1.3	
height [cm]		171.4 ±3.7			164.3 ±6.5	
body mass [kg]	58.0 ±6.1	58.9 ±6.7	1.6 ±2.6	56.6 ±10.1	56.4 ±9.8	-0.2 ±1.7
BMI [kg/m^2]	19.7 ±1.6	20.0 ±1.8	1.6 ±2.7	20.8 ±2.6	20.8 ±2.6	-0.2 ±1.7
waist circumference [cm]	68.1 ±4.0	67.7 ±3.5	-0.5 ±1.8	67.9 ±5.1	68.6 ±4.8	1.1 ±2.0
hips circumference [cm]	95.2 ±3.4	95.3 ±3.4	0.1 ±1.7	94.6 ±7.7	94.8 ±7.5	0.2 ±1.7

EG – experimental group; CG – control group; 1 – value before the experiment; 2 – value after 12 weeks.

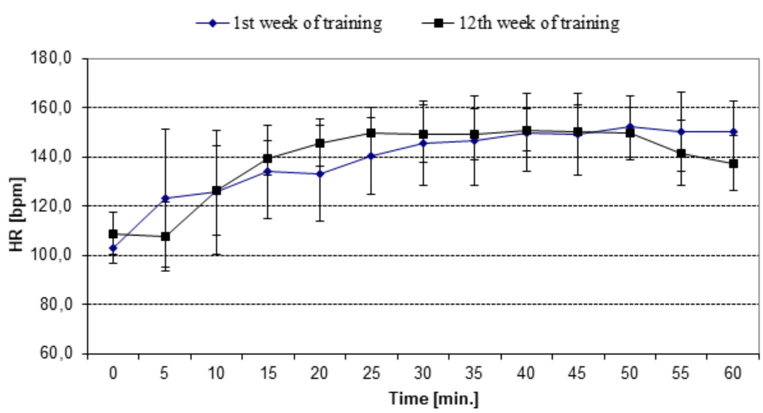

Fig. 1. Profile of the mean heart rate (HR) (a) and changes in lactic acid concentration (LA) in the exercise group (EG) in the first (1) and the twelfth (2) week of training

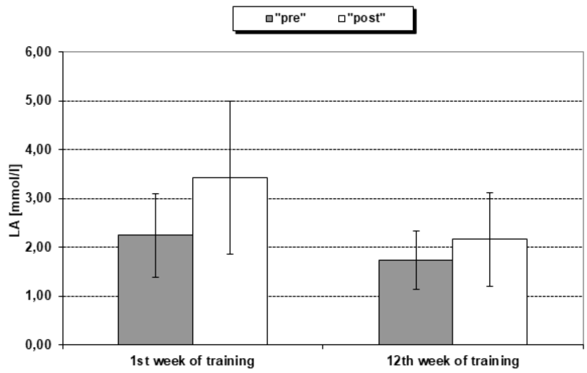

Fig. 2. Profile of the mean heart rate (HR) during individual Nordic walking sessions for the exercise group (EG) in the first (1) and the twelfth (2) week of training

An insignificant increase in body mass was documented after 12 weeks of the experiment, whereas an insignificant decline in this parameter was found in the CG group (Table 2). Furthermore, and insignificant reduction of the waist circumference was observed in the EG group, whereas in the CG group, this parameter was insignificantly higher (Table 2). Analysis of changes in body components of the studied women revealed a statistical decline in ECW in the EG group and a statistically significant increase in ICW ($p < 0.05$) and BMR ($p < 0.01$) (Table 3). Statistically insignificant changes in components of body composition were observed in the CG group, as presented in Table 3.

Analysis of Pearson's correlation coefficients in the EG group revealed significant correlations between changes in: FM [kg] and TBW [%] (r = -0.98), MM [%] and TBW [%] (r = 0.94), MM [%] and FM [kg] (r = -0.92), MM [%] and FM [%] (r = -0.94), MM [%] and FFM [%] (r = 0.94), waist circumference [cm] and body mass [kg] (r = 0.71), waist circumference [cm] and BMI [kg/m^2] (r = 0.72), BMR [kcal] and ECW [%] (r = -0.80), and BMR [kcal] and ICW [%] (r = 0.80).

Table 3. Comparative analysis of changes in selected parameters of body composition of women with division into study groups (values were given in the form of $\bar{x}$ ±SD)

	EG, n = 13			CG, n = 13		
	1	2	Δ%	1	2	Δ%
TBW [%]	54.6 ±3.0	55.1 ±2.9	1.0 ±5.8	53.7 ±3.9	54.3 ±3.5	1.0 ±2.7
ECW [%]	41.4 ±1.7	40.0 ±1.9	-3.3 ±3.5 *	41.8 ±1.9	41.7 ±2.0	-0.4 ±3.1
ICW [%]	58.6 ±1.7	60.0 ±1.9	2.4 ±2.5 *	58.2 ±1.9	58.4 ±2.0	0.4 ±2.2
FM kg]	15.5 ±4.2	15.2 ±4.9	-0.4 ±20.3	16.3 ±6.7	15.8 ±6.3	-1.3 ±11.9
FM [%]	26.3 ±4.8	25.7 ±5.1	-1.2 ±16.2	27.8 ±6.6	27.2 ±6.0	-1.2 ±10.5
FFM [%]	73.7 ±4.8	74.3 ±5.1	1.1 ±6.8	72.2 ±6.6	72.8 ±6.0	1.0 ±2.7
MM [%]	43.3 ±2.9	44.4 ±2.7	2.9 ±5.2	42.4 ±4.0	42.9 ±3.8	1.3 ±3.3
BMR [kcal]	1352.3 ±41.7	1395.6 ±68.6	3.2 ±3.0 **	1327.0 ±70.6	1342.2 ±87.2	1.1 ±3.1

** Statistically significant change p < 0.05; ** Statistically significant change p < 0.01; EG – experimental group; CG – control group; 1 – value before experiment; 2 – value after 12 weeks; TBW - total body water; ECW – extracellular water; ICW – intracellular water; FM -fat mass; FFM – free fat mass; MM – muscle mass; BMR – basal metabolic rate.*

DISCUSSION

Measurement of mean values of the heart rate (HR) at the beginning (1) and at the end (2) of the experiment led to the conclusion that physical exercise was submaximal, since the level of HR did not reach maximal levels on any day of the examinations. Furthermore, based on the HR values at the beginning (ca. 65% of the maximal value) and at the end (ca. 70% of the maximal value) of the experiment, it can be assumed that maximal oxygen uptake in women was ca. 55% and 60% VO_2max, respectively. In most women (85%), lactic acid concentration (LA) did not exceed the threshold of anaerobic changes (4 mmol/l), which indicates that ATP recovery in the working muscles occurred through aerobic processes.

The 12-week Nordic walking training led to changes in deposition of body fat in women from the EG group, i.e. insignificant reductions of the waist circumference at insignificant increases in the hip circumference. The low level of physical activity in the CG group resulted in a tendency for body fat deposition in the areas of both waist and hips. The orientation of these parameters confirms that the training discussed in this study prevents from body fat deposition in upper body parts, which protects human body from numerous diseases, especially those affecting the cardiorespiratory system. [14] Similar results were obtained by Czajkowski et al. in their study that found a substantial effect of Nordic walking training on changes in waist and hip circumferences. However, physical activity of these authors was not the only factor in the observed changes. The participants were also instructed to follow a specific diet. The daily calorie intake was reduced to 1,000 kcal. Therefore, it is impossible to evaluate the body responses induced by Nordic walking training. [15] Reductions in visceral body fat were also documented in studies published by Park, who examined the effect of the same type of exercise on the studied parameters. [16, 17]

It is already known that maintaining an adequate amount of fat mass (FM) compared to fat free mass (FFM) is important with respect to the correct profile of the menstrual cycle. [18, 19] Adequate content of body fat helps maintain energy balance due to effective synthesis of leptin, which is a protein that ensures communication between energy resources in the form of fat and the appetite centres in the hypothalamus, which ensures the efficient appetite regulation [20]. Fat content in women from the EG group in our study exceeded the generally accepted standards (22–25%), with greater fat content compared to fat free body mass (standard: 76–78%). A similar tendency was documented in women from the control group (CG). Insignificant increases in body mass in the group of women participating in Nordic walking training (EG) are likely to have been caused by reductions in FM and increases in FFM, including MM, which were reflected by significant increases in the basal metabolic rate (BMR) ($p < 0.01$). A similar pattern was observed in a study by Sillanpaa et al., who examined the impact of 21-week endurance training in healthy women aged 39–64 years. [21] Furthermore, Martins et al. found no changes in body composition of healthy women (30 ±12 years, BMI=22.7 ±2.3 kg/m^2) participating in 6-week training at moderate intensity (4 times a week, 65–75% HR_{max}) [22]. The most controversy is raised by the results obtained in the group of female non-athletes (CG) who showed a similar tendency in terms of orientation and importance compared to the women from the exercise group (EG). However, the interviews made in order to explain such outcomes revealed that most women from the CG group started additional physical activity (jogging), which was not reported during the experiment. Therefore, the comparative analysis became substantially more difficult.

It is generally accepted that water content in human body (TBW) represents an environment for all life processes that occur in human body [14, 23]. It represents the substrate for digestive processes and a final product of many intracellular processes. It is also a means of intracellular transport of nutrients, hormones, enzymes and other substances. It helps maintain a constant body temperature and regulate arterial pressure. The above-normal TBW levels (58%) were found in the women participating in the experiment (mean value: ~54%). The present study demonstrated that a 12-week Nordic walking training program led to the increase in TBW in all women from the exercise group (EG). Similar results were documented by Quiterio et al. for young athletes (13 years old) following training with various duration (< 4.5h/week, 4.5–8.9 h/week and 9 h/week) [24]. 12-week Nordic walking training led to a significant decline in extracellular water (ECW) ($p < 0.05$) and a statistically significant increase in intracellular water (ICW) ($p < 0.05$). A similar direction of changes in body water was observed in the CG group.

The present study evaluated the effect of a 12-week Nordic walking training on body build and composition of women. Undoubtedly, one limitation of the study is that laboratory settings were not completely maintained (no energy analysis of the consumed meals). The declarations were only obtained from the study participants who claimed that they had not changed anything in their diets, especially in terms of calorie intake restrictions, which was also not maintained. Furthermore, the women from the CG group did not start additional physical activity. Furthermore, the measurements were performed without consideration for days of the menstrual cycle of participants. Only the women who showed no menstrual disturbances had been included in the study.

CONCLUSIONS

A 12-week Nordic walking training program led to an insignificant decline in body fat and increased muscle mass. The training induced a significant increase in intracellular water while decreasing extracellular water levels, which had a positive effect on the efficiency of intracellular processes and prevented from oedemas. Furthermore, the resting metabolic rate was also observed following the training, which leads to the conclusion that this type of exercise prevents from excess body fat deposition (despite using no hypocaloric diets). Limitations of the present study include no analysis of diets of women from both groups.

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