DE GRUYTER OPEN

Pol. J. Sport Tourism **2015**, 22, 64-68
DOI: 10.1515/pjst-2015-0014

Original research papers

THE IMPACT OF TEN WEEKS OF BODYWEIGHT TRAINING ON THE LEVEL OF PHYSICAL FITNESS AND SELECTED PARAMETERS OF BODY COMPOSITION IN WOMEN AGED 21-23 YEARS

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Abstract
Introduction. The aim of the study was to assess the impact of 10 weeks of bodyweight training on selected elements of body composition (body mass, muscle mass, and the percentage of body fat and water) and components of physical fitness (strength, strength endurance, flexibility, and aerobic capacity) of women aged 21-23 years who do not practise sports professionally. ***Material and methods***. The study involved 15 women whose mean age was 22 years 2 months. Their body mass and composition were assessed using a TANITA BC-1000 scale, and the following parameters of physical fitness were measured: the strength and power of the upper and lower extremities; the strength endurance of the shoulders, shoulder girdle, and trunk; as well as their flexibility and physical capacity. The assessment was performed twice, that is before and after the completion of the 10-week programme. ***Results***. The study revealed that the 10-week bodyweight training programme had caused a minor increase in body mass (1.16%) and body fat percentage (2.43%), while muscle mass and body water percentage had not changed. As far as physical fitness is concerned, the bodyweight exercises had had a positive impact on all of the elements of physical fitness which were measured, including statistically significant increases in the explosive strength of the lower extremities (5.6%; $p<0.01$), strength endurance of the trunk (10.7%; $p<0.01$), and aerobic capacity (33.3%; $p<0.05$). ***Conclusions***. Without a properly balanced diet and nutrition control, the bodyweight training programme had a small impact on the parameters of body composition. It was, however, an effective way of enhancing general physical fitness: apart from improving muscle strength and endurance, it also increased physical capacity and flexibility.

Key words: bodyweight training, body composition, physical fitness, female

Introduction

Physical fitness has a major influence on health, appearance, and well-being. A sufficient level of physical fitness guarantees a higher quality of life and helps prevent the development of many “non-contagious diseases”, such as cardiovascular disorders or obesity. According to the concept of Health-Related Fitness (HRF), physical fitness is one of the main factors impacting health [1]. HRF emphasises the importance of maintaining an optimal level of health in terms of the following components: morphological fitness, musculoskeletal fitness, motor fitness, cardiorespiratory fitness, and flexibility. Morphological fitness includes body structure and composition, which, if abnormal, contribute to a higher risk of death and diseases [2]. Musculoskeletal fitness comprises such elements as the strength and endurance of the muscles of the legs, arms, and trunk, a high level of which makes it possible for the entire body to function properly [3]. Low motor fitness, on the other hand, is a risk factor for falls, which frequently lead to bone fractures [4]. Body posture and flexibility also play an important role and insufficient control of the body and reduced trunk flexibility are associated with pain in the lumbosacral region of the spine [5]. However, it is cardiorespiratory fitness that is key in the concept of Health-Related Fitness, as its low level increases the risk of heart disease and premature death [6, 7].

An efficient way of impacting all the components of physical activity listed in HRF is health training, which can have the form of endurance or strength training [8]. Strength training, which has so far mainly been associated with increasing muscle mass by exercising at the gym, can also have the form of bodyweight training, that is exercise using the weight of one's body. This relatively unpopular form of strength training has undergone dynamic development in the past few years, owing to the fact that it benefits muscle strength and endurance and, as is worth emphasising, cardiorespiratory fitness. The advantage of such training is the fact that it includes functional exercises engaging many muscle groups, which additionally help improve balance, prioperception, and flexibility [9]. Moreover, bodyweight training is a plausible option for persons who claim that their recreational physical activity is limited due to a lack of free time and financial difficulties [10]. Such persons could take advantage of the fact that bodyweight training can be done at home, takes a comparatively short time (12-40 minutes depending on the training regime), and does not require using special equipment.

Bearing in mind these benefits of bodyweight training, the aim of the study was to assess the impact of 10 weeks of bodyweight training designed by M. Lauren and J. Clark [11] on selected elements of body composition (body mass, muscle mass, and the percentage of body fat and water) and parameters of physical fitness (strength, strength endurance, flexibility, and aerobic capacity) of women aged 21-23 years who do not practise sports professionally.

Material and methods

The study involved 15 women aged between 21 and 23 years. Their mean age was 22 years 2 months. The women's physical fitness and physical features were assessed twice, that is before implementing the 10-week exercise programme (in December 2012) and after its completion (in March 2013). The assessment was done under identical conditions, at the sports hall and gym at the Cracow University of Economics, and it consisted of the following.

1. The subjects' physical parameters were assessed: height was measured using an anthropometer, and body mass and composition, i.e. muscle mass and the percentage of fat and water in the body, were assessed using a TANITA BC-1000 scale. The subjects' BMI (Body Mass Index) was also calculated.
2. The following physical fitness tests were conducted:
   a) standing long jump (cm) – to assess the explosive strength of the lower extremities;
   b) back overhead 3 kg medicine ball throw (cm) – to assess the dynamic strength of the shoulder girdle, back, and stomach muscles;
   c) arm hang (s) – to assess the strength endurance of the shoulder and shoulder girdle muscles;
   d) sit-ups (number of repetitions/30 seconds) – to assess the strength endurance of the trunk muscles;
   e) dynamometer grip test – to assess of the power of grip of the left and right hands;
   f) sit-and-reach test (cm) – to assess flexibility;
   g) Astrand-Rhyming test – to assess aerobic capacity.
3. An evaluation of the subjects' speed and strength capacities was performed using biomechanical methods: the vertical jump was measured using an accelerometer connected to a computer, by means of the Myotest PRO system. The subjects' goal was to jump as high as possible during:
   a) a counter-movement jump (CMJ) with arm swing;
   b) a squat jump (SJ) with no arm swing.

Each of the jumps was done three times, and the one with the best score was subjected to further analysis. The jumping tests made it possible to calculate the following biomechanical parameters:

a) H (cm) – the height of the centre of gravity;
b) P' (W/kg) – derived power in the takeoff phase.

The bodyweight training programme

According to the guidelines set by the authors of the programme [11], the subjects' level of physical fitness measured before they started doing the exercises qualified as "basic". The bodyweight training programme lasted 10 weeks, and in the course of the programme the subjects did not perform any other physical activity. In the first phase (the first 6 weeks) the exercises were done 4 times a week, and in the final one (starting from the 7th week) the participants exercised 5 times a week. The breaks between the training sessions depended on the individual needs of the subjects. The programme consisted of five basic training regimes (ladders, interval set, super set, tabatas, and stappers), which differed in terms of effort duration, exercise intensity, and the number and length of the breaks. During the first two weeks the subjects performed a block of exercises increasing muscle endurance as part of the ladders regime. These exercises were characterised by low intensity and a high number of repetitions. In the third and fourth weeks the subjects did more intensive exercise which emphasised increasing muscle strength in the form of interval set training. In the following two weeks the subjects performed a block of exercises which were to increase power (super set regime) and in the remaining 4 weeks they completed a block of mixed exercises. The latter block contained exercises from the previous regimes that were extended to include tabatas and stappers, which increased the intensity and variety of the training.

The duration of the training sessions was between 12 and 36 minutes, depending on the week of the programme. The exercises were done with varying levels of intensity, and different groups of muscles were exercised during the week (1st session – upper extremity muscles, "push" exercises; 2nd session – lower extremity muscles; 3rd session – upper extremity muscles, "pull" exercises; 4th session – back and stomach muscles; and 5th session – general fitness training). Altogether the subjects spent 48 to 73 minutes exercising during the week. During the entire programme each of the muscle groups was trained for 4 hours 42 minutes, and the total time spent exercising over the period of 10 weeks was 20 hours 8 minutes.

The data collected were analysed using descriptive statistics. The following were calculated for each parameter: the arithmetic mean, the standard deviation, skewness, kurtosis, and variation. Moreover, the Shapiro-Wilk W-test was used to assess whether the distribution of the data was normal. The results of the test showed that the data were normally distributed. Then the Wilcoxon signed-rank test was used in order to analyse the differences for particular parameters between the two measurements. Statistical significance was set at $p<0.05$.

Results

Changes in body composition

An analysis of the body composition of the subjects revealed that the 10-week bodyweight training programme had caused a minor increase in body mass (of 1.16%) and body fat percentage (of 2.43%), while muscle mass and body water percentage had not changed. These results may indicate that the training period was too short to cause positive changes in body composition, which is mainly determined by diet (in approximately 80%) [14, 15].

Table 1. Differences (%) in the physical parameters of the subjects (n=15) before starting bodyweight training (first assessment) and after completing it (second assessment)

Body composition parameter	First assessment (pre-training)			Second assessment (post-training)			Difference between first and second assessment (%)
	X	±SD	V	X	±SD	V	
Height [cm]	164.0	6.74	0.04				
Body mass [kg]	59.42	10.6	0.18	60.09	11.05	0.18	1.16 NSS
Body Mass Index	21.93	2.5	0.11	22.17	2.66	0.12	1.35 NSS
Fat percentage [%]	24.06	7.69	0.32	24.67	7.49	0.30	2.43 NSS
Water percentage [%]	53.26	4.77	0.90	52.85	4.61	0.09	−0.75 NSS
Muscle mass [kg]	42.13	3.67	0.09	42.26	3.81	0.09	0.30 NSS

Note: statistically significant differences: * <0.05, ** <0.01; NSS – differences not statistically significant; "−" – a decrease in the scores between the first and second assessments.

Changes in physical fitness

As for the level of the subjects' physical fitness before and after the completion of the 10-week bodyweight training programme, it was found that the subjects' scores in seven out of nine tests had improved (tab. 2).

An analysis of the results obtained for strength revealed a minor decrease in the dynamic strength of the shoulder girdle, back, and stomach (test: back overhead medicine ball throw), by 3.5%, and in the static strength (test: dynamometer grip test) of the left hand, by 4.2.%. However, an increase in the static strength of the right hand (by 2.4%) and explosive strength of the lower extremities (from 1.7% to 5.6%) was found in the following tests: standing long jump and two types of jumps measured using the Myotest system, that is the counter-movement jump (CMJ) and squat jump (SJ). The differences between the scores for the first and second assessments were statistically significant only for the standing long jump test (improvement by 5.6%; $p<0.05$), and they were not statistically significant for the other tests ($p>0.05$).

The subjects' scores also improved when it comes to the strength endurance of the shoulder girdle and shoulder muscles (test: arm hang), by 30.9%, and of the trunk muscles (test: sit-ups), by 10.7%. The differences were statistically significant for the trunk muscles ($p<0.01$).

Moreover, the bodyweight training programme was proven to have had a positive impact on the flexibility of the subjects: after completing the 10-week programme the subjects' scores in this respect were better by a mean of 2.6% than before they started it. This improvement was probably due to the specificity of the programme which had been implemented, as apart from strength training it also included elements of dynamic stretching.

A very important component of physical fitness is aerobic capacity, which, owing to the specificity of strength training, is often neglected by persons who train at the gym. Isolated exercises targeting particular muscle groups and the loads used are usually so great that they lead to muscle fatigue rather than stimulate the cardiorespiratory system. In this study, however, the subjects' aerobic capacity increased by as much as 33.3% ($p<0.05$).

Discussion

One of the aims of the current study was to describe the differences in the parameters of body composition in women aged 21-23 years who took part in a 10-week bodyweight training programme. Impacting body composition is one of the goals of this type of training, apart from improving physical fitness [11]. Some studies that have explored this issue have pointed to high-intensity training, which constituted a substantial part of this programme (the programme included interval, tabata, and stapper training), as more effective in helping to achieve this goal than typical endurance training, which is also known as 'cardio' [18, 19]. This may be due to the fact that in high-intensity training one switches between aerobic and anaerobic exercises, which has a positive effect on muscle mass and improves the basal metabolic rate for as many as 48 hours after the training [20]. The increased calorie need, combined with a properly balanced diet, is particularly beneficial for persons who have undertaken physical activity with a view to changing their body composition. An additional consequence of doing bodyweight exercise is a visible enhancement of physical appearance due to increasing the muscle tone without excessive growth of muscle mass [21]. This effect seems to be sought particularly by women, who often avoid strength exercise for fear that their muscle mass will develop excessively.

As far as the body composition parameters are concerned, an increase in body mass and fat percentage was found in the participants of the programme, although the differences in this respect were not statistically significant ($p>0.05$). No changes were found for muscle mass or body water percentage.

No studies concerning changes in the parameters of body composition caused by bodyweight training seem to be available in the research literature. Due to the specificity of the training implemented in this study (high-intensity training using in-

Table 2. Differences (%) in the selected components of the subjects' physical fitness (n=15) before starting bodyweight training (first assessment) and after completing it (second assessment)

Physical fitness component	Parameter	Test		First assessment (pre-training)		Second assessment (post-training)		Difference between first and second assessment (%)
				X	± SD	X	± SD	
Strength	Dynamic strength of shoulder girdle, back, and stomach	Back overhead 3 kg medicine ball throw [cm]		706.3	127.4	681.5	147.1	−3.5 NSS
	Static strength of upper extremities	Dynamometer grip [kG]	RH	32.2	4.9	33.0	4.6	2.4 NSS
			LH	31.3	4.9	30.0	5.3	−4.2 NSS
	Explosive strength of lower extremities (power)	Standing long jump [cm]		162.0	20.3	171.7	18.3	5.6**
		Squat jump (SJ)	H [cm]	24.9	4.0	25.4	3.9	2.0 NSS
			P' [W/kg]	39.1	5.3	40.1	5.6	2.5 NSS
		Counter-movement jump (CMJ) with arm swing	H [cm]	31.0	4.6	31.6	4.1	1.9 NSS
			P' [W/kg]	48.4	6.9	50.1	3.1	3.4 NSS
Strength endurance	Strength endurance of shoulder and shoulder girdle	Arm hang [s]		7.8	7.0	11.28	12.4	30.9 NSS
	Strength endurance of trunk	Sit-ups [n]		18.4	4.0	20.6	3.5	10.7**
Flexibility	Flexibility	Sit and reach [cm]		15.1	5.8	15.5	5.5	2.6 NSS
Physical capacity	Aerobic capacity	Astrand-Rhyming test [l/min-1]		1.6	1.0	2.4	0.6	33.3*

Note: statistically significant differences: * <0.05, ** <0.01; NSS – differences not statistically significant; "–" – a decrease in the scores between the first and second assessments; RH – right hand, LH – left hand.

terval sets, tabatas, and stappers), the results of the current study were compared with the findings of other studies concerning the impact of high-intensity training on the selected parameters.

The results of the current study are comparable with the results of other studies only to a certain extent. Similar results for body mass were obtained by Perry et al. [22] and Tjonna et al. [23]: their studies showed that high-intensity training, lasting 6 or 16 weeks, respectively, caused an increase in the body mass of the participants. According to experts [24, 25, 18], high-intensity training also causes a reduction in adipose tissue in the body; however, the results of the current study did not confirm this. The discrepancies between the findings of the studies may stem from the lower intensity of the training used in this study (bodyweight training is not typical high-intensity training), the shorter duration of the exercises, and the fact that the participants' diet was not monitored.

An analysis of the impact of the training on the level of the subjects' physical fitness revealed that the scores for 7 out of 9 tests conducted had improved, including three in a statistically significant way ($p<0.05$).

As for the parameters related to static and dynamic strength, a minor decrease ($p>0.05$) in the scores for the dynamic strength of the shoulder girdle, back, and stomach (test: back overhead 3 kg medicine ball throw) and the static strength of the left hand (test: dynamometer grip) was found. However, the subjects' scores had improved for the static strength of the right hand (test: dynamometer grip), the explosive strength of the lower extremities (tests: standing long jump, counter-movement jump with arm swing, and squat jump). It is also worth noting that the mean differences between the first and second measurements for the standing long jump test amounted to 5.6% and were found to be statistically significant ($p<0.01$). Similar findings emerged in the study conducted by Tabata et al. [26], which demonstrated a positive influence of a 6-week bodyweight training programme on increasing maximal anaerobic power in students of physical education (by 28.0%).

Another finding of the current study concerned the improvement in the strength endurance of the shoulder girdle and shoulder muscles (test: arm hang), and of the trunk muscles (test: sit-ups). The greatest improvement was found for the strength of the trunk muscles, which increased significantly (by 10.7%, $p<0.01$) between the first and second assessments.

From the point of view of preventing cardiovascular diseases and promoting health, one of the most beneficial effects of the training programme was the major improvement in the aerobic capacity of the participants (by as much as 33.3%; $p<0.05$). These results have important implications, since, according to many experts, a low level of aerobic capacity is a major risk factor for heart disease and premature death [6, 7, 16, 17]. An improvement in the physical fitness of the participants of a 6-week bodyweight training programme (by 4.0% compared to a control group who did standard cardio training) was also found by Tabata et al. [26].

To conclude, the current research is one of few studies concerning training which involves using the weight of one's body, which is becoming increasingly popular. Bodyweight training differs substantially from traditional techniques of training at the gym, among others due to the fact that the exercises are done in intervals, and for this reason they not only increase the strength and endurance of the muscles, but they also improve physical capacity. Moreover, this training is functional. The movements of the body are physiological and natural, and they engage many groups of muscles. The exercises additionally stimulate the postural muscles, as well as improving balance, proprioception, and flexibility. The benefits of bodyweight training mentioned above, the relatively short duration of one training session, and the virtually unlimited accessibility of this training make it a particularly useful form of daily physical activity aimed at preventive health. Due to the popularity and availability of bodyweight training, the impact of its different forms on body composition and the level of physical fitness in women and men of different ages is worth investigating further.

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Submitted: August 5, 2014
Accepted: May 26, 2015