SECTION – EXERCISE SCIENCES

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THE EFFECT OF 10-WEEK BODYWEIGHT TRAINING ON BODY COMPOSITION AND PHYSICAL FITNESS IN YOUNG MALES

Authors' contribution:

A. Study design/planning
B. Data collection/entry
C. Data analysis/statistics
D. Data interpretation
E. Preparation of manuscript
F. Literature analysis/search
G. Funds collection

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Key words: intervention, fat loss, strength, cardiorespiratory capacity, agility, flexibility

Abstract:

Aim. The aim of the study was to evaluate changes in body compositions and physical fitness among young males performing 10-week bodyweight training.

Material and Methods. The study examined body height and composition (body mass, fat percentage and body water) in 15 healthy male adults (23.4 ± 3.3 years, 180.3 ± 6.8 cm, 75.7 ± 7.6 kg). The physical parameters included: running speed, agility, explosive power and strength endurance, flexibility and cardiorespiratory capacity. The examinations were conducted before and after 10 weeks of bodyweight training.

Results. The results did not indicate any significant changes ($p>0.05$) in the body composition of the examined men. Improvement was observed in the measured parameters of physical fitness, agility (4.1%, $p<0.01$), dynamic strength of the shoulder girdle muscles, the back and the abdomen (by 12.1%, $p<0.01$), static strength of the right hand (6.7%, $p<0.05$), strength endurance of the upper limbs (by 30.1%, $p<0.01$), strength endurance of the body trunk muscles (7.0%, $p<0.01$), flexibility (20.1%, $p<0.05$) and cardiorespiratory capacity (6.1%, $p<0.05$).

Conclusions. The bodyweight training by Lauren and Clark does not have a significant effect on changes in body composition, running speed or explosive strength of the lower limbs of young men. The training concept leads to significant improvement in muscle strength and endurance, agility, cardiovascular endurance and flexibility, but due to the high frequency and intensity of exercise, it is recommended for young healthy people who have high motivation and determination in the pursuit of self-improvement regarding physical fitness.

Introduction

Nowadays, people undertaking physical activity have specific requirements in terms of objectives and results. Their diverse needs induce specialists to create training programmes tailored to expectations and capabilities. In recent years, programmes aimed at specific goals, such as fat reduction [1, 2], improvement of cardiopulmonary function [3] or muscle strength [4, 5], have been very popular. Currently, the activities of scientists and trainers focus on increasing the effectiveness of individual programmes (maximizing benefits while reducing working time), using high-intensity exercises [6, 7].

Among young people, for whom caring for the body, figure and physical appearance is important, strength exercises are very popular. Unfortunately, they still take on a traditional form, i.e. isolated muscle exercises. They extend working time and only bring benefits to the range of strength, without affecting the other components of physical fitness. Bodyweight training seems to be a very interesting, more effective option [8]. Although the concept is not new, the effectiveness and practicability of such training lead to a gradual increase in its popularity. Bodyweight training was ranked fourth position on the list if top 10 fitness trends in 2018 [9]. Apart from the development of muscular strength, bodyweight training improves balance and flexibility, which is especially important from the standpoint of health prevention and cardiorespiratory endurance [10, 11]. The programme is based on performing functional multi-joint exercises that engage large muscle groups, while the interval nature of training helps to induce the expected responses in a short time (depending on the training regimen, the duration of a training session ranges from 12 to 40 minutes). An additional asset of bodyweight exercises is that the athlete does not need to have access to special equipment and training sessions can be easily performed anywhere, even at home.

Studies in international literature have examined the effect of bodyweight training on the physical fitness of employees of uniformed services, including police officers [12, 13] and soldiers [14, 15]. One can also find reports which regard this type of training for seniors [16]. However, few studies have evaluated the effects of bodyweight training among young adults [17, 18]. Physical exercises in this period of life seem to be particularly important, as young people who begin adulthood often stop practicing sports, and the main reported barrier being the lack of time due to fulfilling new social roles (starting a job, looking for a job, starting a family, etc.) [19, 20]. Appropriate training programmes with relatively short training sessions, unlimited access (no need for training equipment) and the benefits of improving many fitness components may encourage young adults to continue training, which will affect their quality of life in the future.

Therefore, the aim of the study was to determine changes on body composition (body mass, percentage of fat and water in the body) and physical fitness parameters (running speed, agility, explosive power and strength endurance, cardiorespiratory capacity, flexibility) in young males performing the 10-week bodyweight training by Lauren and Clark [8].

The following research hypotheses were adopted:

1. 10 weeks of bodyweight training contributes to improvement in body composition of young men by reducing fat percentage.
2. The bodyweight exercise programme improves all components of physical fitness (speed, agility, explosive power, strength endurance, cardiorespiratory endurance and flexibility) in young males.

Material and methods

Participants

Examinations were performed twice, i.e., before the beginning of the training programme and after its completion. The first examination evaluated 31 young healthy males. However, for unplanned reasons (illness, injuries, discontinuation of performing the exercise resulting from failure to keep the training regime), the programme was completed by 15 people, who were tested for the second time. The analysis concerned the results of people who completed the programme (n=15, mean 23.4±3.3 years, 180.3±6.8 cm, 75.7±7.6 kg). All participants were volunteers and each participant gave written consent for participation. Furthermore, the study was conducted according to the Declaration of Helsinki, and was approved by the local ethics committee. The participants were not involved in any other physical training programmes at the time of the study while recreational physical activity (1-2 times a week) before the start of research was declared by almost half of the respondents. Each study was preceded by measurement of anthropometric parameters and body composition with the maintenance of the methodology, and a 20-minute warm-up was carried out before the trials. The volunteers were familiarised with the study aim and the measurements were performed in a standard environment of an indoor arena.

Measures

Anthropometric Measurements

The anthropometric characteristics of each participant were evaluated. Body height was measured by means of an anthropometer, whereas body mass and its composition were evaluated using the TANITA BC-1000 electronic scale [21]. Anthropometric parameters of the participants are presented in Table 1.

Physical fitness tests

During one session, nine components of physical fitness were evaluated in the following order: *Standing Broad Jump Test, 5-m Sprint, 10-m Sprint, Handgrip Strength Test, Backward Overhead Medicine Ball Throw, Envelope Run, Bent-Arm Hang Test,* Sit and Reach Test, *Sit Up Test, 20-m Shuttle Run Test.*

a) running speed: *5-m and 10-m sprint* [s]. Each study participant was instructed to run the distances of 5 m and 10 m as fast as possible. The running time was measured with an accuracy of 0.001 s, using the MICROGATE photocell system (Witty, Microgate, Bolzano, Italy - Manual version 1.4: impulse transmission accuracy ± 0.4 ms; delay with respect to the event 1 ms). The start line was coincident with the line of the first photocell gate, whereas other gates were located at the distances of 5 and 10 metres. The participants performed a standing start 3 times with at least 3-minute rests. Further analysis was based on the best results obtained for each distance;
b) agility: *Envelope Run (ER) (5x3 metres)* [s] [22] - participants completed 3 laps of a specified route

Table 1. Percentage differences [%] in body composition parameters of men (n=15) before bodyweight training (examination 1) and after its completion (examination 2)

Parameter	Examination 1 (pre-test)			Examination 2 (post-test)			Difference (%) between examination 1 and 2
	X	±SD	Cv	X	±SD	Cv	
Body height [cm]	180.30	6.84	3.79	-	-	-	-
Body mass [kg]	75.66	7.61	10.05	76.16	7.72	10.13	0.66 SI
Body Mass Index [kg/m²]	23.25	1.79	7.69	23.41	1.89	8.07	0.68 SI
Body fat [%]	14.60	3.16	21.64	14.10	2.46	17.44	- 3.42 SI
Body water [%]	59.70	2.41	4.03	59.36	1.54	2.59	- 0.56 SI

*Notes: X- arithmetic average, SD- standard deviation, Cv – coefficient of variance; significant differences: * <0.05; ** <0.01; ***, 0.001; SI – statistically insignificant differences*

(figure-8 shape). Running time was measured by the MICROGATE photocell system (Witty, Microgate, Bolzano, Italy - Manual version 1.4) with an accuracy of 0.001 s. The start line with the photocell gate was located at a distance of 2 metres from the first pole at the extension of the shorter side of the rectangle. The width of the start gate, which was also the finish gate, was 3 metres. The participants performed the run twice, with an at least 5-minute break, whereas further analysis was based on the better result;

c) dynamic strength of the shoulder girdle, back and abdomen: *Backward Overhead Medicine Ball Throw (BOMB)* [m] [23] – participants threw a 5-kg ball and further analysis was based on the best results of 3 attempts;
d) hand grip for the right and left hand: *Handgrip Strength Test (HGR)* [kg] [22] – hand grip strength was measured twice using a KERN Model MAP 130K1 hand grip tester with an accuracy of 0.1 kg. Further analysis concerned the better handgrip result for the right and left hand, regardless of hand dominance;
e) explosive strength of the lower limbs: *Standing Broad Jump Test (SBJ)* [cm] [22] - further analysis concerned the best results of 3 attempts;
f) strength endurance of the body trunk muscles: *Sit Up Test (SUT)* [n] [22], the number of sit ups performed in 30 s was counted;

Table 2. Characteristics of the first 6 weeks of bodyweight training

Week	Training block	Day	Exercises performed	Time [min.]
1-2	Muscular endurance - *Ladders*	Day 1 and 3 Push/Pull	Push Ups, Let Me Ups, Military Press, Let Me Ins	30
		Day 2 and 4 Legs/Core	Alternating Back Lunges, Alternating 1-Legged RDLs, Toyotas, Hypertension (on the fourth day Russian Twist)	
3-4	Strength Block - *Interval Sets*	Day 1/Push	Push Ups w/feet elevated, Military Press, Close Grip Push Ups, Assisted Dips	36
		Day 2/Legs	Legs: Bulgarian Split Squats, Side Lunges, Toyotas, 1-legged RDLs	
		Day 3/Pull	Pull: Assisted door Pull Ups, Let Me Ups, Let Me Ins, Towel Curls	
		Day 4/Core	Leg Lifts, Supermans, Bicycles, Hyperextensions	
5-6	Power Block – *Super Sets*	Day 1/Push	Push Ups & Shove Offs, Military Press & Thumbs Up, Push Ups & Assisted Drips	24
		Day 2/Legs	1-Legged Squats & Toyotas, Side Lunges & Back Lunges, 1-Legged RDLs & Box Jumps	
		Day 3/Pull	Door Pull Ups & Let Me Ins, Let Me Ins w/4-6 second contraction at top & Let Me Ups, Let Me Ups w/reverse grip and feet elevated & Let Me Ins w/palms up	
		Day 4/Core	Hanging Leg Lifts & Iron Crosses, 1-Legged Hip Extension & Supermans, V-Ups & Russian Twist	

g) strength endurance of arm muscles and shoulder girdle: *Bent Arm Hang Test (BAH)* [s] [22] - overhang time on a stick was measured with an accuracy of 0.1 s;
h) flexibility: S*it and Reach Test (SAR)* [cm] - further analysis concerned the best result of 3 attempts [22];
i) cardiorespiratory fitness: *20-m Shuttle Run Test (20-m SRT)* [level] [22] - the result was the level and section. In addition, the test results were converted in accordance with EUROFIT standards into an estimated VO2max [mml/kg^{-1}/min^{-1}] [24].

Experimental design

Based on the evaluation of physical fitness before training, the participants were classified for the 1st Class Programme of Intermediate Level (the second of the four levels of difficulty) [3]. The participants followed a 10-week bodyweight training programme. In the initial phase (first 6 weeks), exercises were performed 4 times a week, whereas in its final part, 5 days a week. The duration of rests between individual training sessions was arbitrary, according to individual needs. The programme was composed of 5 basic training regimens (*ladders*, *interval set*, *super set, tabatas, stappers*) which differed in exercise duration, number and duration of rest and exercise intensity (Tab. 2 and 3). For the first two 2, participants followed a block which improved muscle endurance and performed ladders, characterised by low intensity and a large number of repetitions (regimen: ladders – training involves 4 different exercises (7.5 minutes each) using the ladder pattern: the athlete performs 1 repetition, followed by the rest period and next performs

Table 3. Characteristics of the "mixed block" carried out by the subjects in the last 4 weeks (7-10 weeks) of the bodyweight programme

Week	Day	Exercises performed	Time [min.]
7	Day 1/Push	LADDERS: Chinese Push Ups, Push Ups, Close Grip Push Ups, Seated Dips	30
	Day 2/ Legs	SUPER SETS: 1-Legged Squats & Toyotas, Side Lunges & Back Lunges, 1-Legged RDLs & Box Jumps	24
	Day 3/Pull	INTERVAL SETS: Assisted Door Pull Ups, Let Me Ups, Let Me Ins, Towel Curls	36
	Day 4/Core	TABATAS: Russian Twist, Flutter Kicks, Squats	12
	Day 5	STAPPERS: Let Me Ups x 6, Side Lunges x 12, Push Ups x 8	20
8	Day 1/Push	TABATAS: Push Ups, Seated Dips, Squats	12
	Day 2/ Legs	LADDERS: Back Lunges, Side Lunges, Toyotas, 1-Legged RDLs	30
	Day 3/Pull	SUPER SETS: Door Pull Ups & Let Me Ins, Let Me Ins w/ 4-6 second pause at top & Let Me Ups, Let Me Ups w/reverse grip and feet elevated & Let Me Ins w/palms up	24
	Day 4/Core	INTERVAL SETS: Leg Lifts w/hands on chest, Supermans, Bicycles, Hyperextensions w/hands under chin	36
	Day 5	STAPPERS: Let Me Ups x 6, Side Lunges x 12, Push Ups x 8	20
9	Day 1/Push	INTERVAL SETS: Push Ups w/feet elevated, Chinese Push Ups w/hands elevated, Close Grip Push Ups w/hands elevated, Assisted Dips	36
	Day 2/ Legs	TABATAS: Iron Mikes, Side Jumps, Squats	12
	Day 3/Pull	LADDERS: Let Me Ups, Let Me Ins, Let Me Ups w/reverse grip, Let Me Ins w/palms up	30
	Day 4/Core	SUPER SETS: Hanging Leg Lifts w/knees bent & Iron Crosses, Alternating 1Legged Hip Extensions & Supermans, V Ups & Russian Twists	24
	Day 5	STAPPERS: Let Me Ups x 6, Alternating Side Lunges x 12, Push Ups x 8	20
10	Day 1/Push	SUPER SETS: Push Ups w/feet elevated and 1-3 second pause at bottom & Shove Offs, Military Press w/feet elevated & Overhead Presses, Close Grip Push Ups w/feet elevated & Assisted Dips	24
	Day 2/ Legs	INTERVAL SETS: Bulgarian Split Squat w/1-3 second pause at bottom, Side Lunges w/4-6 second pause at bottom, Toyotas w/4-6 seconds at bottom, 1 Legged RDLs on pillow	36
	Day 3/Pull	TABATAS: Let Me Ups, Let Me Ins, Squats	12
	Day 4/Core	LADDERS: Bicycles, Hyperextensions w/hands under chin, Hello Darlings, Swimmers	30
	Day 5	STAPPERS: Let Me Ups w/knees bent x 6, Alternating Side Lunges x 12, Push Ups x 6	20

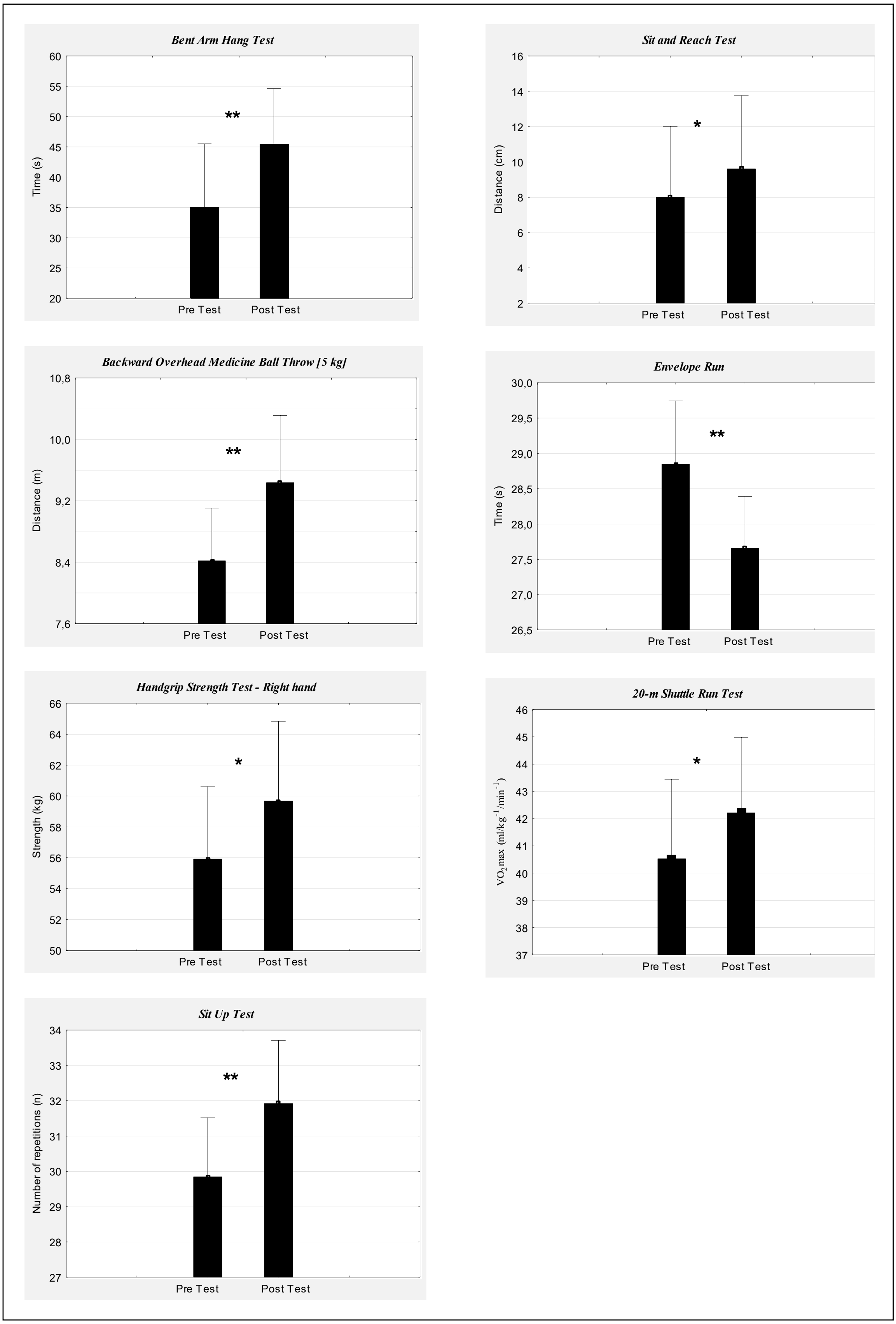

Figure 1. Physical fitness changes between pre-post test. Statistically significant differences: * <0.05; ** <0.01.

2 repetitions, rest, 3 repetitions etc. until reaching the maximum value). The 3rd and 4th week aimed to increase muscle strength using *interval sets* (faster pace of exercises; training consists of 3 sets of each of the four different exercises, one set takes 3 minutes (1.5 minutes of exercises with 6-12 repetitions and 1.5 minutes of rest). In the next 2 weeks, participants performed a block that increased muscle power (regimen: *superset*: 4 minute intervals for each set, perform 1 - 5 reps for the first set, and 6 - 12 reps for the exercise that immediately follows, 2 sets per exercise pair, the first exercise in each pair should be done with slow negative movements (2 - 3 seconds) and controlled, explosive concentric movements (about 1 second) with a 1 second pause at the beginning and end of each movement) whereas the last 4 weeks were based on a mixed block.

The mixed block contained exercises from previous regimens additionally extended with *tabatas* (8 rounds of 20 seconds of exercise followed by 10 seconds of rest, for a total of 4 minutes, exercises should be executed as fast as possible) and *stappers* (performing a cycle of three exercises continuously for 20 minutes: the first exercise with 6 repetitions, the second exercise with 12 repetitions, the third exercise with 6 repetitions) to increase intensity and variety of training.

The duration of training sessions, depending on the week, ranged from 12 to 36 minutes. The exercises were performed at various levels of intensity, whereas training accents were distributed over the week to different muscle groups (session 1: push type muscles of the upper limbs, session 2 - lower limb muscles, session 3 - pull type muscles of the upper limbs, session 4 - muscles of the back and abdominal muscles, session 5 - general fitness training). The total duration of exercises per week ranged from 48 to 73 minutes. During the entire programme, each muscle group was exercised for 4 hours and 42 minutes in total, whereas the total time for exercises over 10 weeks amounted to 20 hours and 8 minutes.

Statistical Analysis

The STATISTICA 12 PL (for Windows) software was used for statistical analysis of data. First, the results were tested for normal distribution using the Shapiro-Wilk test (for $n<100$). The results demonstrated that the distribution of the features is not consistent with normal distribution. Therefore, the evaluation of significance of differences between the test results in the first and second examinations was based on the Wilcoxon signed-rank test. The level of significance of differences was set at $p<0.05$. The basic measures (i.e., percentage distribution, means, standard deviations, confidence intervals and coefficients of variation) were also computed.

Results

The results indicated that bodyweight training did not have a significant effect ($p>0.05$) on changes in body composition components in the men studied (Tab. 1). Insignificant increases were revealed in body mass (by 0.7%) and while insignificant reduction was observed in body fat percentage (by 3.4%).

In terms of physical fitness, improvement was recorded in all measured parameters, with significant progress ($p<0.05$) observed in 7 of the 9 tests (Fig. 1). The training programme did not have a significant effect on running speed and explosive strength of the lower limbs (by 1.7%-2.1%, $p>0.05$). Significant changes were found in flexibility (4.1%, $p<0.01$), static strength (6.7%, $p<0.05$), strength endurance of body trunk muscles (7.0%, $p<0.01$) and cardiorespiratory capacity (6.1%, $p<0.05$). Slightly greater progress of results was recorded in the dynamic strength of the shoulder girdle muscles, as well as the back and abdominal muscles (12.1%, $p<0.01$) and flexibility (20.1%, $p<0.05$). The highest changes in percentages were observed for strength endurance of the upper limb muscles (by 30.1%, $p<0.01$).

Discussion

The exercise programme did not cause any significant changes in body composition components among the men under study. Similarly, no significant changes in the components of body composition following identical bodyweight training were documented in the group of young women [17].

Analyses of the effectiveness regarding various types of training programmes designed to reduce body fat have demonstrated the superiority of interval training over conventional cardio regimens [1, 2, 25]. The exercise programme that involved *interval sets*, *tabata* and *stappers*, also had interval training nature, with the major benefit of such regimens being the improvement in basal metabolic rates even up to 48 hours post-exercise [26]. The lack of significant changes in body composition components can result from a too short a period of training (only 10 weeks) or the lack of food control (calorie intake). A substantially higher effect on the reduction in body mass and body fat is observed for diets (80.0%) compared to physical activity (20.0%) [27].

In terms of physical fitness, improvement was documented in 7 out of 9 of the evaluated fitness components. When analysing strength parameters, increases were found in strength endurance, arm, shoulder girdle (*BAH* – by 30.1%, $p<0.01$) and dynamic strength of the muscles of the shoulder girdle, the back and the abdominal muscles (*BOMB* – by 12.1%, $p<0.01$). Significant progress was also observed in static hand grip strength (*HGR* - 6.7%, $p<0.05$) and strength endurance of the body trunk (SUT – 7.0%, $p<0.05$). A similar training regimen used in the group of women [17] led to improvement in strength endurance of the arms and shoulder girdle (*BAH* – by 30.9%, $p>0.05$) and body trunk (*SUT* – by 10.7, $p<0.01$). Furthermore, significant improvement was found in the case of dynamic strength of the lower limbs (*SBJ* – by 5.6%, $p<0.05$), which was not observed in the studied men (2.1%, $p>0.05$). Greenlee et al. [28] and Crawey et al. [12] did not note significant improvement in the dynamic strength of the lower limbs following bodyweight training either.

An additional benefit of the programme was the use of stretching exercises during each training session [8]. Improvement in flexibility (*SAR* – by 20.1% ($p<0.05$) was observed, which can be regarded as an exceptionally beneficial change in the context of prevention of injuries and back pain [29]. No significant changes in flexibility (2.6%, $p>0.05$) following a similar training programme were documented in the group of young women [17], the differences in changes to have likely been caused by a lower level of this component before training.

Exercise also led to improvement of agility (ER by 4.1%, $p<0.01$), contrary to the adults who followed a 16-week high-intensity bodyweight circuit training programme [28].

Enhanced cardiorespiratory capacity (*20-m SRT* by 6.1%, $p<0.05$) seems to be especially critical to health as it is claimed to be a key factor in combating diseases of affluence (obesity, type 2 diabetes, arterial hypertension, etc.) and reduction in premature death rates [3]. Comparison of the author's findings with the reports presented by other authors reveals a 4.0% improvement in aerobic capacity among the people who followed 6-week bodyweight training regimens [30]. Furthermore, high-intensity strength training performed for 6 to 16 weeks in a group of healthy adults led to improvement in VO_2max from 6.0% to 7.0% [28, 31, 32]. Even more improved cardiorespiratory capacity (by 33.3%) due to bodyweight training was observed in the group of young women [17].

Despite beneficial changes in most of the physical fitness parameters, the assumption of the programme's author with discretionary (according to the individual needs) distribution of rests between individual training sessions [8], raises certain doubts. Performing exercises without a rest day can limit their effectiveness because the level of changes induced by training largely depends on the adopted strategy of removing fatigue and recovering strength [33]. Therefore, the adoption of guidelines which indicate that training with the highest load should be followed by a rest day, although this requires greater discipline from the participants, can lead to greater changes while minimising the risk of overtraining or injury.

The present study has some limitations. One of them is the lack of a control group and the control of diets of study participants, which prevents formulation of an unequivocal conclusion regarding the extent to which the observed changes result from the exercise programme or disturbing factors (learning effect during performance of tests, nutrition and supplementation). It should also be emphasised that the results concern a group of men in a narrow age range (i.e., 20 to 30 years). This limits the opportunities for generalisation of the results, since the sex and age of the respondents can impact the changes in both somatic parameters and physical fitness. Another limitation is the inability to assess the effectiveness of the periodisation adopted in the programme (high intensity periods with less demanding exercises) because the results do not provide information about the dynamics of changes concerning individual fitness components during the programme, but only about their level after 10 weeks of exercise. Without intermediate tests (between the period before and after the test), it is not possible to say whether the observed effects are the highest or whether they have been achieved earlier, and regression is observed in the following weeks. Therefore, the results of indirect research may be useful in the examination of experimental exercise programmes, allowing to determine the dynamics of training adaptations.

In conclusion, it should be emphasised that bodyweight training seems to be an excellent form of physical activity for young healthy people. It does not require any equipment, and the exercises are functional while engaging many muscle groups. This training also stimulates the development of postural muscles and improves proprioception and agility. Despite its utilitarian nature (training time, lack of equipment) and advantages (improvement of physical fitness), this training concept is not recommended for everyone. The limitations are high demands on the participants resulting from the frequency and intensity of the exercises. 5 training sessions a week require a lot of determination and perseverance, along with high intensity of earlier preparation. In beginners (untrained), this type of exercise may increase the risk of injuries. In the author's research, despite the fact that the participants were young, highly motivated and determined men who declared earlier physical training (they were not beginners), and voluntarily took part in the programme, over half of them did not complete the programme. It seems that such programmes should be mainly aimed at young healthy people who have high motivation and determination in the pursuit of self-improvement in the field of physical fitness.

Conclusions

The bodyweight training by Lauren and Clark does not have a significant effect on changes in body composition, running speed and explosive strength of the lower limbs among young men. The training concept leads to significant improvement in muscle strength and endurance, agility, cardiovascular endurance and flexibility, but due to the high frequency and intensity of exercise, it is recommended for young, healthy people who have high motivation and determination in the pursuit of self-improvement regarding physical fitness.

Conflict of interest

The author states no conflict of interest.

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