Physical fitness improvement after 8 weeks of high-intensity interval training with air bike

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ABSTRACT

Physical fitness is an important part of overall health and its level does not have a positive trend in the long term. High-intensity interval training (HIIT) is a popular form of exercise that has been repeatedly proven as a functional way of developing cardiorespiratory fitness. Air bike is a widespread cardio machine suitable for HIIT. The aim of this research was to verify the effect of HIIT using air bike on the development of selected physical fitness parameters and compare it to moderate-intensity continuous training (MICT). Twenty active young adults (age 22.1) took part in the research. The participants underwent a complex strength and endurance test, a spiroergometric examination, and a body composition analysis. The experimental group (EG) did HIIT twice a week with work intervals (15–45 seconds), while the control group did MICT in a comparable time period. The results have shown significant improvement in back squat (8.25 %), pulling strength (7.07 %), aerobic endurance (18.74 %), and VO_{2peak} (10.62 %). Comparison of the groups has shown a significant difference in bench press (ES=1.01), back squat (ES=0.68), anaerobic endurance (ES=0.97), aerobic endurance (ES=1.456), and VO_{2peak} (ES=0.92). According to the results, we can conclude that HIIT using air bike is an effective way of developing multiple aspects of physical fitness and is thus suitable for training programs that aim to develop health and sports performance.

Keywords: cardiorespiratory fitness, VO_{2peak}, endurance, strength, body composition

Highlights

- Air bike is a suitable tool for HIIT and the development of physical fitness
- HIIT with an air bike develops the upper and lower body strength
- HIIT with air bike is more effective in the short-term program than running MICT

INTRODUCTION

Physical fitness is an essential part of health and is directly connected to the quality of life, development of diseases of civilisation or mortality (da Silva Machado et al., 2019). The main aspects of physical fitness are cardiorespiratory fitness, strength, flexibility, and body composition. The secular trend clearly shows a negative trend, especially in cardiorespiratory parameters (by 2.4 % per decade) and in an increase of body fat percentage (Lamoureux et al., 2019; Blüher et al., 2019). That is why it is important to look for effective training programs developing physical fitness.

High-intensity interval training (HIIT) is a popular form of exercise used to improve sports performance and health (Gibala & Jones, 2013). HIIT is an activity specific for its short intense intervals with prescribed rest periods. Although HIIT protocols used might be rather variable (number and length of the intervals, type and length of the rest periods, chosen intensity, chosen exercise, etc.), their effect on improving endurance, reducing the amount of body fat and developing cardiorespiratory fitness is shown in short-term interventions (Keating et al., 2017; Sultana et al., 2019).

Cardiorespiratory fitness, body composition, and strength parameters are most likely the most significant factors influencing overall health and quality of life. The effect of HIIT on developing VO_{2peak} or reducing body fat percentage has been proven repeatedly (Batacan et al., 2016; Sultana e tal. 2019). The activation of muscle fibres during HIIT and sprint-interval training (SIT) especially is similar to the activation during resistance training, and analogic adaptation mechanisms can be expected (Callahan et al., 2021). Optimally designed HIIT or SIT could positively affect a wide spectrum of physical fitness aspects.

Very frequent activities used in HIIT are running, cycling or rowing (Laursen et al, 2002; Menz et al., 2019). It is shown that due to their different nature, they lead to unequal physiological reactions (maximal HR, blood lactate, VO_{2peak}). The activity used is an important factor in the efficiency and effect of a HIIT protocol and it is crucial to have detailed information about this variable.

Air bike is already a widespread cardio machine used by the general population, individuals with health problems, and professional athletes. It gained great popularity especially in the context of strenuous exercise like HIIT. Air bike differs significantly from classic endurance disciplines. The riding has a low frequency, is more strength-based and works both upper and lower body. The load during the ride is created by a big flywheel and its resistance grows exponentially with the increase of speed. Air bike is a comfortable cardio machine from the user's point of view (Looney & Rimmer, 2002), yet it also allows for high to maximal intensity (Schlegel & Křehký, 2020).

Most of the studies assessing the effect of air biking used ramp test and analysed maximal intensity in the context of spiroergometry. So far, there is a small number of intervention studies. Moreover, they focused only on specific groups, such as people with type 2 diabetes, seniors or patients who had suffered a myocardial infarction (Hwang et al., 2016; Kim et al., 2017). The aim of the study was to verify the effect of a HIIT protocol with air bike on developing cardiorespiratory fitness, strength and endurance parameters, and change in body composition.

METHODS

The experimental group comprised 22 healthy, physically active individuals (average age 22.1, weight 70.6 kg, height 172.5 cm). Participants (14 women, 6 men) were introduced to the testing and research process. Participants were divided into experimental (EG) and control (CG) groups randomly. They were supposed to not change their usual daily routines or sleeping and eating habits during the research. A rest day was prescribed one day before the testing. The anthropometric parameters were measured using bioimpedance scales (Tanita® RD-545), specifically weight, fat-free mass (FFM), body fat percentage, body mass index (BMI). Potential participants who engaged in other intense sports activities were not allowed to take part in the research. The participants who missed more than one workout session (n=2) were excluded from the final analysis.

Testing

The testing was done using an air bike (Echo bike, Rogue®). It was preceded by a very light 3 minutes warm-up and 3 minutes passive rest. The testing protocol was a ramp test to failure, the load was increased every 3 minutes with no break (Lamont et al., 1992). The test was ended when the subject was not able to maintain the required speed. In spiroergometry (METAMAX® 3B, CORTEX Biophysik GmbH), the following parameters were measured: VO_{2peak}, respiratory equivalent ratio (RER), heart rate (HR), minute ventilation (V'E), oxygen uptake to work rate (VO_2/WR) and total test time that corresponds to absolute endurance performance (Total). So far, there are not enough studies that would use ramp tests on air bike, so it was necessary to rely on own experience combined with researches by Lamont et al. (1992), Hoffman et al. (1996). The increasing intensity in the individual levels was organized by RPM (revolution per minute) and it differed for men and women, the base value was 40 RPM (85 watts) for men and 35 RPM (65 watts) for women.

All the participants had had previous experience with the selected strength tests. The following exercises were chosen to test strength: bench press (BP) and back squat (90°) (BS), the subjects had 20 minutes to find their 1 repetition maximum (1 RM) — the number of sets was not limited; pulling strength dynamometer (SH5007, Saehan Dynamometer) (Pull); standing broad jump (SBJ) (they had three attempts, and the best one was recorded, the same principle was used with the back dynamometer). The following tests were used to assess aerobic and anaerobic endurance: 30sec all-out test on an air bike (AN); 2 km on rowing machine test (Concept2®). Flexibility tests were not included in the research as it does not play such significant role in overall health (Nuzzo, 2020).

Intervention

8-Week training program comprising three types of sessions. The experimental group did two workout sessions (HIIT and SIT) on air bike (1. 20 sets: 15 sec work, 45 sec rest; 2. 25 sets: 40 sec work, 20 sec rest). There was a minor adjustment after the first four weeks (1. 20 sets: 20 sec work, 40 sec rest; 2. 25 sets: 45 sec work, 15 sec rest) in order to make the training more variable and maintain participants' motivation. There was a requirement to maintain high intensity during all work sets—significant intensity drop was to be avoided. The rest was passive, the participants stayed seated on the air bike. The first workout session can be called sprint interval training (Gist et al., 2014), but an unconventional work-to-rest ratio of 1:3, or 1:2 respectively, was chosen and the number of intervals was increased as well. The control group did two MICT running sessions (1. 25 minutes run; 2. 30 minutes run). The intensity was kept by monitoring heart rate in combination with the Borg rating of perceived exertion scale. The instruction was to keep heart rate about 70 % HR_{max} and at the same time between 14 and 15 on the Borg scale. The third workout session was the same for both groups and comprised bodyweight exercises with low demands for space and equipment (squat, push up, lunge, plank, sit up, handstand hold). The workout session resembled high-intensity functional training and consisted of two 10-minute parts. The exercise was designed to engage the entire body in a complex way. All the workout sessions contained a general warm-up (5 minutes) and a specific preparation (5 minutes) according to the main part (run, air biking, resistance training).

Figure 1. Study design

Statistical data processing

The data is presented as an average ± SD (standard deviation). Before the statistical testing, to assess statistical significance, data normality was evaluated using two tools: histogram and Shapiro wilk test. In case the normality was confirmed, parametric tests were used, specifically two-sample t-tests for unpaired samples (testing between EG and CG) and two-sample t-test for paired samples (with the premise of an F-test of equality of variances; testing between pre- and posttest in the group). In the case the data was not normally distributed, non-parametric tests were used, specifically for matched testing: Wilcoxon signed-rank test, and for unmatched samples, Mann-Whitney U test. Using non-parametric tests was necessary to ensure coherence of the whole research. To assess statistical significance, Cohen's d with the scale of <0.20 = trivial, 0.20– 0.49 = small, 0.50–0.79 = medium, ≥ 0.80 = large was used (Cohen, 1992). The significance was tested at a significance level of p> 0.05.

RESULTS

Anthropometric parameters

EG noticed only small changes in weight and body composition (fat -0.84 %, ES=0.18, p= 0.169; FFM 0.51 kg, ES=0.04, p=0.316), CG noticed almost no changes. The difference between EG and CG was medium for FFM (ES=0.5, p=0.3), and small for body fat % (ES= 0.28, p=0.56). Although only small changes can be identified, it can be claimed that EG noticed an increase in muscle mass while decreasing the amount of fat. That is why the weight changed only slightly.

Table 1. Testing and body composition results

Strength and endurance testing

EG noticed a statistically more significant improvement in the basic strength test (ES=0.68-1.01, p=0.06-0.17). The greatest improvement was made in the back squat by 6.8 kg. The smallest improvement was made in SBJ, yet the EG still improved more than the CG (ES=0.38, p=0.53). 2 km row test was the only one where both groups made similar changes (ES=0.02). As for the anaerobic endurance test, the EG improved significantly (ES=0.97, p=0.08).

Spiroergometry

Both groups improved their VO_{2peak}, EG by 4,6 ml/kg/min (10.62 %) which was significantly more than CG (ES=0.92, p=0.06). A similar result was noticed also in the total duration of the ramp test where the groups improved by 9.03 % (CG) and by 18.74 % (EG). EG also reached higher RER_{max} in the posttest which meant medium effect in comparison with CG (ES=0.53, p=0.28). EG got a higher value of $V'E_{max}$ (124 l/min) compared to CG (118.5 l/min) which was a significant difference (ES=0.68, p=0.17).

Table 2. Comparison of HIIT and MICT group

DISCUSSION

It was confirmed that HIIT using short intervals is an effective way to develop strength parameters. A positive (even though not significant) progress in isokinetic strength of the lower body (Sökmen et al., 2018) or squat jump (Soylu et al., 2021) was made as a result of running SIT. Although short rest periods were used in our research, there was still significant progress in the upper and lower body strength compared to CG. It seems that not only short intervals of high intensity but also the chosen means (air bike) have potential in strength development. Progress in strength was made also in the bench press (ES=1.01, p=0.06) which proves that air biking develops upper body strength too. Although both groups did one resistance training session a week, it did not lead to a significant improvement for CG. The combination with air bike was more effective.

In the studies (Hwang et al., 2016; Kim et al., 2008) that applied air bike in intervention, the work interval was 4 minutes which was also used in other researches focused on endurance athletes (Stepto et al., 1999; Sultana et al., 2019). In this study, a HIIT protocol with 15-45 sec intervals was used which allowed for higher power output, or higher speed. Air biking is more strength-based which is why it is logical to use SIT or HIIT with short intervals. During shorter and more intense intervals, fast-twitch fibres get more engaged and they consequently adapt more which results in strength parameters improvement (Chalmers, 2008). Especially in SIT, it is very important to maintain the correct form. On air bike, it is easier to maintain the correct form and it does not require any previous experience or a longer time to learn the proper technique.

The same modality in the intervention program and the testing program is a common practice (Rosenblat et al., 2020). The 2 km row test was a nonspecific endurance test—the participants were not introduced to the proper form before or during the research. In the posttest, there were similar positive changes in performance (ES=0.02). The nonspecific test might not show such positive transfer as the Total test, where EG improved significantly (ES=1.456; p=0.006). When designing HIIT programs, it is necessary to take into account coordination/technical or mental adaptation to the specific movement which might affect the test results (Franchini et al., 2016).

To develop cardiorespiratory fitness, differently designed HIIT and SIT sessions with modalities, such as running, cycling or rowing, were found effective (Batacan et al., 2016; Rosenblat et al., 2020; Sultana et al., 2019). Based on significant VO_{2peak} (by 10.62 %) and $V'E_{max}$ (by 7.66 %) improvement, air bike can be also labelled as an effective tool. In this context, Kim et al. (2017) also claim its positive effect on arterial stiffness as another possible result of training programs using air bike. Cervantes (2021) comes with different results when he notices a slight increase in VO_{2peak} following a 4-week intervention, which however did not differ significantly from MICT. It is important to note that a low volume SIT was used (8 sets, 20 seconds work: 10 seconds rest).

Despite there were only small changes in body composition, a certain tendency was found—together with minor fat loss, FFM increased compared to the CG (ES=0.5, p=0.3). This trend can be observed in other authors too (Sultana et al., 2019). More significant changes can be expected in a sedentary population or obese individuals (Keating et al., 2017). In physically active population that undergoes a short HIIT program, only minor body composition changes can be expected. It seems that HIIT using air biking can expand the scale of effective ways to change body composition.

The results prove that different HIIT protocols can lead to a VO_{2peak} improvement. This fact can be influenced by various variables: improvement in strength parameters, change in metabolic flexibility, muscle fibres conversion, improvement in respiration function, improvement in mental resilience towards physical discomfort during exercise, better movement efficiency (Callahan et al., 2021; Dolci et al., 2021; MacDougall et al., 1998). It is difficult to determine which specific factors were dominant in this research. There are, most likely, multiple factors at work in synergy.

A limitation of this research can be seen in the design of the whole intervention where simple bodyweight strength training sessions was also used. It is another variable affecting the whole adaptation of the organism and the final tests. However, the combination of resistance and endurance training is often included in programs aiming at the development of cardiometabolic health (Hunter et al., 2020).

It also has to be noted that even though spiroergometric testing using air bike is not a new method, it begins to gain significance only with this cardio machine's extended usage. It is a nonspecific tool that engages both the lower and upper body. Due to that, it has different demands for, e.g. cardiac output (Schlegel et al., 2020).

CONCLUSION

HIIT has been used for a long time to develop endurance or cardiorespiratory fitness. Given the wide variability of individual programs and modalities, it is necessary to analyse new tools. Air bike is a new tool whose functionality and efficiency has not yet been sufficiently confirmed. It has been shown that HIIT using air bike can positively influence cardiorespiratory, strength and endurance parameters in an 8-week intervention. A significant effect related to the characteristics of air bike is that it affects the strength performance of both the upper and lower body at the same time. Based on the findings of the research, air biking can be recommended as a suitable tool for developing physical fitness and performance. Because this it an original research, more related studies are required.

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Figure 1. Study design

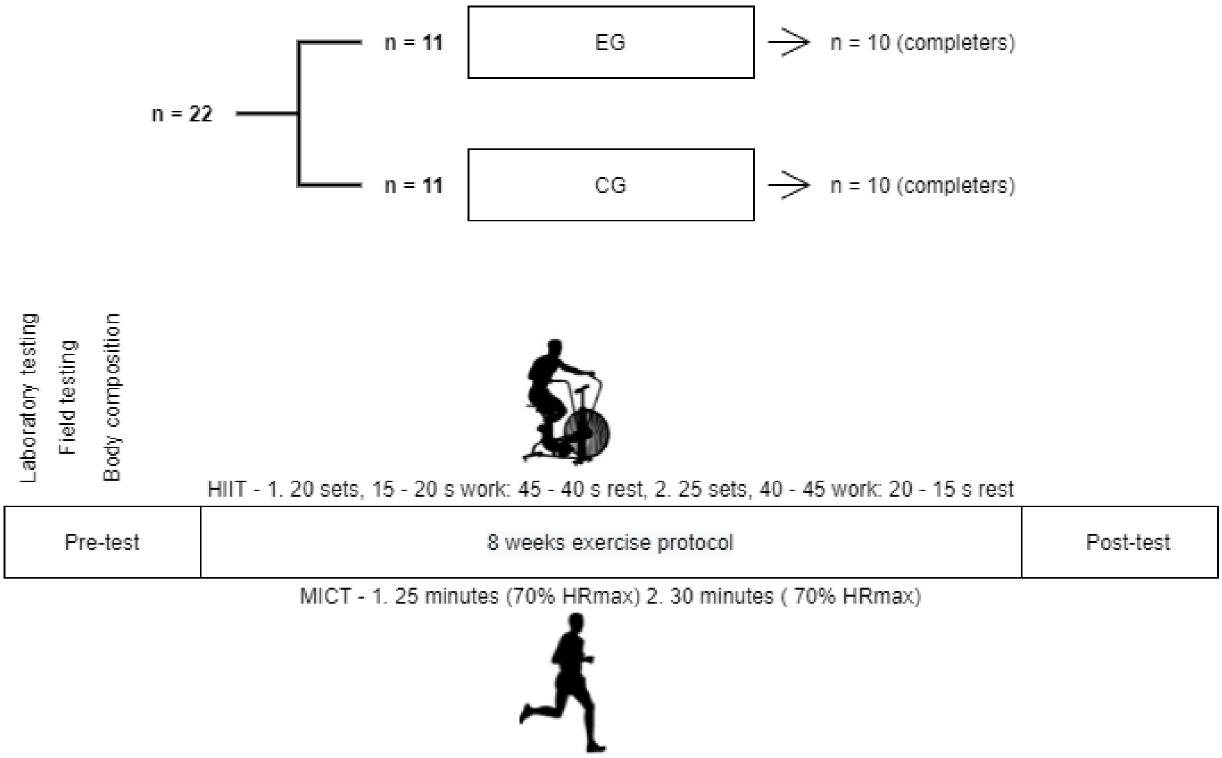

Table 1. Testing and body composition results

	EG						CG					
	PRE	POST	% change	Cohen´s d	p value	Descriptor	PRE	POST	% change	Cohen´s d	p value	Descriptor
Weight (kg)	74.49 ± 13.71	74.29 ± 13.10	-0.27	0.01	0.740	trivial	66.6 ± 9.37	66.07 ± 8.80	-0.80	0.05	0.264	trivial
BMI	24.49 ± 3.09	24.4 ± 2.91	-0.37	0.02	0.611	trivial	22.68* ± 2.28	22.53* ± 2.25	-0.66	0.06	0.476**	trivial
Body fat (%)	18.44* ± 4.64	17.6 ± 4.53	-4.56	0.18	0.169**	trivial	17.41 ± 5.17	17.04 ± 5.02	-2.13	0.07	0.540	trivial
FFM (kg)	57.64 ± 10.84	58.15 ± 10.83	0.88	0.04	0.316	trivial	52.3 ± 8.85	52.18 ± 8.68	-0.23	0.01	0.737	trivial
BS (kg)	82.4 ± 28.75	89.2 ± 31.35	8.25	0.22	0.0117	Small	66.55 ± 19.95	69.9 ± 22.03	5.03	0.15	0.010	trivial
BP (kg)	57.25 ± 22.54	59.25 ± 23.95	3.49	0.08	0.120	trivial	52.05 ± 22.43	50.1 ± 20.30	-3.75	0.09	0.207	trivial
Pull (kg)	183.9 ± 39.29	196.9 ± 36.54	7.07	0.34	0.009	small	148.1* ± 32.29	152.7* ± 34.38	3.11	0.11	0.173**	trivial
SBJ (cm)	215 ± 32.53	223.5 ± 29.02	3.95	0.27	0.018	small	214 ± 33.40	219.5 ± 29.93	2.57	0.17	0.043	trivial
AN (m)	262 ± 29.26	272 ± 28.91	3.82	0.34	0.004	small	249 ± 23.43	251 ± 22.56	0.80	0.08	0.507	trivial
2 km row (s)	530.8 ± 47.89	515.8 ± 50.22	-2.83	0.30	0.025	small	555.7 ± 31.59	534.4 ± 35.05	-3.83	0.64	0.019	medium
Total (s)	862.4 ± 223.56	1024 ± 217.78	18.74	0.73	0.0001	medium	823.9 ± 134.48	898.3 ± 134.98	9.03	0.56	0.0001	medium
VO_{2peak} (l/min/kg)	43.3 ± 5.02	47.9 ± 6.47	10.62	0.79	0.007	medium	44.4 ± 4.88	46.3 ± 5.14	4.28	0.38	0.097	small
RER_{max}	1.11 ± 0.05	1.14 ± 0.03	2.25	0.72	0.177	medium	1.13 ± 0.03	1.13 ± 0.03	0.09	0.00	0.940	trivial
$V'E_{max}$ (l/min)	115.21 ± 24.32	124.04 ± 24.83	7.66	0.35	0.045	small	116.72 ± 24.04	118.45 ± 25.47	1.48	0.06	0.590	trivial
HR_{max} (bpm)	187.5 ± 8.43	190.8* ± 5.93	1.76	0.45	0.110**	small	191.8 ± 7.44	188.6 ± 9.95	-1.67	0.36	0.124	small
VO2/WR (ml/watt)	12.3 ± 1.19	11.6* ± 1.28	-5.69	0.05	0.17**	trivial	12.5* ± 1.63	11.6* ± 0.66	-7.20	0.19	0.11**	trivial

EG – experimental group; CG – control group, FFM – fat-free mas; BS – Back squat; SBJ – standing broad jump; AN- 30 seconds all-out test; Total – Endurance ramp test on air bike; RER – respiratory exchange ratio; HR_{max} – maximal heart rate.

Table 2. **Comparison of HIIT and MICT group**

	EG*	CG*	Cohen´s d	p value	Descriptor
Weight (kg)	-0.20 ± 1.75	-0.55 ± 1.33	0.21	0.66	small
BMI	-0.089 ± 0.51	-0.15 ± 0.53	0.11	0.81	trivial
Body fat (%)	-0.84 ± 1.63	-0.37 ± 1.74	0.28	0.56	small
FFM (kg)	0.51 ± 1.44	-0.12 ± 1.04	0.50	0.30	medium
BS (kg)	6.8 ± 6.48	3.35 ± 3.09	0.68	0.17	medium
BP (kg)	2 ± 3.50	-1.95* ± 4.30	1.010	0.06***	large
Pull (kg)	13 ± 11.82	4.56 ± 8.88	0.80	0.11	large
SBJ (cm)	8.5 ± 8.79	5.5* ± 7.02	0.38	0.53***	small
AN (m)	1.8 ± 1.83	0.30 ± 2.19	0.74	0.14	medium
2 km row (s)	-15 ± 16.75	-15.3 ± 13.84	0.02	0.51	trivial
Total (s)	161.6 ± 76.97	74.4 ± 35.31	1.456	0.006	large
VO_{2peak} (l/min/kg)	4.6 ± 2.76	1.9 ± 3.08	0.92	0.06	large
RER_{max}	0.03 ± 0.05	0.001 ± 0.04	0.53	0.28	medium
$V´E_{max}$ (l/min)	8.83 ± 11.41	1.73 ± 9.31	0.68	0.17	medium
HR_{max} (bpm)	3.30 ± 5.73	-3.20 ± 5.65	1.142	0.02	large
VO2/WR (ml/watt)	-0.7 ± 1.42	-0.9 ± 1.45	0.14	0.77	trivial

*average change between pre- and posttest; EG – experimental group; CG – control group, FFM – fat-free mas; BS – Back squat; SBJ – standing broad jump; AN- 30 seconds all-out test; Total – Endurance ramp test on air bike; RER – respiratory exchange ratio; HR_{max} – maximal heart rate.