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Review

BENEFICIOS DE LA UTILIZACIÓN DE AIR BIKING EN LA SALUD: UNA REVISIÓN SISTEMÁTICA

HEALTH BENEFITS OF USING AIR BIKING: A SYSTEMATIC REVIEW

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RESUMEN

Air bike se ha extendido mucho en todo el mundo y, a menudo, es utilizada por la población en general y los atletas. Para el desarrollo de los aspectos de salud y rendimiento, es necesario un análisis detallado del efecto sobre el organismo. El objetivo del artículo era determinar los efectos de la air biking en el sistema cardiovascular y especificar su uso óptimo. Se realizó una revisión sistemática utilizando la guía PRISMA. Los estudios de investigación se seleccionaron en función de temas de investigación, como “air bike, air braked ergometer, arm-leg, exercise, ergometry, oxygen consumption, rating of perceived exertion, testing, aerobic, fitness, high-intensity, functional, training” que se encuentra en las bases de datos Web of Science, PubMed, Springer y Scopus Se identificaron un total de 65 artículos de texto completo elegibles, de los cuales 26 se seleccionaron para el análisis final. Se dividieron en dos grupos según la forma en que se utilizó la bicicleta de aire: 1. Protocolo de prueba, 2. Parte de un programa de intervención. Air bike es una herramienta adecuada para probar la aptitud aeróbica y anaeróbica no específica. Tiene el potencial de alcanzar valores elevados de frecuencia cardíaca (FC), relación respiratoria equivalente (RER), ventilación y lactato. Parece ideal para el desarrollo de la función cardiorrespiratoria y la salud. Sin embargo, es necesario tener en cuenta el menor número de estudios encontrados, especialmente en el contexto de programas de ejercicio y muestras de investigación seleccionadas. Se necesita más investigación para sacar conclusiones prácticas específicas, especialmente en los programas de intervención.

Palabras clave: brazo-pierna, cardiovascular, alta intensidad, functional training, ergometría, fitness.

ABSTRACT

Air bike has become very widespread worldwide and is often used by the general population and athletes. For the development of health and performance aspects, a detailed analysis of the effect on the organism is necessary. The aim of the article was to determine the effects of air biking on the cardiovascular system and specify its optimal use. A systematic review was performed using PRISMA guidelines. The research studies were selected based on research topics, such as “air bike, air braked ergometer, arm-leg, exercise, ergometry, oxygen consumption, rating of perceived exertion, testing, aerobic, fitness, high-intensity, functional, training” found in databases Web of Science, PubMed, Springer, and Scopus. A total of 65 eligible full-text articles were identified, of which 26 were selected for the final analysis. They were divided into two groups according to the way the air bike was used: 1. Testing protocol, 2. Part of an intervention program. Air bike is a suitable tool for testing non-specific aerobic and anaerobic fitness. It has the potential to achieve high values of heart rate (HR), respiratory equivalent ratio (RER), ventilation, and lactate. It seems ideal for the development of cardiorespiratory function and health. However, it is necessary to take into account the lower number of studies found, especially in the context of exercise programs and selected research samples Further research is needed to make specific, practical conclusions, especially in intervention programs.

Keywords: arm-leg, cardiovascular, high intensity, functional training, ergometry, fitness.

INTRODUCTION

The air bike can be described as a type of stationary bike, which is additionally enriched with two bike's arms allowing the work of arms, respectively the upper body. The movement on the air bike can be divided into two parts. One is comparable to the structure of cycling; the other is original and concerns the work of the upper body, which controls the bike's arms. The pedals and bike's arms are mechanically connected, resulting in a same frequency (Hoffman et al., 1996). The action and the ratio of forces can be freely distributed and also changed at any time. The air bike has two bike's arms, the movement of which depends on each other, they work asynchronously. By means of the construction, they are mechanically connected to the pedals, and together, they rotate the massive flywheel. The bike's arms move in a slight arc, and it is possible to act on them by pulling and pushing.

The air bike's starting point was a stationary bike, which began to appear in the late 19th century (Vandewelle & Driss, 2015). Schwinn was the first company to introduce a product called Air-Dyne in its 1979 catalog. The design is comparable to today's air bikes; the weight was similar (almost 35 kg). As with stationary bicycles, air dyne was equipped with a device containing a stopwatch, a dispensing indicator, distance traveled, and speed (Schwinn catalog, 1979).

Mass expansion had not occurred until the 21st century when the air bike became part of HIFT (high-intensity functional training), HIIT (high-intensity interval training) (Haynes & DeBeliso, 2019). It tends to be part of gyms attended by a wide range of people with reduced fitness or disabilities (Jensen et al., 2019). It is used for health and fitness development. It also found its place in sports training, such as hockey, MMA (mixed martial arts), rugby etc.

At the global level, there is a long-term trend in reducing the level of cardiorespiratory fitness. This is closely related to mortality and quality of life (Lamoureux et al., 2019). Therefore, it is important to find effective ways to affect cardiometabolic health. During air biking, large muscle groups of the upper and lower body are activated. Compound movements requiring the work of large muscle groups are characterized by high consumption of energy substrates (Schlegel & Křehký, 2020). At the same time, there is a need for increased oxygen supply associated with increased respiratory rate and cardiac output (Hoffman et al., 1996). These processes indicate the potential for achieving high physiological values, improving cardiorespiratory fitness, or weight management (Hwang et al., 2019).

For the correct use of the air bike, it is necessary to precisely know the effect on the human body, resulting in the instructions aimed at optimal use for health purposes, fitness development, performance improvement or weight management. On the contrary, improper use can lead to overload, lower efficiency, or improper training volume and exercise intensity settings.

The aim of the article was to determine the effects of air biking on the cardiovascular system and specify its optimal use.

METHODS

The author performed a systematic literature review of available human studies on the research describing air biking, arm-leg exercise, and their effect on physiological aspects. The methodology follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The end of the search period is limited by November 2020. The research studies were selected based on research topics, such as "air bike, air braked ergometer, arm-leg, exercise, ergometry, oxygen consumption, rating of perceived exertion, testing, aerobic, fitness, high-intensity, functional, training" found in the world's acknowledged databases Web of Science, PubMed, Springer, and Scopus. The terms used were searched using AND to combine the keywords listed and using OR to remove search duplication where possible. In addition, a backward search was also performed, i.e., references of detected studies were evaluated for relevant research studies that the author might have missed during their search. Journals focusing on a given topic or systematic review were also used for the search. Also, a Google search was conducted to identify unpublished (gray) literature (research reports, theses, preprints, conference proceedings etc.). The author performed an independent quality assessment of these studies. He read the articles to assess eligibility and to determine the quality. The author selected these basic quality criteria using the Health Evidence Quality Assessment Tool for review articles. The primary outcome of this review was to explore the physiological response of air biking.

All studies were investigated in full, and they were considered against the following inclusion and exclusion criteria:

- Only peer-reviewed English-written full-text journal articles were involved.
- The time of publishing the article was limited to November 10, 2020.
- An air bike or arm-leg exercise has been included in the protocol or program.
- Arm-leg exercise had to be similar to air biking.
- The stress protocol or intervention program had to be clearly defined
- The primary outcome focused on air biking (arm-leg exercise) and physiological responses or adaptation.

The exclusion criteria were as follows:

- The articles focusing on different research topics.
- The primary focus was on elliptical, rowing machine, Versa climber or other aerobic machines.
- The intervention or testing included arm or leg exercise only.
- There was no clear description of the arm-leg exercise.
- PEDro score below 6

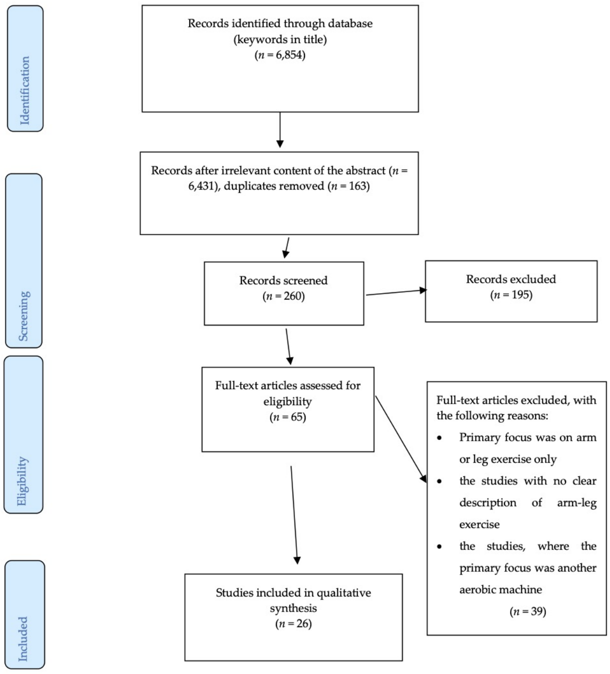

Figure 1. An overview of the selection procedure.

The quality of each article was assessed using the Physiotherapy Evidence Database Scale (PEDro) which has been reported to be valid and reliable to assess the internal validity of randomized controlled trials (Maher et al., 2003). The PEDro scale scores studies using an 11-point scale and includes information about randomization, blinding procedure, statistical analysis, and presentation of the results in the evaluated research. Any studies with a PEDro score below 6 points would have been excluded from the systematic review.

RESULTS

Altogether 6,854 were identified in all these databases. After removing duplicates and titles/abstracts unrelated to the research topic, 260 English-written studies remained. Of these, 26 articles were relevant to the research topic. The designations VO_{2max} and VO_{2peak} are used differently in the studies. The original was cited in the tables and results. In the following text, VO_{2peak} is used, which better describes the given parameter.

Table 1. An overview of the studies using an air bike in the test protocol

Study	N (M/F)	Subjects (age)	Protocol	Main outcome
Nagle et al. (1984)	10 (10/0)	healthy individuals (23,4)	ramp test every 3 minutes, different ratio of arm and leg work	maximum power output and VO2max reached at ratio 10 % arms / 90 % legs
Eston & Brodie (1986)	19 (19/0)	healthy individuals (27,7)	ramp test every 4 minutes	HR (121 vs 121 bpm), oxygen consumption, ventilation (41.1 vs 39.8) and RPE (12.4 vs 12.3) similar with stationary bike
Pitetti et al. (1988)	33 (26/7)	mentally retarded (12-49)	2x 3 minutes (60-85% maximum HR)	suitable instrument for testing aerobic fitness
Lamont et al. (1988)	65 (27/38)	active; high trained; sedentary individuals (29,9)	ramp test every 3 minutes	nonlinear growth of power output to RPM; achievement of VO2max and theoretical maximum HR (183 ± 12 bpm)
Foster et al. (1991)	16 (10/6)	healthy individuals (41-43)	ramp test every 2 minutes, 30 seconds rest between	linear relationship between power output (Watts) and HR
Lamont et al. (1992)	78, 18	healthy individuals; cardiological patients	ramp test every 3 minutes	VO2max and oxygen consumption can be derived based on calculation according to air bike power output and body weight
Brown et al. (1993)	23 (0/23)	active adults (41,5)	1. submaximal intensity (85% maximum HR) 2. ramp test every 2 minutes	VO2max can be derived based on the air bike power output at 85% maximum HR
Hoffman et al. (1996)	9 (5/4)	healthy individuals (32)	ramp test every 4 minutes, 2 minutes rest between	at the same power output (Watts) and RPE was higher ($p < 0.05$) oxygen consumption (0,04 l/min), lactate level, HR than stationary bike
Zeni et al. (1996)	13 (8/5)	healthy individuals (27-35)	5 minutes with different RPE (11,13,15)	lower ($p < 0.05$) oxygen consumption, HR and total energy expenditure than on a treadmill; lower ($p < 0.01$) lactate level than stepper, rowing machine
Allen et al. (1998)	28 (20/8)	healthy individuals (23,2)	ramp test every 2 minutes	unproven effect of ginseng supplementation on VO2max
Donahue (2001)	12 (6/6)	healthy individuals (23)	ramp test every 5 minutes	lower values ($p < 0.05$) of maximum HR, VO2, RPE than StairMaster upright at the same power output
Looney & Rimmer (2003)	16 (4/12)	seniors (82)	5 minutes on different aerobic machines	Nu-Step and air bike as the most preferred (comfort, display visibility, pedal placement)
Garber et al. (2006)	20 (12/4)	patients with peripheral arterial disease	ramp test every 3 minutes	HR (133 vs 135 bpm), RER (1.13 vs 1.09), RPE (16 vs 16), oxygen uptake (16.7 vs 16.2 ml/kg.min) comparable to a treadmill

Kim et al. (2008)	12 (7/5)	obese (37-71)	15 minutes with RPE 11-12 (15 points scale)	higher (p < 0.05) energy consumption, % maximum HR, % VO2peak on elliptical than on air bike, lower values (p < 0.05) on stationary bike
Jensen et al. (2019)	16 (8/8)	active adults (18-25)	5 minutes with different RPE (11,13,15)	lower (p < 0.05) oxygen consumption than on a treadmill and stepper, comparable to an elliptical and stationary bike
Browne et al. 2020)	13 (7/6)	active adults (23-59)	mixed circuit training (air bike and compound exercises); work: rest ratio 6:1	a suitable instrument for HIFT; helps maintain exercise intensity (maximum HR 172 bpm)
Schlegel & Křehký (2020)	12	crossfiters (28,1)	1 minute all out test; Wingate test	air bike as a suitable instrument for anaerobic fitness testing; higher maximum lactate values than Wingate (15.98 vs 14.01 mmol / l); different lactate curve
Schlegel et al. (2020a)	1	crossfiter (35)	HIFT (wall ball, ski erg, toes to bar, air bike); 60 second work : 60-30 second rest	air bike suitable for increasing exercise intensity (up to 170 bpm); high fluctuation of local oxygen saturation in the lateral vastus
Schlegel et al. (2020b)	1	crossfiter (20)	HIFT, 6 minutes work : 2 minutes rest 1. 10x deadlift (100kg), 15 calories air bike 2. 12x lunge (2x20 kg kettlebell), 10x push up, 8x pull up 3. 20 calories SkiErg, 10x back squat 50 kg, 10x toes to bar	significant reduction of oxygen saturation after air bike; significant effect on RER (>1.0) and HR (up to 182 bpm)

Legend: M - men, F - women, HR - heart rate, RER - respiratory equivalent ratio, HIFT - high-intensity functional training, RPE - rating of perceived exertion, RPM - revolutions per minute

Table 1 lists the studies in which the air bike was used in the test protocol, and at the same time, it was possible to reach valid conclusions related to this machine, respectively with the resulting load while riding it. The research sample was mostly made up of healthy adults and was not a large group. The air bike was also used in a group of seniors (Looney & Rimmer, 2003), cardiology patients (Lamont et al., 1992; Garber et al. 2006), mentally impaired (Pitetti et al., 1988), obese (Kim et al., 2008) or performance-oriented athletes (Schlegel & Křehký, 2020).

The stationary bike's efficiency has been repeatedly compared to an air bike (Eston & Brodie, 1986; Hoffman et al., 1996; Donahue et al., 2001; Kim et al., 2008). Testing shows that it is possible to achieve greater efficiency on the air bike in energy consumption, higher VO_{2peak} values or heart rate. However, the conclusions are not uniform. Jensen et al. (2019) report statistically insignificant ($p < 0.05$) differences in oxygen consumption. Eston & Brodie (1986) state comparable minute ventilation. In contrast, when running on a treadmill, participants achieved statistically higher ($p < 0.05$) HR and oxygen consumption at the same subjective intensity (Zeni et al., 1996; Jensen et al., 2019). Only Garber et al. (2006) found identical VO_{2peak} results. Testing on the elliptical yielded conclusions in the form of higher ($p < 0.05$) monitored parameters (energy consumption, HR) than with the air bike (Kim et al., 2008). When comparing traditional aerobic machines, inconsistent physiological responses were found (Zeni et al., 1996; Jensen et al., 2019). But the air bike is one of the subjectively more demanding machines with the potential to more easily increase the heart rate or achieve higher VO_{2peak} values.

The blood lactate parameter is used to monitor the physiological response to exercise. Hoffman et al. (1996) state a faster increase and the potential for higher values on the air bike compared to a stationary bike. The selected test did not run until its termination but was stopped when the 4 mmol/l limit was exceeded. Comparable results were reached by Kim et al. (2008) during continuous work for 15 minutes. Only one study (Schlegel & Křehký, 2020) tested anaerobic fitness using an air bike. The participants were shown to achieve higher lactate levels (15.98 mmol/l) than the Wingate test and showed significant differences in the development of the lactate curve after exercise.

In several cases, graded protocols (ramp tests) have been applied to gradually increase the intensity until rejection (Lamont et al., 1992; Garber et al., 2006). Various grades from 2 to 4 minutes were used, with rests between work intervals in some studies (Foster et al., 1991; Hoffman et al., 1996). These are tests from which it is possible to determine the organism's limit values (e.g. VO_{2peak}, maximum heart rate, minute ventilation) at high load. In the studies by Zeni et al. (1996), Kim et al. (2008), Jensen et al. (2019), a model with a constant load and identical RPE was applied on different machines. Based on these protocols, it is possible to determine the exercise's effectiveness in connection with the subjective evaluation of the load intensity. Based on the results, the air bike feels more difficult. Brown et al. (1993) also worked with constant intensity testing. Here the intensity was set at 85% of the maximum HR. Furthermore, the air bike was incorporated into HIIT resp. HIFT, where it was part of other exercises using body weight or external load (Browne et al., 2020; Schlegel et al., 2020a; Schlegel et al., 2020b). In the selected stress tests, the work interval's time significantly prevailed over the rest (6: 1, 6: 2, 2: 1). RER values (> 1.0) or local oxygen saturation show the potential to increase load intensity.

The relationship between HR, performance, and VO_{2peak} was also monitored. A linear relationship can be established between power increase (in Watts) and HR (Foster et al., 1991). Conversely, a nonlinear relationship arises between the power output and RPM. Lamont et al. (1992) conclude that oxygen consumption can be calculated according to mathematical formula (based on VO2peak, maximum HR), and thus, the intensity of exercise can be regulated. The opposite procedure is provided by Brown et al. (1993), which derives VO_{2peak} based on submaximal loading.

Air biking allows different arm and leg involvement, which can be reflected in the performance. Nagle et al. (1984) tested the work of the upper and lower body in different proportions. The optimal ratio for the performance was shown in the ratio of 90-10% and 80-20%, and the outputs were comparable. When transmitting 30% to the arm, the performance decreased significantly. The most significant difference was then observed in the independent work of arms or legs.

Table 2. An overview of the studies using the air bike as part of the intervention

Study	N (M/F)	Sample	Duration	Program	Main outcome
Pitetti & Tan (1991)	12 (7/5)	mild mentally retarded (25)	3x weekly, 16 w	maximum 25 minutes, 50-70% VO2peak	increase of VO2peak (4.3 ml/kg.min), peak ventilation (8/min)
Fernandez & Pitetti (1993)	7 (5/2)	individuals after cerebral palsy (29-33)	2x weekly, 8 w	30 minutes, 40-70% work capacity	physical work capacity increase (p<0.01)
Nyquist-Byttie et al. (2007)	7 (-/-)	patients after myocardial infarction (-)	3x weekly, 12 w	40 minutes, 75-85% maximum HR (air bike,	increased test duration by 22% RER by 10%, power output 10.2%; air

				arm ergometer ARM ExTR, NuStep)	bike as a suitable instrument for patients
Kim et al. (2015)	25 (-/-); HIIT (12), MICT (13)	seniors and postmenopausal women (65)	4x weekly, 8 w	HIIT - 40 minutes, 90 a 70% maximum HR MICT - 47 minutes, 70% maximum HR	improving arterial stiffness in MICT (9.26 vs 8.75 m/s)
Hwang et al. (2016)	35 (16/19); HIIT (17), MICT (18)	healthy seniors (55-79)	4x weekly, 8 w	HIIT - 4x4 minutes 90% maximum HR, MICT - 32 minutes 70% maximum HR	greater improvement in VO2peak (11%), ejection fraction (4%) in HIIT; decreased insulin resistance (26%) in HIIT
Kim et al. (2017)	35 (16/19); HIIT (17), MICT (18)	healthy seniors (55-79)	4x weekly, 8 w	HIIT - 4x4 minutes 90% maximum HR, MICT - 32 minutes 70% maximum HR	improved aortic pulse wave velocity by 0.5 m/s; improved arotid artery compliance (p>0,01) in MICT
Hwang et al. (2019)	58 (30/28); HIIT (23), MICT (19)	diabetics II. type (46-78)	4x weekly, 8 w	HIIT - 4x4 minutes 90% maximum HR, MICT - 32 minutes 70% maximum HR	improvement of VO2peak by 10% (HIIT) a 8% (MICT)

Legend: M - men, F - women, w - week, HIIT - high-intesity interval training, MICT - moderate intensity continuous training, HR - heart rate

The air bike was also used for the intervention programs. These are specific research samples involving seniors (Kim et al., 2015), diabetics II type (Hwang et al., 2019), patients after myocardial infarction (Nyquist-Byttie et al., 2007) or individuals after cerebral palsy (Fernandez & Pitetti, 1993).

Exercise programs were shorter, between 8 and 16 weeks, with a frequency of 2-4 times a week. The content of the interventions was based on continuous and interval loading, lasting up to 40 minutes. The intensity ranged from 70-90% maximum HR.

The studies did not have the same focus but mostly looked at the effect on cardiovascular system's function and condition. Improvement in arterial stiffness (Kim et al., 2017), development of VO_{2peak} by up to 11% (Hwang et al., 2016), or aortic pulse wave velocity of 0.5 m / s was confirmed (Kim et al., 2017).

DISCUSSION

The aim of the review was to analyze studies dealing with air biking with subsequent determination of effects on the cardiovascular system and optimal use of air bike.

Air biking is based on stationary bike movement, so they have been repeatedly tested simultaneously (Eston & Brodie, 1986; Hoffman et al., 1996). The main difference is the involvement of the upper body; the bike's arms allow pushing and pulling, which results in the activity of many muscle groups. It increases the demands on oxygen supply and the function of the cardiovascular system. The air bike can achieve higher VO_{2peak}, ventilation, lactate, or HR values (Stenberg et al., 1967; Gleser et al., 1974; Hoffman et al., 1996; Kim et al., 2008). The added arm work increases exercise effectiveness, which is suitable for health-oriented programs or weight management. Another difference is the difficulty of pedaling, which increases exponentially with increasing speed (Foster et al. 1991). Also, a lower cadence can be stated compared to cycling.

From the point of view of VO_{2max}, 10-19% higher values were found than leg work only (Gleser et al., 1974; Reybrouk et al., 1975). Similarly, Secher et al. (1974) report 106% in combined work versus the bike. Higher efficiency in terms of HR and ventilation was found in Bevegård et al. (1966). In contrast, lower VO_{2max} values of 4-10% were found compared to the treadmill (Bergh et al., 1976; Kostuck et al., 2020). At maximum effort, HR was measured in the range of 185-189 bmp (Bergh et al., 1976; Secher et al., 1977; Volianitis & Secher, 2002; Kostuck et al., 2020).

It seems the body cannot optimally saturate all the necessary muscles with oxygen under high load, which results in a reduction in blood flow to the arms by up to 19%. On the contrary, when arm cranking is added to pedaling, the leg blood flow decreases by 10%. The resulting vasoconstriction is probably caused by arterial baroreflex (Volianitis & Secher, 2006). This condition also puts high demands on cardiac output, which can be the main limit when delivering high (maximum) performances. Thanks to the complex (strength requiring) involvement of the body, it is easier to reach the point where performance is limited due to insufficient oxygenation. It is one of the reasons why lower values of maximum HR are achieved compared to running (Bergh et al., 1976; Zeni et al., 1996; Kostuck et al., 2020. Therefore, it is important to optimally set the form of exercise and clearly specify which fitness parameter should be developed.

The air bike's arms are structurally connected to the pedals, and they, therefore, work at the same frequency. The overall performance can be affected by different arm and leg involvement. It appears that the optimal ratio should be 90/10% or 80/20% in favor of the legs (Bergh et al., 1976; Nagle et al., 1984). Other ratios lead to reduced performance, VO_{2peak}, or HR. It is possible that in certain sports oriented more on the upper body (e.g., swimming), the ratio could be different (Volianitis & Secher, 2006). No study focused on distinguishing between pulling and pushing arm movements. In practice, however, pushing is preferably used. The lower body setting is essential for riding, as it is dominant for performance. The results by Sakamoto et al. (2007) or Sakamoto et al. (2014) can contribute to the greater importance of leg work in terms of cadence, which should be determined by the lower body.

Due to a large number of aerobic machines, the air bike was compared with other exercise machines (Zeni et al., 1996; Donahue, 2001; Jensen et al., 2019). The conclusions are not uniform, but with a treadmill or elliptical, individuals achieved higher HR, oxygen consumption with the same RPE. It was a medium to submaximal load, but the results would likely be confirmed at higher intensities. It is possible due to the higher resistance (it is necessary to make more effort for one repetition/ movement), the feeling of subjective exertion worsens and thus the higher consumption of oxygen or HR is not achieved. The cause will not be the number of muscles involved, which is comparable to the elliptical. The opposite tendency was found for blood lactate levels, which is related to the activity of large muscle groups (Secher et al., 1974; Zeni et al., 1996). Simultaneously, RPE was confirmed to be a suitable tool for determining the intensity in the general population (Jensen et al., 2019; Hill et al., 2020).

Schlegel & Křehký (2020) tested anaerobic fitness using an air bike and compared it with the Wingate test. A very similar study design was performed by Ozkaya et al. (2013) with elliptical. The research sample achieved higher lactate values on the air bike (15.98 mmol/ L) than in the Wingate test or elliptical (14.4 mmol/L). Increased resistance of large working muscles allows attacking the limits of the glycolytic system. It seems the air bike might be suitable for testing non-specific VLa_{max}. The air bike has, therefore, good potential for HIIT, especially for short intervals (<15 seconds), where it is possible to make a high effort quickly (see Kappenstein et al., 2015). Unfortunately, there has not been any study with such a design yet.

The air bike has repeatedly been used as an instrument of stress testing to determine the cardiovascular system's function. These were ramp tests or short continuous tests to reach maximum values, such as VO_{2peak}, minute ventilation, or HR (Vander et al., 1984; Hoffman et al., 1996; Allen et al., 1998; Garber et al., 2006, Kostuck et al., 2020). As it turned out, the air bike did not reach such high values as, for example, treadmill running. Higher values can be found also in classic running. Only Garber et al. (2006) report comparable results, but it is necessary to consider the research sample - cardiac patients. During air bike stress testing, it should be considered that these are unlikely to be absolute limit values of the organism. The mentioned lower parameters at high to maximum effort are essential, especially for advanced athletes, but they are not crucial for the general population. Lamont et al. (1992) sought to establish a formula for calculating

VO_{2peak} and oxygen saturation values based on the produced performance. The individual's weight was included in the calculation (Lamont, 2000). However, similar mathematical calculations must be considered indicative due to possible deviations and individual differences.

The air bike allows for a relatively comfortable riding and sitting position (Looney & Rimmer, 2002). It appears to be a suitable tool for various specific groups, such as the elderly, obese, or cardiac and neurological patients. It demonstrated functionality in terms of the development of cardiovascular fitness and weight reduction (Nyquist-Byttie et al., 2007; Kim et al., 2017; Hwang et al., 2019). The air bike was applied only to specific samples and it did not include healthy middle-aged individuals or athletes. Although it is likely to bring significant benefits to them, this cannot be confirmed based on available evidence.

In air biking, individuals must overcome the resistance, which leads to significant muscle desaturation (Schlegel et al., 2020a). This increased effort anticipates the involvement of glycolytic fibers. The activation of fibers IIa and IIx leads to more efficient muscle growth and strength development (maintenance). Especially the use of HIIT with short intervals will use a large number of muscle fibers. Therefore, it could be a suitable part of mixed aerobic and strength exercise program (Murlasits et al., 2018).

The air bike construction does not allow adjustment of the bike's arms, only the seats. The handle's rigid position affects the biomechanics of movement, which is manifested mainly in above-average tall or short people, respectively men, and women. The arm's position and work are also transferred to the movement of the torso and the overall riding efficiency. The specific use of pulling and pushing work or pedaling method is also important. The riding technique and the economics of movement, as with other exercises, are essential factors for the performance. However, no attention has been paid to these areas.

In several cases, the air bike was included in HIFT, where its effectiveness in influencing the overall exercise intensity was confirmed (Browne et al., 2020; Schlegel et al., 2020a; Schlegel et al., 2020b). The evidence is the reduced oxygen saturation in the vastus lateralis with a consequent increase in RER (>1.0). Furthermore, the body responds by increasing HR, ventilation, and oxygen consumption. A combined load with the air bike and other exercises seems to be a suitable tool for a positive impact on physical fitness. Although little evidence-based information is available, real practice (e.g., CrossFit®) shows that it could be an interesting instrument for developing endurance and fitness.

The air bike was also used in a group of seniors (Looney & Rimmer, 2003), cardiology patients (Lamont et al., 1992; Garber et al. 2006), mentally impaired (Pitetti et al., 1988), obese (Kim et al., 2008) or performance-oriented athletes (Schlegel & Křehký, 2020). In the mentioned samples, it was found to be a suitable tool for testing the organism's functional parameters. The air bike is not technically demanding and, at the same time, allows the activity of the upper body.

The results of exercise programs confirm a positive effect on the increase in VO_{2peak}, minute ventilation, or work capacity (Pitetti & Tan, 1991; Fernandez & Pitetti, 1993; Hwang et al., 2019). For continuous work, an effect on improving arterial stiffness or aortic pulse wave velocity would be demonstrated (Kim et al., 2015; Kim et al., 2017). A significant impact was reported in reducing insulin resistance and improving cardiovascular fitness (Hwang et al., 2016). Continuous and interval exercising bring different results, however, both variants are safe and effective. Cardiac patients have also been shown to have a positive effect on quality of life (Nyquist-Battie et al., 2007).

Draper & Dustman (1992) study provides ample possibilities of using an air bike as part of a rehabilitation program after a pelvic fracture. Furthermore, it was successfully implemented into a program in patients after leg amputation (Pitetti et al., 1987). Thanks to its stability and low technical complexity, it is also recommended for exercise in individuals with (moderate) mental retardation (Pitetti et al., 1993).

Although the principle of use remains the same, all air bikes are not identical. The design differences are reflected in the flywheel resistance, mechanical inertia, or handle design. It can be significantly exhibited in the power output, RPE or physiological parameters. None of the detected studies addressed these specifics.

CONCLUSIONS

The air bike is a widespread tool for fitness training, is used by general population or specific groups. Its use is technically relatively simple and convenient. It can be recommended for testing non-specific aerobic and anaerobic endurance. The stress tests show the potential for achieving high physiological values, which can develop aerobic fitness. Furthermore, its effectiveness in positively influencing the parameters of the cardiovascular system has been proven. It seems its use will be ideal for HIIT or HIFT, either alone or in combination with other exercises. Further research would be needed for intervention programs with air bike.

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