

Comparative Effects of Arm Cycle Ergometer and Leg Cycle Ergometer on Vital Capacity, Blood Pressure, and Resting Heart Rate in Sedentary Adolescents

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ABSTRACT

Introduction: A cycle ergometer is a stationary machine that enables cyclic rotations and can be used to carry out passive, active, and resistance exercises. Cycle ergometry promotes early healing and increases the individual's functional ability; lung capacity, blood pressure, and cardio-pulmonary endurance while they are sedentary. The experimental study aimed to investigate the comparative effects of arm cycle ergometers and leg cycle ergometers on vital capacity, blood pressure, and resting heart rate in adolescent sedentary subjects.

Methods: Participants were twenty-eight male adolescents who do not have regular physical activity and were divided into 2 groups; leg cycling (n=14) and arm cycling (n=14). On the first occasion and post-trial, participants were evaluated for their vital capacity, systolic and diastolic blood pressure, and resting heart rate. Both intervention conditions were performed for 60 minutes (10 mins for warm-up, 40 mins for exercise, and 10 mins for cooldown), three times per week for 8 weeks. Descriptive statistics were frequency, percentage, mean, and standard deviation. The inferential statistic was an independent t-test used to compare vital capacity, heart rate, systolic blood pressure, and diastolic blood pressure after 8 weeks (post-test) in the arm cycling group and the leg cycling group at a 95% confidence interval.

Results: The resting heart rate and the diastolic blood pressure of the arm cycling group were significantly different from the leg cycling group (p-value=0.002 and p-value=0.010, respectively). Conversely, the vital capacity and the systolic blood pressure of the arm cycling group were not significantly different from the leg cycling group (p-value=0.290 and p-value=0.480, respectively).

Conclusions: According to the present study, confirmed that this program has beneficial effects for improved cardiorespiratory fitness and decreased diastolic blood pressure in adolescent sedentary subjects.

Keywords: Arm cycle ergometer, Leg cycle ergometer, Vital capacity, Blood pressure, Resting heart rate

Introduction

In developed countries, sedentary lifestyles are prevalent among children and adolescents [1] with fewer active leisure activities and a greater emphasis on sedentary activities [2]. Sedentary activities, especially those centered on the use of electronic devices, are linked to an increased risk of obesity and a decline in physical fitness, regardless of physical activity levels [3]. Numerous studies, however, have demonstrated a strong correlation between children's and adolescents'

functional capacities and levels of physical activity and fitness [4].

Functional exercises all over the body, especially running or cycling, would result in an increase in the rate of oxygen consumption, including lung capacity, blood pressure [5], and cardio-pulmonary endurance [6] are an important test of athletes' abilities used to estimate the maximum oxygen utilization rate (VO_{2max}) [7]. The maximum oxygen consumption rate (VO_{2max}) is the maximum amount of oxygen that an individual can

utilize during maximal intensity exercise, which is the measurement that is commonly considered the best indicator of the exercise capacity of the individual [8] and physical inefficiency [9]. Exercise on a treadmill or leg cycle ergometer is usually an examination for cardiorespiratory endurance. However, some previous studies revealed several reasons for the replacement of leg exercise with cycling to test cardiorespiratory endurance [10]. For instance, Vanhees, et al [11] suggested that the maximal oxygen utilization rate test should be performed with arm cycling to serve as an alternative to testing upper body performance for athletes who may have difficulty in leg cycling exercise [12]. Nevertheless, some studies have found that cycling with arms has limitations among athletes who did not receive regular exercise training. When examined using arm cycling, there was a relatively low rate of maximal oxygen consumption and no increase in cardiopulmonary effort [13], compared to leg cycling [14]. In addition, it was also found that there was less muscle mass, and reduced cardio and lung endurance during the arm cycling exercise. External factors, such as the presence of lactic acid, immediately limit the work of the heart and blood vessels. In addition, Walker et al [15] also found that upper and lower limb exercises had a statistically significant difference in maximal muscle power due to both exercises stimulating the work of the heart and blood vessels more. Bronas, et al [16] also found that both arm cycling and treadmill running affected cardio-pulmonary endurance in 28 ischemic leg pain patients as well as increased the maximum oxygen consumption rate, maximum respiratory rate, and maximum power from arm cycle ergometer compared to arm crank ergometer exercises [17]. In addition, the total exhaled air volume after normal exhalation, the volume of air flowing into and out of the lungs per breath, and the maximum oxygen consumption rate are lower than that of leg cycling in healthy subjects [18].

According to previous studies, it can be seen that there are a wide variety of studies and methods related to exercise. However, few studies have compared and clarified the effects of arm and leg cycling on functional performance in non-exercise adults. Therefore, the researchers are interested in studying the comparative effects of arm cycle ergometers and leg cycle ergometers on blood pressure, vital capacity, and resting heart rate in adolescent sedentary subjects. The research hypothesis is that the effect of arm cycling affects blood pressure, vital capacity, and resting heart rate are different from leg cycling. It may be a guideline for choosing an exercise regimen for healthy people who do not exercise regularly. This study's findings may serve as a guideline for selecting suitable exercise programs for sedentary individuals who do not engage in regular physical activity.

Methodology

Participants

Twenty-eight men adolescents who do not have regular physical activity were selected by purposive random sampling and were divided into 2 groups; arm cycling (n=14) and leg cycling (n=14). It was obtained by calculating the sample size using the G*power program. The screening was used as a standard evaluation based on the "FITT" by the American College of Sports and Medicine [19]. The Physical Activity Readiness Questionnaire (PAR-Q) was used to identify potential risk factors that could impair their capacity to exercise safely. All of the participants stated that they were right-handed and did not use corrective lenses. Age (18-35 years) and body mass index (BMI) < 23.0 kg/m², were used as a criterion for inclusion. Self-reported history of mental, neurological, cardiovascular, or pulmonary disorders, orthopedics pathology, or musculoskeletal dysfunctions were all considered exclusion criteria.

Intervention

Both conditions were performed 60 minutes three times per week (Monday, Wednesday, and Friday; 09.00-10.00) for 8 weeks. The ergometer was secured to a strong table for the arm cycling experiment, and the foot pedals were substituted with pronated-position hand grips. The ergometer's height could be adjusted, allowing the crank axis to be aligned with the glenohumeral joint's center as follows:

The arm cycling training program (Monark 881E, Vansbro, Sweden) included 60 minutes of exercise with arm cycling at 20 W for warm-up (10 mins), then 4 times per round of the arm-cycling procedure included 35 W of initial power output, followed by 20 W increments every 3 minutes until volitional exhaustion was reached and 1 minute of recovery between rounds and cool down 10 minutes [20].

The leg cycling training program (Lode Excalibur Sport Ergometer, Lode B.V., Netherlands) included 60 minutes of exercise with leg cycling at 50 W for warm-up (10 mins), then 4 times per round of the leg-cycling procedure included 70 W of initial power output, followed by 35 W increments every 3 minutes until volitional exhaustion was reached and 1 minute of recovery between rounds and cool down 10 minutes [20].

Outcome measurements

On the first occasion, the participants underwent familiarization. It also served as a habituation test to familiarize participants with arm-cycling. Then, the participants were evaluated for their vital capacity, systolic and diastolic blood pressure and resting heart rate (baseline). Across all variables, the participants took measurements using standardized protocols. Started an experimental period of parallel 2 conditions for 8 weeks and re-evaluated their vital capacity, systolic and diastolic blood pressure, and resting heart rate (after 8 weeks) as follows:

For vital capacity (VC), Measurement of vital capacity was performed as described by the American Thoracic Society and by the European Respiratory Society [19]. It is the total amount of air exhaled after maximal inhalation (Spiropet spirometers T20) (ml). All participants were familiarized with the equipment and procedures before testing. The measurement was taken when the participants were relaxing in the standing position with a nose clip. The participants have performed at least three times to take the best value to analyze the data.

For blood pressure (BP) including systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mm Hg). BP was measured twice with participants in the sitting position after a rest of at least 5 minutes using an autonomic BP monitor (Omron HEP-1300). The mean of the two measurements was used for analysis. The researchers who had undergone training used automated and calibrated electronic BP monitors (Omron HBP-1300) to assess office BP at baseline and after 8 weeks

Resting heart rate (RHR): Heart rate was obtained at rest in sitting position and during the exercise protocol using a Polar Heart Rate Monitor (Lake Success, NY). HR data were stored in the internal memory of the Polar H10 HR sensor. Polar Beat version 2.4.5 for Android (Polar Electro Oy, Kempele, Finland) was loaded on each participant's phone for transferring HR data from H10 through Bluetooth. After each test protocol was performed, data was provided, and HR was assessed using Polar Flow (Polar Electro Oy, Kempele, Finland).

Statistical analysis

Statistical analysis used STATA 13 (Texas, USA, 2007). The S-Wilk test was used to test the normal distribution of values. Descriptive statistics were frequency, percentage, mean, and standard deviation to express age and body mass index. The inferential statistic was an independent t-test used to compare vital capacity, heart rate, systolic blood pressure, and diastolic blood pressure after the trial (post-test) in the arm cycling group and the leg cycling group at 95% confidence interval. We used $\alpha=0.05$ as the cut-off point of statistical significance [21].

Results

Age and body mass index (baseline)

Twenty-eight male adolescents were divided into 2 groups; the leg cycling group (n=14) had a mean age of 27.57 (SD=3.18) years old and a body mass index of 22.10 (SD=1.19) and the arm cycling group (n=14) had a mean age of 22.43 years old (SD=2.73) and a body mass index of 21.54 kg/m² (SD=1.45) (Table 1).

Table 1 Age and body mass index

Variable	Leg cycling group	Arm cycling group
	Mean/SD (n=14)	Mean/ SD (n=14)
Age (years)	27.57/3.18 Min/Max: 19/31	22.43/ 2.73 Min/Max: 19/28
BMI (kg/m ²)	22.10 (1.19) Min-Max: 19.18/22.55	21.54 (1.45) Min/Max: 19.38/23.00

Vital capacity, resting heart rate, and blood pressure (a) Baseline of all variables

At the baseline, found that all variables of the arm cycling group were not significantly different from the leg cycling group (p-value = 0.330, p-value= 0.080, p-value= 12, and p-value=0.220, respectively) (Table 2).

Table 2 Baseline of all variables

Variables	Leg cycling group	Arm cycling group	p-value
	Mean/ SD (n=14)	Mean/SD (n=14)	
Vital capacity	3211.31	3256.98	0.330
Resting heart rate	83.86	86.82	0.080
Systolic blood pressure	114.32	115.11	0.120
Diastolic blood pressure	72.14	74.25	0.220

(b) Vital capacity after 8 weeks (post-test) in the arm cycling group and the leg cycling group

Using the S-Wilk test assumes that all the populations are normally distributed (p-value=0.180), all the population variances are equal and they are randomly collected from all the populations [22]. After 8 weeks (post-test), the vital capacities of the arm cycling group and the leg cycling group were 3242.85 and 3335.71, respectively. The results showed that the vital capacity of the arm cycling group was not

significantly different from the leg cycling group (p-value=0.290) (Table 3).

Table 3 Vital capacity after 8 weeks (post-test) in the arm cycling group (n=14)

Vital capacity	Two-sample t test with equal variances		t-test	p-value
	Mean	SD		
Leg cycling group (n=14)	3242.85	202.72	-1.06	0.290
Arm cycling group (n=14)	3335.71	256.02		

(c) Resting heart rate after 8 weeks (post-test) in the arm cycling group (n=14) and the leg cycling group (n=14)

After 8 weeks (post-test), the resting heart rate of the arm cycling and the leg cycling groups were 76.71 and 82.85, respectively. The results showed that the resting heart rate of the arm cycling group was significantly different from the leg cycling group (p-value=0.002) (Table 4).

Table 4 Resting heart rate after the trial (post-test) in the arm cycling group (n=14) and the leg cycling group (n=14)

Heart rate	Two-sample t test with equal variances		t-test	p-value
	Mean	SD		
Leg cycling group (n=14)	76.71	5.31	-3.42	0.002
Arm cycling group (n=14)	82.85	4.09		

(d) Systolic blood pressure after 8 weeks (post-test) in the arm cycling group (n=14) and the leg cycling group (n=14)

After 8 weeks (post-test), the systolic blood pressure of the arm cycling and the leg cycling groups were 115.85 and 115.14, respectively. The results indicated that the systolic blood pressure of the arm cycling group was not significantly different from the leg cycling group (p-value=0.480) (Table 5).

Table 5 Systolic blood pressure after 8 weeks (post-test) in the arm cycling group (n=14) and the leg cycling group (n=14)

Systolic blood pressure	Two-sample t test with equal variances		t-test	p-value
	Mean	SD		
Leg cycling group (n=14)	115.85	3.41	0.71	0.480
Arm cycling group (n=14)	115.14	1.56		

(e) Diastolic blood pressure after 8 weeks (post-test) in the arm cycling group (n=14) and the leg cycling group (n=14)

After the trial (post-test), the diastolic blood pressure of the arm cycling and the leg cycling groups were 72.71 and 80.00, respectively. The results indicated that the diastolic blood pressure of the arm cycling group was significantly different from the leg cycling group (p-value=0.01) (Table 6).

Table 6 Diastolic blood pressure after 8 weeks (post-test) in the arm cycling group (n=14) and the leg cycling group (n=14)

Diastolic blood pressure	Two-sample t test with equal variances		t-test	p-value
	Mean	SD		
Leg cycling group (n=14)	72.71	6.80	2.55	0.010
Arm cycling group (n=14)	80.0	6.22		

Discussion

According to the current findings, the leg cycling group had a mean age of 27.57 years old and a normal weight (BMI=22.10), while the arm cycling group had a mean age of 22.43 years old and a normal weight (BMI=21.54). The arm cycling group and the leg cycling group have vital capacities of 3242.85 and 3335.71, respectively. Our data also show that mean vital capacity was not significantly different during the leg cycling ergometer compared to arm cycling ergometer (p-value=0.290). However, previous meta analyses study found that when high-intensity interval exercise (HIIE) was long-term, it increased VO₂max more than moderate-intensity continuous exercise (MICE) in both active people [23] and those with

chronic disease [24]. Furthermore, despite the higher intensities of HIIE compared to MICE, similar to Stork et al [25] and Olney et al [26] and in some cases greater post-exercise enjoyment has been reported, substantiating its broad application as an additional option for many adults to engage in physical activity [27, 28]. Previous research in active men shows that chronic HIIE arm cycling improves VO₂max and time trial performance, but no studies have looked at the acute response to this modality or compared it to leg cycling [29]. The mean heart rate (HR) during arm cycling ergometer was significantly greater than during leg cycling ergometer, indicating a 'large effect' which is corroborated by previous graded exercise data showing a higher HR for combined leg/arm activity compared to arm exercise alone [30]. According to Astorino and Emma [31], confirmed that women had a higher heart rate during HIIE when compared to males (8–18 bpm higher, $d = 1.3$ -3.3) and arm cycling ergometer (12-20 bpm higher, $d = 2.4$ -4.0) (p -value=0.001) [32]. Furthermore, peak VO₂ and heart rate do not alter between modes, implying that peak cardiorespiratory strain during HIIE is analogous to having various amounts of trained muscle mass during exercise. During isometric handgrip vs. cycling at comparable speeds heart rate (about 90 beats per minute). In addition, Bassett (2002) confirmed that the main reason for the gender difference in VO₂max, a crucial factor in determining aerobic capacity, has been suggested as the reason why men do better in endurance exercises [33]. When expressed in mL/kg/min, even the most elite women have VO₂max values that are almost 10% lower than those observed in men with comparable elite status [34]. Due to the increased oxygen demand from the working muscles, whole-body oxygen consumption (VO₂) rises with increasing exercise intensity. Due to the increased oxygen demand from the working muscles, whole-body oxygen consumption (VO₂) rises with increasing exercise intensity. Because practically all of the energy (ATP) used during an endurance exercise performance (aerobic exercise) will be resynthesized in the mitochondria through oxidative metabolism, there is an increase in oxygen demand [34]. Concurrently rising heart rate, ventilation, and stroke volume are just a few of the cardiovascular and respiratory parameters that rise with this surge in oxygen use. VO₂ is essentially the capacity of the muscles to deliver and utilize oxygen when they are working out. Exercise intensity can be increased until VO₂ hits a plateau known as VO₂max that is unaffected by additional increases in exercise intensity [35]. Exercise tolerance is constrained by VO₂max, which measures the maximum rate at which ATP may be produced again by aerobic pathways [36]. In 2008, Leicht and colleagues demonstrated the comparison between a rating of perceived exertion (RPE) and cardiorespiratory response to dynamic muscular exercise of different muscle groups at 50% and 65% maximal HR (HR_{max}) [37].

Our findings showed that blood pressure parameters during both arm cycling ergometer and leg cycling ergometer were not significantly different from the systolic blood pressure of the arm cycling group, whereas the diastolic blood pressure of the leg cycling group was significantly lower than the arm cycling group. There are only a few studies that compare the two thus far the pattern of cardiovascular response at identical heart rates [38] discovered a greater rise in SBP and DBP. The cause of the problem is assumed to be caused by three methods. During voluntary muscle contraction, neuronal cardiovascular modulation occurs contractions: higher brain areas are activated (in the middle compel) as well as reflex activity that is purely input-based from mechanoreceptors and chemoreceptors ('muscle metaboreflex') and the afferents of baroreceptors ('baroreflex') [39]. Each mechanism modifies the sympathetic and parasympathetic outflow from the cardiovascular control center by activating neural circuits within the medulla [40]. The impact of each mechanism on the heart rate and blood pressure response to exercise is determined by a variety of parameters, including recruited muscle mass, muscle fiber type, exercise intensity, and activity style [41]. Early research comparing the cardiovascular responses to static and dynamic muscular actions found that dynamic work causes significant increases in heart rate (HR), systolic arterial pressure (SBP), and minor changes in diastolic arterial pressure (DBP), whereas isometric work causes only modest increases in HR but significant increases in SBP and, in particular, DBP [41]. However, the generalizability of these findings is limited because a) the cardiovascular effects of static (SE) and dynamic (DE) exercise have been investigated independently; and b) it is difficult to quantify and thus equate workload during different exercise modes [40] and c) the muscles being compared were frequently of different sizes and locations. Similar heart rate and blood pressure responses were evoked by static vs. dynamic contractions of identical tiny muscles, such as during submaximal handgrip exercise [40], while it was shown that submaximal isometric contractions of bigger muscles (e.g. knee extensors/flexors) at 40% of maximum effort have been found to cause lower heart rate and blood pressure responses than isokinetic or isotonic contractions [41]. During moderate exercise intensity, Chapman and Elliott (1988) [42] found a significant increase in heart rate and systolic blood pressure during dynamic exercise, while diastolic blood pressure was highest during static exercise.

Conclusions

In summary, although healthy sedentary' resting heart rates and diastolic blood pressure may decrease, other characteristics will not significantly change as a result. However, the findings of this study can offer suggestions for selecting suitable exercise programs for inactive individuals who don't engage in regular

physical activity. To demonstrate the significance of arm and leg cycling in promoting another sedentary subject, more studies are required.

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