

Research article

Arm vs. combined leg and arm exercise: Blood pressure responses and ratings of perceived exertion at the same indirectly determined heart rate

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Abstract

Pre-participation screening is very important for prescribing and practising exercise safely. The aim of this study was to investigate both ratings of perceived exertion (RPE) and blood pressure responses in two different types of exercises with matching duration and indirectly determined working heart rate (HR). Participants were 23 male students, who were generally healthy but sedentary. The time course of their RPE and blood pressure during a 50-minute work-out session on an arm crank ergometer and a cross trainer were compared. RM-ANOVA showed both a higher RPE ($p < 0.001$) and diastolic blood pressure (DBP) ($p < 0.001$) response to the arm exercise that were shown significantly correlated ($r = 0.883$; $p = 0.008$). Linear regression analysis ($p = 0.001$) confirmed the ability to predict the time course of DBP by knowing the RPE on the arm crank ergometer. Even if people use the recommended relative intensity, the HR method is not always safe for health without pre-participation screening because exercise characteristics can negatively influence physiological responses. The HR method could be substituted by the RPE method.

Key words: Diastolic blood pressure, arm crank ergometer, cross trainer.

Introduction

The World Health Organization (WHO) estimates that physical inactivity causes 1.9 million deaths and 19 million disability-adjusted life years annually worldwide (WHO, 2002). At the same time, epidemiological studies have shown the powerful influence of increased levels of physical activity (Andersen et al., 2000; Caspersen et al., 1985) and aerobic fitness (Blair et al., 1996) on the treatment and prevention of a number of diseases (Department of Health, 2004; Pate et al., 1995; Pedersen and Saltin, 2006; US Department of Health, 1996; Warburton et al., 2006). Therefore, the promotion of physical activity programmes, including participation in physical exercise (Caspersen et al., 1985), has become an important public health objective involving multiple sectors and disciplines (WHO, 2002; 2004), including family physicians. As a consequence, physical activity and/or exercise prescriptions rise among general practitioners and patients who have to improve their health (Sorensen et al., 2006).

Although pre-participation screening is a useful evaluation tool both to detect cardiovascular abnormalities, and thus prevent sudden death or progression of

disease (Corrado et al., 2005; Maron et al., 2007), and personalize training to suit the individual's effective exercise capacity to gain healthy advantage from the exercise, not all practitioners perform stress testing. Physical exercise participation without the right prescription and/or qualified supervision may be both dangerous to health, when its intensity is excessive, and ineffective for health enhancement, when its intensity is too low. The most frequently used tool to monitor exercise intensity is heart rate (HR), and with a validated formula based on age and basal heart rate (Karvonen et al., 1957), it is simple to calculate *healthy exercise intensity*. Even if, in the majority of cases, this method is safe for our health, in some cases, its use, in conjunction with the absence of qualified supervision, could be dangerous for health. In fact, ambient temperature, emotional stress, high humidity, caffeine, medications, dehydration, postural position, size of muscle mass involved in exercise, fatigue and illnesses (Ainslie et al., 2003; Colberg et al., 2003; Dehne and Protas, 1986; Freedson and Miller, 2000; Sirard and Pate, 2001) can all influence HR, altering the real work done and the blood pressure response. In adjunction, Weltman and colleagues (1989; 1990) reported that, in both sedentary men and women, exercise performed at a specified percentage of HR_{max} ($\%HR_{max}$) and heart rate reserve ($\%HRR$) elicited a wide range of metabolic responses, suggesting that the use of standard HR intensity guidelines results in different levels of metabolic stress across subjects (Meyer et al., 1999). This probably occurs because HR response during incremental stress testing is shown neither linear nor uniform during the work done between the first lactate turn point and the maximal performance (Hofmann et al., 2001). Wonisch and colleagues (2003), studying the influence of beta-blocker use on percentage of target HR exercise prescription, suggested that, even if $\%HR_{max}$ and $\%HRR$ are easy to determine, the most precise exercise intensity calculation would take into account both aerobic and anaerobic thresholds. Therefore, especially in unsupervised work-outs, it could be healthier to use other methods to control exercise intensity, such as the RPE, which uses a subjective rating from 6 to 20 (Borg, 1982) to quantify an individual's perceived exercise intensity that has been found to closely correlate with relative exercise intensity measured by VO_{2max} (Robertson, 1982).

The aim of this study was to investigate the time course of both RPE and blood pressure during two different types of exercise matched for duration and working

HR, that was calculated according to the indirectly determined HRR method, instead of specific stress testing, usually used in gyms.

Methods

Study population

Twenty-three sedentary male university students (26.2 ± 1.0 yrs) were recruited after undergoing a medical examination and maximal cycle stress test, excluding cardiovascular, hormonal and orthopaedic pathologies. None of the participants received any medication known to affect the measured variables and none were smokers. Sedentary group requirement was no participation in a regular exercise programme or intentional activities beyond normal daily habits, within the previous 12 months. Characteristics of the selected population are shown in Table 1.

Table 1. Basal physiological characteristics of participants (n =23). Data are means (±SD).

Age (yrs)	25.13 (2.39)
Weight (kg)	77.38 (6.31)
Body Mass Index (kg·m ⁻²)	24.24 (1.73)
Fat Mass (%)	19.3 (3.52)
Waist Circumference (cm)	84.87 (4.72)
Systolic Blood Pressure (mm Hg)	119.78 (4.82)
Diastolic Blood Pressure (mm Hg)	75.86 (5.30)
Heart Rate (bpm)	61.13 (8.4)

Environmental characteristics

The study was carried out in the Sports Medicine Center of the University of Chieti-Pescara in Italy. Laboratory conditions were controlled for temperature (21–23 °C) and humidity (50%) (American College of Sports Medicine [ACSM], 2005).

Medical examination

Participants presented after overnight fasting without having performed maximal muscle exertion the day before (ACSM, 2005). In order of execution they were examined for resting blood pressure, ECG, HR and body composition, followed by an assessment of their cardio-circulatory responses to a maximal cycle stress test.

After 5 min of sitting rest, resting arterial blood pressure was twice measured by a mercury sphygmomanometer (Erkameter 3000, Erka, Bad Tolz, Germany) and auscultation technique while the subject was in a comfortable sitting position with their right arm fully exposed on a supportive surface at heart level. The average of those measurements was used as the participant's resting blood pressure. If there was > 5 mm Hg difference between the first and second measurement, an additional reading was taken and the average of these multiple readings was used. There was 1 min between each measurement (Pickering et al., 2005).

Resting 12-lead ECG (P8000, Esaote) was performed after 10 min of supine rest, while resting HR was measured after the ECG recording. An expert researcher counted the number of pulsations occurring in 1 min at radial artery through palpation technique (Heyward, 2006). The reliability of manual HR measurement was controlled through the data from the previous ECG recording. The choice of the data obtained from manual

resting HR measurement was needed to reproduce the method usually used in gyms, i.e. to calculate exercise intensity without data from medical examination and/or stress testing.

Body composition was assessed by a single-frequency electrical bioimpedance analyser (EFG, Akern, Pontassieve, Italy), giving values of bodily resistance and reactance that were integrated with sex, age, weight and height and processed by Bodygram PRO software (Akern, Pontassieve, Italy). The analysis was performed with the subject supine on a non-conducting bed after 10 min in a clinostatic position. The upper limbs were set at a 30° angle from the chest and the lower limbs at a 45° angle between them. Four electrodes (PG 500, FIAB, Vicchio, Italy) were placed on the body's right side: two on the back of the hand, with one proximal and the other distal to the wrist, and two on the instep of the foot, with one distal and the other proximal to the ankle. A minimum distance of 5 cm between the two electrodes was observed (Kyle et al., 2004). Measurements of body weight (kg) and height (cm) were rounded off to the nearest 0.1 kg and 0.1 cm respectively. They were taken with a medical scale and height rod (Seca 220, SecaHamburg, Germany), with participants in stockinged feet and light clothing. Waist circumference was measured with an anthropometrical tape (Seca 200, Seca, Hamburg, Germany); it was taken at the narrowest part of the torso at the end of normal expiration and rounded off to the nearest 0.1 cm (Lohman et al., 1988).

The incremental maximal cycle test (Astrand, 1965) was performed on an electromagnetic cycle ergometer (Ergocard II, Esaote, Genoa, Italy) under continuous 12-lead electrocardiograph monitoring. The final height of the seat was adjusted so that leg extension was approximately at a 165 to 170° angle at the knee joint. Participants started the test against an initial workload of 100 W and maintained a constant pedalling rate (i.e. 50 rev·min⁻¹) for the whole test. Every 2 min the workload was increased by 50 W until the participants were able to maintain the assigned pedalling rate and/or reach the item suggested by Gibbons and colleagues (1997) to standardize the end of the stress test. Blood pressure was taken at the end of each step while the participants were cycling and the same guidance previously described regarding both the method and the number of measurements was followed (Pickering et al., 2005). Maximal stress test was used as exclusion criteria for the study: people with non-physiological cardio-vascular response to the performed maximal effort were excluded.

Study design

Each participant trained on both a Cross Trainer Advance Lux (Panatta Sport, Apiro, Italy) and an Arm Crank Ergometer (Panatta Sport, Apiro, Italy). They trained at the same time (11:00), every four days, for a total of two sessions with a randomly assigned order of execution. During the study period participants were not allowed to take stimulants, including tea and coffee. The subjects had fasted for 2 h before each trial. Clothing was the same for all subjects: a short-sleeved cotton T-shirt; short pants, and jogging shoes. Each training session comprised a total of 50 min of work-out. The exercise session was divided

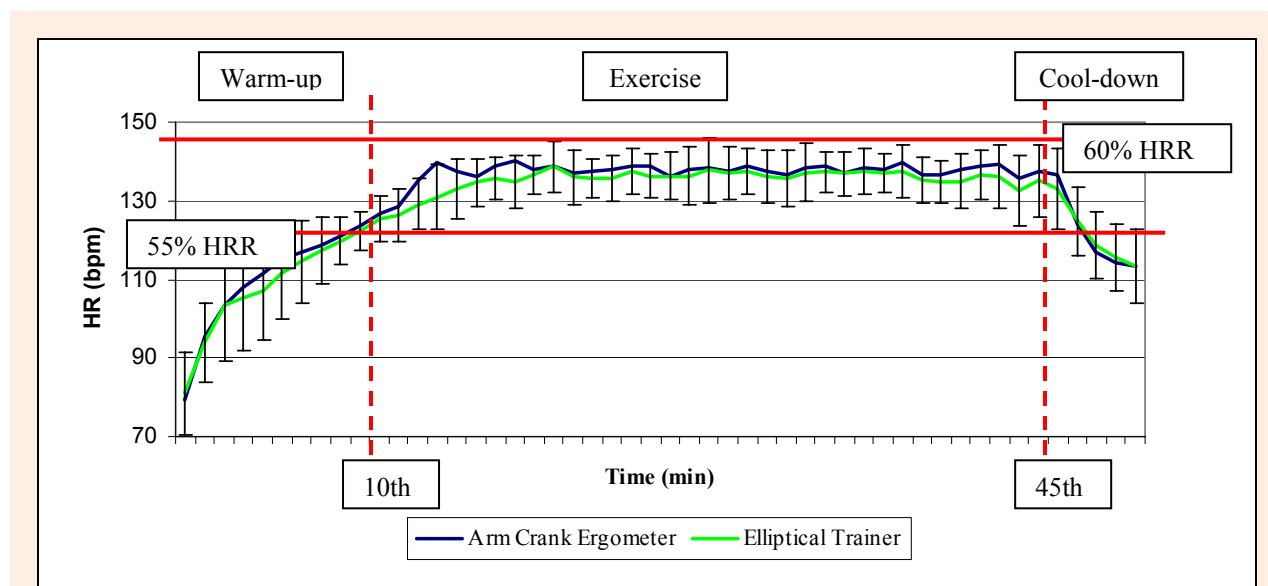


Figure 1. Time course of heart rate (HR) during the two training sessions. Vertical dashed lines show how was organized each session: warm-up (10 min), exercise (35 min), cool-down (5 min). Horizontal continue lines show the range of HR used to train in the exercise share. RM-ANOVA did not found differences between the time course of HR during training at arm crank ergometer and elliptical cross trainer.

into a 10 min warm-up gradually reaching 45% of their HRR, 35 min at 55–60% HRR and a 5 min cool-down. To calculate the target heart rates we alternately substituted 0.45 (i.e. 45% HRR), 0.55 (i.e. 55% HRR) and 0.6 (i.e. 60% HRR) to the voice *exercise intensity* of the Karvonen's formula (1957). $Target\ HR = [(220 - age - resting\ HR) \times exercise\ intensity] + resting\ HR$.

Resting HR reference was the value manually measured during the medical examination. Arterial blood pressure was measured on the left arm by the same physician using a mercury sphygmomanometer and auscultation technique at the start of each session, after 5 min of sitting rest, and after 10, 15, 25, 35, 45, and 50 min of exercise. The same applied to the registration of RPE scores (Borg, 1982). Continuous HR was monitored and recorded using a WearLink (Polar, Kempele, Finland) which transmitted HR through a telemetry system both to a S-810i (Polar, Kempele, Finland) and to a receiver integrated in the ergometers. The reliability of the receivers was provided by the manufacturer. Each participant placed the transmitter on the xiphisternum, in direct contact with the skin, and the S-810i on their left wrist. The work-out protocol, performed at target HR, was standardized for all participants in the following fashion: (a) automatically regulated exercise workload at a constant speed of 50 rev·min⁻¹ on the cross trainer (Chien et al., 2007); and (b) automatically regulated exercise workload at a constant speed of 70 rev·min⁻¹ on the arm crank ergometer (Price et al., 2007; Smith et al., 2001; 2006). The speed of the exercises was settled according to their specific literature, which suggested the exercise characteristics to consider in order to optimize both the effort and human body response. Participants performed the work-out under the control of the *C.H.R. program*, an option of the system software of the ergometers. The program automatically regulated the workload (i.e. increased or decreased) in order to maintain HR between the assigned

values. Before the beginning of the session, the physician set the program for each phase (i.e. warm-up, exercise and cool-down) by inserting the duration and the upper and lower values for working HR. This program allowed participants to keep HR in the assigned range by managing just one parameter (i.e. speed) instead of two (i.e. speed and workload). Participants had information about the expressed watts, HR and speed on the ergometer screens, while the S-810i recorded the time course of HR in beat-to-beat modality. Data from the S-810i were obtained through Polar Precision Performance software (Polar, Kempele, Finland).

RPE

Participants were familiarized with the RPE scale according to the instructions recommended by Pollock and colleagues (1984). Participants were asked to rate the exertion that they felt at a given time.

Statistical analysis

Descriptive statistics were performed to describe basal characteristics of participants (Table 1), while RM-ANOVA was carried out to investigate differences in blood pressure and RPE time course during the performed exercises, matched for HR. Spearman's correlation tested relationships among the investigated parameters.

Results

Participants were normotensive and borderline overweight (i.e. some were normoweight and some were slightly overweight borderline with normoweight) (Table 1). They did not show different time courses of HR because the two exercises were matched for HR (Figure 1). In fact, RM-ANOVA performed for HR response showed differences only within groups ($F_{(1,43)} = 1.445$, $p = 0.025$). The same applied to the systolic blood pressure response

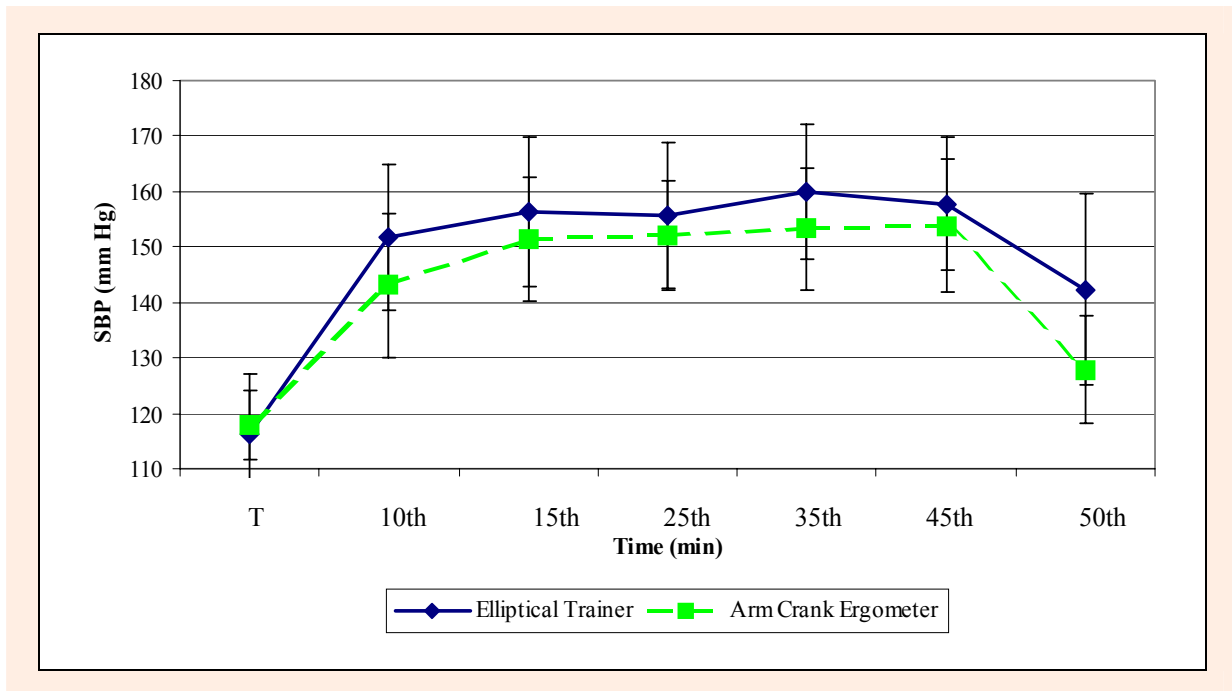


Figure 2. Time course of systolic blood pressure (SBP) during training on the arm crank ergometer and elliptical cross trainer. Because of two training sessions were matched for heart rate, elliptical cross trainer and arm crank ergometer elicited the same SBP response.

($F_{(1,43)} = 2.747$, $p = 0.020$) (Figure 2). However, RM-ANOVA showed significant differences within and between groups for RPE ($F_{(1,43)} = 5.173$, $p < 0.001$ and $F_{(1,43)} = 8.314$, $p = 0.006$ respectively) and diastolic blood pressure (DBP) response ($F_{(1,43)} = 6.361$, $p < 0.001$ and $F_{(1,43)} = 34.797$, $p < 0.001$ respectively). Figure 3 shows that the arm crank ergometer elicited a constant rise of RPE, whereas the cross trainer increased RPE only until the 35th minute when it reached a plateau. Regarding DBP, while the cross trainer showed a minor increase until the 15th minute and then a constant decrease until the end, the arm

crank ergometer elicited a constant rise of DBP until the 25th minute when it reached a plateau (Figure 4). Table 2 shows the data of the time course of investigated parameters elicited by the experimented exercises. The arm crank ergometer elicited a poorer response of DBP and a higher mean RPE (14.02 ± 1.26) compared with the cross trainer (12.19 ± 1.16) ($p < 0.001$). Significant correlation was found between DBP and RPE responses when participants exercised on the arm crank ergometer ($r = 0.883$, $p = 0.008$), but the cross trainer did not elicit significant correlation between the two variables (Figure 5). Taking into

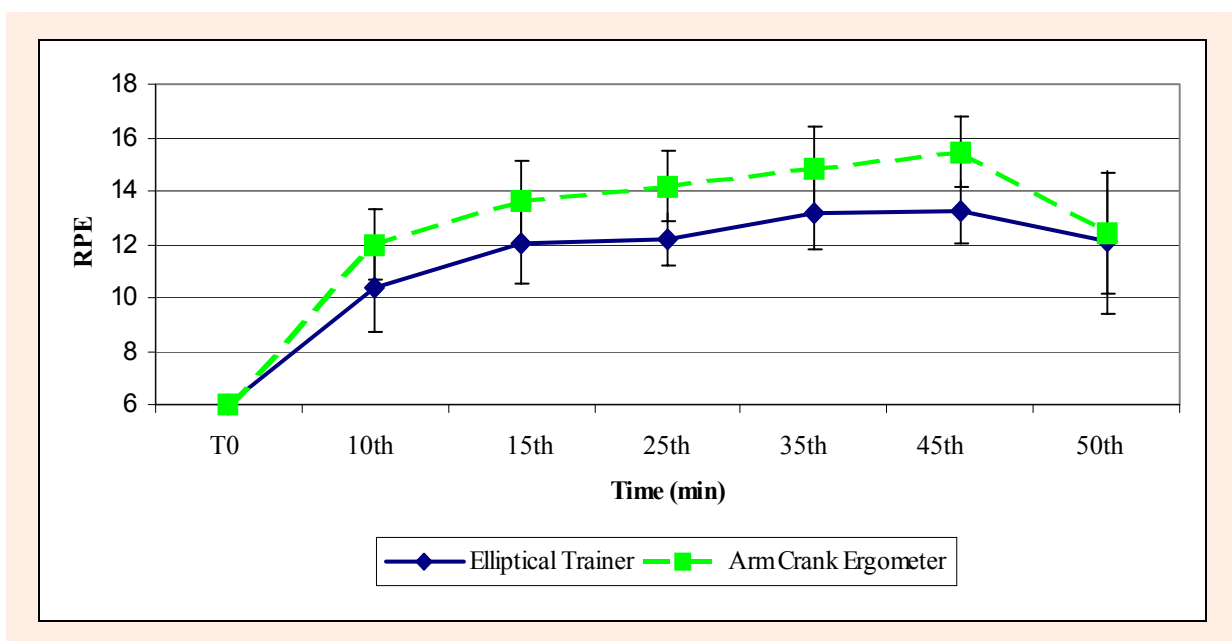


Figure 3. Time course of ratings of perceived exertion (RPE) during training on the arm crank ergometer and elliptical cross trainer. Even if the training sessions were matched for heart rate, arm crank ergometer elicited a significant higher RPE response than elliptical cross trainer ($p=0.006$).

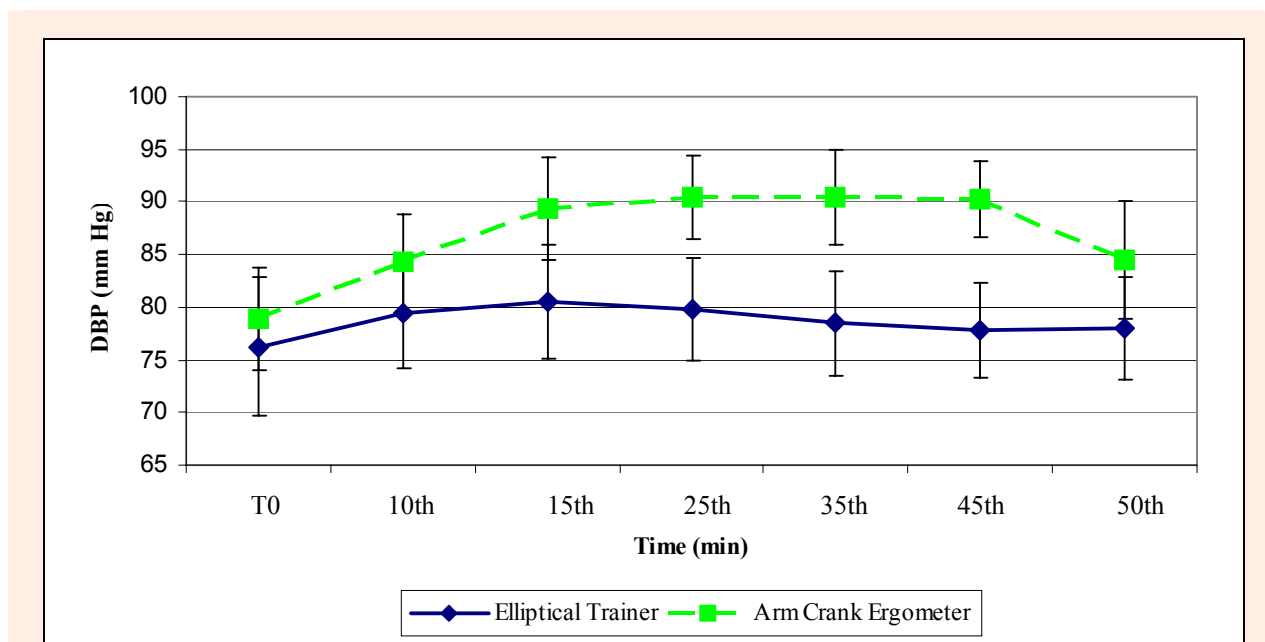


Figure 4. Time course of diastolic blood pressure (DBP) during training on the arm crank ergometer and cross trainer. Even if the training sessions were matched for heart rate, arm crank ergometer elicited a significant higher DBP response than elliptical cross trainer ($p < 0.001$).

account this significant correlation, a linear regression model was performed ($R^2 = 0.896$, $p = 0.001$) in order to use RPE response to predict DBP while exercising on the arm crank ergometer (Table 3). Data from the statistical analysis predicted the following formula:

$$DBP = 70.122 + 1.324 \times RPE$$

Table 2. Time course of all investigated physiological parameters. Data are means (\pm SD).

	Arm Crank Ergometer	Cross Trainer
SBP T0 (mm Hg)	116.3 (18.9)	117.9 (6.3)
SBP 10 th (mm Hg)	151.8 (13.1)	143.1 (13.0)
SBP 15 th (mm Hg)	156.3 (13.6)	151.5 (11.2)
SBP 25 th (mm Hg)	155.8 (13.2)	152.0 (10.0)
SBP 35 th (mm Hg)	160.0 (12.2)	153.2 (11.0)
SBP 45 th (mm Hg)	157.7 (11.9)	153.9 (12.0)
SBP 50 th (mm Hg)	142.2 (17.2)	127.9 (9.6)
DBP T0 (mm Hg)	76.3 (6.7)	78.9 (4.8)
DBP 10 th (mm Hg)	79.4 (5.2)	84.2 (4.6)
DBP 15 th (mm Hg)	80.5 (5.4)	89.3 (4.9)
DBP 25 th (mm Hg)	79.8 (4.9)	90.5 (4.0)
DBP 35 th (mm Hg)	78.5 (5.0)	90.5 (4.5)
DBP 45 th (mm Hg)	77.8 (4.5)	90.2 (3.6)
DBP 50 th (mm Hg)	78.0 (4.9)	84.5 (5.6)
RPE T0	6.0 (0)	6.0 (0)
RPE 10 th	10.4 (1.6)	12.0 (1.4)
RPE 15 th	12.1 (1.5)	13.6 (1.5)
RPE 25 th	12.2 (1.0)	14.2 (1.3)
RPE 35 th	13.1 (1.4)	14.9 (1.6)
RPE 45 th	13.2 (1.2)	15.5 (1.3)
RPE 50 th	12.1 (2.7)	12.4 (2.3)

Discussion

Our findings indicate that to reach the healthy physiological effects elicited by an aerobic exercise session, the estimation of exercise intensity, without specific stress testing, is not always safe even if it occurs through a well-

known standardized formula. In fact, the same working HR provided different time courses of RPE and DBP during the two exercises. The choice to compare a whole body exercise (i.e. exercise on elliptical cross trainer) with an upper body exercise (i.e. exercise on arm crank ergometer) was linked to the necessity to deepen our previous findings about the time course of blood pressure and RPE elicited by five different modalities of aerobic training (i.e. treadmill, recumbent bike, bike, elliptical cross trainer and arm crank ergometer) (Ripari et al., 2008). Also in that case, our research showed that arm crank exercise elicited the worst DBP and RPE response while exercise at elliptical cross trainer the best. Unfortunately, limitations of that protocol did not permit to investigate if the time course of DBP and RPE were correlated.

Table 3. Linear regression model performed to use RPE to predict DBP responses while exercising on the arm crank ergometer.

	Coefficients estimation	Std. Error	t	p
Constant	70.122	2.621	26.756	<.001
RPE	1.324	.202	6.562	.001

DBP = diastolic blood pressure; RPE = ratings of perceived exertion

On the arm crank ergometer, exercise movement and breathing compete in the recruitment of small muscle masses (i.e. upper body and shoulder muscles) that should contemporaneously ensure two tasks. This leads to an early rise in ventilatory and sympathetic stimulation (Roussos, 1985; Romagnoli et al., 2006), the alteration of the natural rhythm of ventilation (Mangum, 1984) and early fatigue (Roussos, 1985; Romagnoli et al., 2006), all shown limiting factors of exercise tolerance and performance (Romer and Polkey, 2008). In fact, during the arm crank exercise, the isometric work of the muscles of

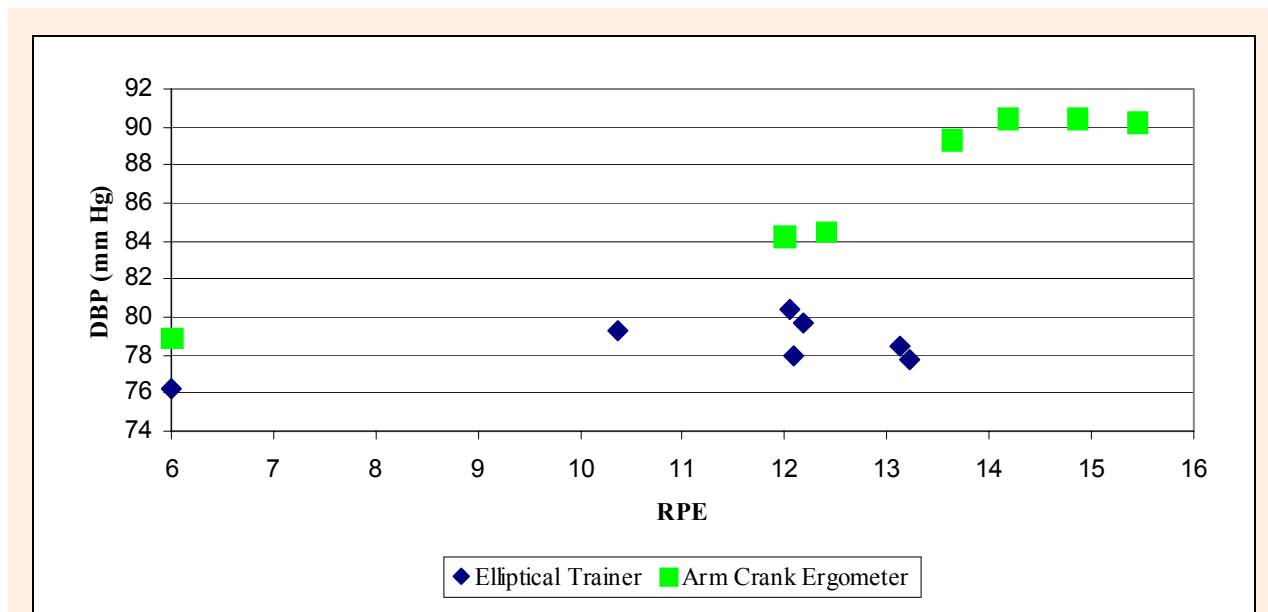


Figure 5. Relationship between the time course of diastolic blood pressure (DBP) and ratings of perceived exertion (RPE) during training on the arm crank ergometer and elliptical cross trainer. Only the latter elicited a positive significant relationship between the investigated parameters.

the trunk is needed to maintain the required body position and furnish a fixed point to those muscles executing the technical movement. On the other hand, the same isometric contractions become a limiting factor of the ventilation because abdominal and intercostal muscles, pectoralis and sternocleidomastoids are also accessory respiratory muscles that ensure the forced ventilation necessary to maintain performance during exercise (Cerqueira and Garbellini, 1999; Mangum 1984). The diaphragm, of which fatigue has been shown to be linked with whole body fatigue and performance, also becomes a limiting factor because its work is increased through the isometric contraction of the abdominal muscles, increasing intra-abdomen pressure, and the impairment of other muscles (Romer and Polkey, 2008). Assuming that for a given VO_2 arms receive about 27% more blood flow than the legs (Calbet et al., 2004), providing a 20 to 30% lower $\text{VO}_{2\text{max}}$ and both a lower maximal respiratory and heart rate than the combined arm and leg exercise, this dual muscular task leads to a lower mechanical efficiency of the arm crank exercise (i.e. ratio between the output of external power and caloric expenditure) that negatively affects the RPE score. Therefore, for the given HR, our participants worked at a higher proportion of $\text{VO}_{2\text{max}}$ during the arm exercise than that simultaneously involving arm and leg, reaching higher values of RPE (Figures 1 and 3). The stated 20 to 30% lower $\text{VO}_{2\text{max}}$ of the arm crank exercise, the chosen absolute exercise intensity (i.e. 55–60% of indirectly determined HRR) and the observed different RPE response all suggested that participants worked at the same absolute, but at a different relative exercise intensity. Participants' performances on the arm crank ergometer were closer to the anaerobic threshold than those on the cross trainer, meaning the former elicited a major activation of the anaerobic system, producing higher levels of intracellular lactate and hydrogen ions affecting the RPE response (Allen et al., 2008). The mis-

match between the indirectly determined working HR and the real exercise intensity performed on the arm crank ergometer was also underlined by the alteration of the relationship among HR, RPE and the physiological responses to exercise (e.g. breathing, sweating) as stated by Warburton and colleagues (2006). In fact, as shown in Figures 1 and 3, for an assigned duration and HR, the arm crank ergometer elicited higher RPE scores than the cross trainer. RPE scores of the arm crank exercise corresponded to 60 to 84% of indirectly determined HRR, whereas exercise on the cross trainer maintained the correct RPE–%HRR relationship (12–13 vs 40–59%).

The arm crank ergometer also provided a higher DBP response (Figure 4). The concomitant presence of isometric contraction of chest cage muscle groups, and frequent intense concentric-eccentric contractions of the small muscle groups of arms and shoulders, generated increased intramuscular pressure, which negatively affected the duration of exercise, reducing muscular perfusion and increasing resistance to blood circulation. Peripheral vascular resistances, and hence DBP, were also increased during exercise on the arm crank ergometer as a consequence of the physiological response of the vascular system to physical exercise: vasodilatation in the working limbs and vasoconstriction in the resting limbs to support the working muscles and cardiac output (Astrand et al., 1965). In fact, if the cross trainer requires whole body engagement, the arm crank ergometer requires only the work of the upper body, eliciting the vasoconstriction of the lower body vessels and rising DBP in conjunction with the increased intramuscular pressure of the upper body muscles. Therefore, upper body vasodilatation was impaired when respiratory muscle fatigue increased because it has previously been shown that an increased sympathetic vasoconstrictor outflow to working skeletal muscle reduces limb blood flow and increases the severity of both fatigue and peripheral vascular resistances (Romer

and Polkey, 2008). The absence of leg muscle pump, elicited by the arm crank ergometer, also provided a reduced venous return to the heart, leading to both a reduced ventricular filling and stroke volume. As a consequence, there is an increased production of catecholamines which leads to a major increase of both heart and respiratory rate in arms compared with the combined arm and leg exercise (Goodman et al., 2007).

The observed worst response of DBP on the arm crank ergometer suggests the necessity of avoiding the arm crank exercise without specific stress testing, stating the real maximal oxygen uptake and HR to train under healthy conditions when the relative exercise intensity was calculated. However, the significant positive correlation between DBP and RPE (Figure 5), and the result of the linear regression model (Table 3), suggested the possibility of training safely on the arm crank ergometer, without specific stress testing, under the control of RPE. According to our predicting formula, to maintain DBP below the value of 85 mm Hg, physical exercise on the arm crank ergometer could be undertaken by remaining below an RPE value of 12. Although our findings are obtained for healthy sedentary men (giving the assumption that there were no differences between normotensive and hypertensive men (Jones et al., 2006) in the 24-hour variation in blood pressure reactivity to daily physical activity), the use of the RPE method instead of the indirectly determined HRR could be useful to avoid the unhealthy effect of exercise on DBP, especially in hypertensive people who should benefit from physical exercise practice. However, further research is needed before we can be completely sure that exercise practice under the RPE method elicits a safe DBP response on the arm crank ergometer in people with pathological conditions and/or with different characteristics respect to our sample.

Conclusion

Taking into account that the right exercise prescription and effective exercise training require a pre-participation medical examination and a stress test, we can infer from our results that when a sedentary person exercises on an arm crank ergometer, without a specific stress test to provide the maximal HR and monitor the blood pressure response, it would be safer and healthier to monitor him/her according to the RPE scale, assigning a task of working at an exercise intensity lower than 12, instead of using the indirectly determined HR method. In fact, *how* people monitor their physical exercise intensity in relation to *what* people train with could elicit opposing physiological body responses, making exercise potentially dangerous to health.

The main study limitations are the small sample size and the use of both the auscultation technique and a mercury sphygmomanometer to measure blood pressure that, even if we standardized the measurements according to international guidelines, could be negatively affected by human movements.

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Key points

- Arm Crank Ergometer elicits a higher diastolic blood pressure response respect to Cross Trainer when people exercise at the same heart rate.
- Arm Crank Ergometer elicits a higher rating of perceived exertion respect to Cross trainer when people exercise at the same heart rate.
- Indirect determined working heart rate is not always safe even if the theoretical intensity is that recommended for health.
- Rating of perceived exertion method should be used instead of heart rate method to avoid the dangerous physiological responses observed.

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