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Cardiorespiratory responses to graded exercise in Thai cyclists

การตอบสนองของระบบหัวใจและระบบหายใจต่อการออกกำลังกายแบบเพิ่มความหนัก ของนักกีฬาจักรยานไทย

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ABSTRACT

There is little information regarding the cardiorespiratory effects of graded exercise in Thai cyclists. Therefore, the purpose of this study was to investigate the cardiorespiratory responses to graded exercise in Thai cyclists. Eight healthy male cyclists aged 20-41 years old were recruited. They performed 3-min leg cycling exercise at mild, moderate, and heavy intensities continuously. Expired air was collected throughout the exercise to determine oxygen consumption ($\dot{V}O_2$) and minute ventilation ($\dot{V}_E$). Heart rate (HR) was monitored throughout the exercise. Rate of perceived dyspnea (RPD) and rate of perceived exertion (RPE) were asked at the last minute of each exercise intensity. $\dot{V}O_2$, $\dot{V}_E$, HR, RPD, and RPE significantly increased during the exercise at higher intensity compared with lower intensity ($p < 0.01$). The findings suggest that cardiorespiratory responses in Thai cyclists increase with the increased exercise intensity.

บทคัดย่อ

ข้อมูลเกี่ยวกับการศึกษาถึงการตอบสนองของระบบหัวใจและระบบหายใจต่อการออกกำลังกายแบบเพิ่มความหนักในนักกีฬาจักรยานไทยยังมีไม่มากนัก ดังนั้นการศึกษานี้จึงมุ่งศึกษาการตอบสนองของระบบหัวใจและระบบหายใจต่อการออกกำลังกายแบบเพิ่มความหนักในนักกีฬาจักรยานไทย อาสาสมัครประกอบด้วยชายไทย 8 คน อายุ 20 ระหว่าง 41 ปี ทำการปั่นจักรยานที่ระดับความหนักเบา ปานกลาง และมากตามลำดับ ระดับละ 3 นาทีอย่างต่อเนื่อง ตลอดการปั่นจักรยานลมหายใจออกของอาสาสมัครถูกนำไปวิเคราะห์เพื่อหาค่าการใช้ออกซิเจนและการระบายอากาศในหนึ่งนาที รวมทั้งได้รับการบันทึกอัตราการเต้นของหัวใจ ระดับความเหนื่อย และระดับความเมื่อยล้าในนาทีสุดท้ายของแต่ละระดับความหนัก ผลการทดลองพบว่านักกีฬาจักรยานไทยมีค่าการใช้ออกซิเจน การระบายอากาศในหนึ่งนาที อัตราการเต้นของหัวใจ ระดับความเหนื่อย และระดับความเมื่อยล้าของอาสาสมัครเพิ่มขึ้นตามระดับความหนักของการออกกำลังกาย

Key Words : cardiorespiratory responses, exercise**,** Thai cyclists

คำสำคัญ : ระบบหัวใจและระบบหายใจ การออกกำลังกาย นักกีฬาจักรยานไทย

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Introduction

Regular exercise makes strong, positive contributions to optimal health and well-being. There is growing evidence that exercise training has substantial health benefits in improving cardiorespiratory fitness (Rimmer *et al*., 2009). Exercise monitoring is becoming recognized as an important tool for both promoting exercise and assessing the outcome of interventions. Methods used to date include physiological responses such as heart rate (HR), oxygen consumption ($\dot{V}O_2$), minute ventilation ($\dot{V}_E$), and self-reported questionnaires such as rate of perceived exertion (RPE) scale, rate of perceived dyspnea (RPD) scale. The cardiorespiratory responses to exercise affected by diseases such as heart failure, inspiratory muscle weakness (Winkelmann *et al*., 2009) or adapted by exercise training (Mezzani *et al*., 2008) are well established. Yet, there is no research in this who conducted in the Thai population. Therefore, the purpose of the present study was to investigate the cardiorespiratory responses to graded exercise in Thai cyclists. We hypothesized that the cardiorespiratory responses to exercise is augmented in cyclists.

Methods

Subjects: Subjects were eight healthy male trained Thai cyclists, aged 20 to 41 years old. All subjects were evaluated by blood chemistry, health screening questionnaire and physiological examinations before enrolling in the study. None of the subjects smoked and had cardiovascular, renal, neuromuscular, orthopedic or liver diseases. They were informed both verbally and in writing before signing a consent form to participate in this study. A consent form is approved by the Human Ethical Committee of Khon Kaen University in accordance with the 1964 Declaration of Helsinki.

Study procedures

Before the experiment, all subjects participated in a routine medical examination, food intake and physical activity questionnaires, anthropometric measurement (height, body mass, body mass index, and body composition), electrocardiogram (ECG), blood sample for routine blood chemistry and haematology (complete blood count, liver function test, renal function test, fasting blood glucose, and lipid profiles).

All subjects performed a continuously graded exercise on an electrically braked cycle ergometer (Corival, Load, Netherlands) at 3 intensities i.e. 25%, 65%, and 85% of $\dot{V}O_{2max}$ defined as mild, moderate, and heavy intensities until exhaustion. .

They began the test with warming up by cycling at free workload (0 watt) for 2 minutes. Then they started cycling at workload 50-90 watts depending on fitness status of the subject. Workloads were increased by 30-50 watts every 3 minutes until they reach the criteria which determine $\dot{V}O_{2max}$; maximal symptoms of dyspnea and fatigue determined by RPD and RPE scales, unable to maintain cycling speed at 60 rpm, HR increases to predicted HR_{max} (220-age), and $\dot{V}O_2$ deterioration. Expired-air, and HR were recorded during the test and subjects were asked the dyspnea and fatigue symptoms at the end of each workload.

After the subjects reach the criteria, they were asked to continue cycling to relax at free workload. Then, they were allowed to rest, drink some water, and measured their HR until return to normal.

Fat mass was measured indirectly by taking skinfold thickness. Subjects sat on a stool for the arm and shoulder (subscapular) measurements and stood for the suprailiac measurement. Measurements were made on the right side of the body. The sites that were measured in the subjects are biceps, triceps, subscapular, and suprailiac regions. At each site, the skin fold was pinched up firmly between the thumb and forefinger and pulled away slightly from the underlying tissues before applying the Harpenden skinfold calipers (British Indicators Ltd, St Albans, Herts.) for the measurement. The width of opening was read off on a scale incorporated to the apparatus. The sum of the four sites was then used, in calculating percent body fat provided by the British Indicator Ltd. Fat distribution was measured indirectly by measuring waist (W) and hip (H) circumferences. Waist circumference was measured at the midpoint between the lower rib margin and the iliac crest (normally the umbilical level), and hip circumference was measured at the trochanter level.

Statistical analysis

All data were presented as mean±SD. A p-value <0.05 was considered significant. SPSS (version 12) was used to analyze statistical differences. Descriptive statistics were used to analyze physiological variables during the exercise at various intensities.

Results and discussion

Subjects' anthropometric and physiological parameters are shown in Table 1.

Table 1 Characteristics of the subjects

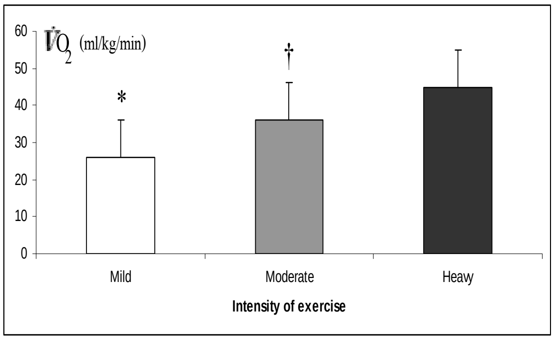
	Mean±SD	Min	Max
Age (yr)	27±6.6	20	41
Body weight (kg)	63.6±8.3	54	81
Height (m)	1.73±0.0	1.68	1.77
BMI (kg/m^2)	21.3±2.2	18.7	25.8
W/H ratio	0.83±0.0	0.75	0.88
Body fat (%)	26.0±5.7	19.1	36.2
Fat mass (kg)	16.9±6.0	10.3	29.3
Fat free mass (kg)	46.7±3.1	43.6	51.7
$\dot{V}O_{2max}$ (ml/kg/min)	52.9±7.5	42.5	61.0

Values are expressed as mean±SD, n=8.

To our knowledge, this is the first attempt to investigate the cardiorespiratory responses to incremental exercise in Thai cyclists. The results support our hypothesis that the cyclists would present an increase in cardiorespiratory response to higher intensity compared to lower intensity.

Figure 1 shows the $\dot{V}O_2$ presented significant increases during the incremental exercise at mild (26.02±8.96 ml/kg/min), moderate (36.14±6.91 ml/kg/min), and heavy (44.98±7.31 ml/kg/min) intensities (p <0.01).

Figure 1 $\dot{V}O_2$ during graded exercise

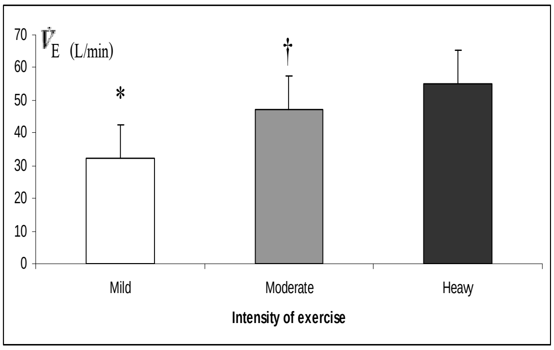


Data are expressed as mean±SD, n=8.

* Significantly different from moderate and heavy intensities, † significantly different from heavy intensity (p <0.01)

Figure 2 demonstrates that the $\dot{V}_E$ also significantly increased during incremental exercise at mild (32.4±9.92 L/min), moderate (47.28±6.6 L/min), and heavy (55.23±5.44 L/min) intensities ($p < 0.01$). Our finding is comparable to the previous studies (Takano *et al.,* 1997; Barfield *et al*., 2003; Niemela *et al*., 1980; Turner, 1991) who found the increase of $\dot{V}_E$ during incremental exercise.

Figure 2 $\dot{V}_E$ during graded exercise

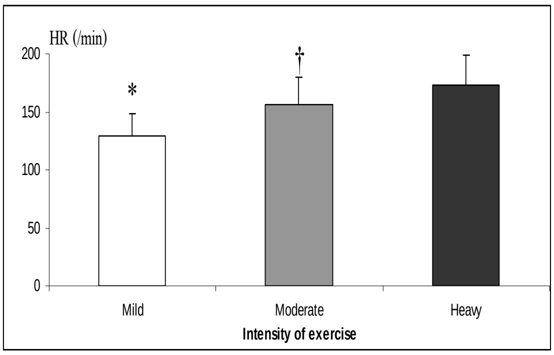


Data are expressed as mean±SD, n=8.

* Significantly different from moderate and heavy intensities, † significantly different from heavy intensity ($p < 0.01$)

Figure 3 presents the HR response which demonstrated significant increases in HR during the incremental exercise at mild (129±13.7 /min), moderate (156±10.7 /min), and heavy (173±12.5 /min) intensities ($p < 0.01$).

Figure 3 HR responses to graded exercise



Data are expressed as mean±SD, n=8.

* Significantly different from moderate and heavy intensities, † significantly different from heavy intensity ($p < 0.01$)

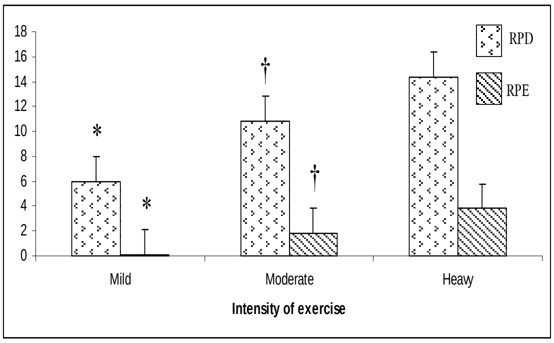
The comparison of HR at heavy intensity showed a significantly higher value compared with moderate and mild intensities and also found in moderate intensity when compared with mild intensity.

During exercise, HR was directly related to cardiorespiratory fitness (Laukkanen *et al*., 2009). They found HR at heavy exercise had a relationship with $\dot{V}O_2$. This component is determined by age, genetic factors, and health habits.

As expected, $\dot{V}O_2$, $\dot{V}_E$, and HR increased for a given increased workload in all of our cyclists (38.9% vs 45.9% vs 20.9% increase at moderate intensity, 24.5% vs 16.8% vs 10.9% increase at heavy intensity). This is consistent with many previous studies (Barfield *et al*., 2003; Niemela *et al.*, 1980; Turner, 1991). Barfield and coworkers (2003) reported increased $\dot{V}O_2$ and HR values during progressive submaximal exercise (18.9±1.87 ml/kg/min vs 112±4.98 /min at workload 50 watts, 25.69±3.78 ml/kg/min vs 136.88±11.09 /min at workload 100 watts (35.9% vs 22.2% increase compared with 50 watts), 33.06±3.4 ml/kg/min vs 161.38±16.39 /min at workload 150 watts (28.7% vs 17.9% increase compared with 100 watts)).

Figure 4 presents the increased RPD and the RPE during incremental exercise at mild (6±0 and 0.1±0.4), moderate (10.8±3.1 and 1.8±1.5), and heavy (14.4±1.3 and 3.8±1) intensities ($p < 0.01$).

Figure 4 RPD and RPE during graded exercise



Data are expressed as mean±SD, n=8.

* Significantly different from moderate and heavy intensities, † significantly different from heavy intensity ($p < 0.01$)

The present study is in agreement with by the previous studies (Foster *et al*., 2001; Sweet *et al*., 2004) who found greater RPD and RPE in higher exercise intensity compared with lower intensity.

RPD and RPE have been used to measure the intensity of exercise. A number of studies have shown that RPD and RPE are valid tools for quantifying the intensity of steady-state aerobic exercise (Borg *et al*., 1987; Borg *et al*., 1985; Dunbar *et al*., 1992; Noble *et al*., 1983). Sweet and colleagues (2004) reported that RPE for cycling increased from 3.6±1.1 to 5.1±1.3 to 7.8±1.3 as the intensity increased from 56% to 71% to 83% $\dot{V}O_{2max}$ respectively.

Graded exercise has been shown to increase the workload of the cardiovascular and respiratory muscles (McConnell and Romer, 2004). The mechanisms responsible for this are exercise-induced stimulation of sympathetic and hormonal activities (Frayn, 1996). Therefore, at a given exercise intensity, relative inspiratory pressures and cardiovascular stimulation that are required to produce the appropriate ventilation and circulation would be increased and would result in an increased sensation of respiratory discomfort or in an increase of the nervous activity required to generate a given respiratory pressure and cardiovascular response. During incremental exercise, respiratory muscle fatigue and peripheral muscle fatigue involve in parallel, increasing the intensity of both muscle effort and dyspnea (Chua *et al*., 1995; Kearon *et al*., 1991).

Conclusion

Although the augmentation of Thai cyclists was lower than Caucasian cyclists, they had positive cardiorespiratory responses to the incremental intensity exercise similar to Caucasian cyclists.

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