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Full Length Research Paper

Evaluation of the relationships between aerobic fitness and O_2 uptake to heart beat during an incremental exercise tests

Çağrı Özdenk

School of Physical Education and Sports, University of Çoruh, Artvin,Turkey.

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ABSTRACT

Maximal exercise capacity (W_{max}) and anaerobic threshold (A_T) are important tools used non-invasively to evaluate aerobic fitness levels and clinically possible risk. It has been shown that O_2 uptake to heartbeat ratio (O_2 pulse) at the maximal exercise test is an important parameter used to evaluate fitness levels of the subjects. However, O_2 pulse at the anaerobic threshold and fitness status of the subjects has not been described yet. In this study, we comparatively evaluated the fitness levels and O_2 pulse at A_T and at W_{max} in healthy young male subjects during an incremental exercise test. A total of 20 healthy male performed an incremental exercise test (15 W/min) to exhaustion on a cycle ergometer. Ventilatory and pulmonary gas exchange parameters were measured breath-by-breath using the metabolic gas analyser and turbine volume-meter. A_T has been estimated using the V-slope method. The work rate at A_T and W_{max} was found to be 135 ± 4 W and 225 ± 4 W, respectively. O_2 pulse was found to be 13.49 ± 0.3 ml/beat at A_T and 16.53 ± 0.31 ml/beat at W_{max}. There was a significant positive correlation between W_{max} and O_2 pulse R = 0.75184 ($P < 0.05$). In addition, there was a significant correlation between work production capacity for each kg of body weight and O_2 pulse R = 0.68811 ($p < 0.0001$). We have shown that O_2 pulse at A_T can also be used to evaluate the fitness status. Thus, considering effective fitness measurement at the A_T, investigators should be avoiding difficulty in maximal exercise performance.

Keywords: O_2 pulse, exercise, fitness.

E-mail: ozdenkcagri@hotmail.com. Tel: +90 553 535 36 42. Fax: +90 466 215 10 55.

INTRODUCTION

Cardiopulmonary exercise tests are an important tool used in noninvasive determination of individuals' clinical aerobic fitness levels and potential risks (Force et al., 2007; Ridgway and Howell, 2010; Wasserman et al., 2012). The increasing intensity exercises against weight based training which in terms of experiencing metabolic stress lead from resting level to high pressure training cardiopulmonary therefore is the most preferred exercise protocol (Wasserman et al., 2012; Ozcelik and Ayar, 2004; Ramos et al., 2013).

The maximum work rate known as W_{max} and O_2 uptake levels (VO_{2max}) is used to denote the important fitness criteria. In the clinical knowledge, for the maximum exercise O_2 intake (VO_{2max}) levels of each kilogram of body weight, there is an increasing aerobic fitness and decreasing organs and systems deterioration, which indicates a decreasing fitness level shown by a regularly used parameter (Wasserman et al., 2012; Boone et al., 2016; Riebe et al., 2015). Another important fitness parameter measure is metabolism from aerobic to anaerobic point, an increased level of lactic acid in the blood reached before the highest level of anaerobic threshold (A_T) (Wasserman et al., 2012; Gitt et al., 2002; Ozcelik et al., 2015).

Every heart beat pending blood to prefer which holds O_2 pulse parameter that can be used to observe aerobic fitness levels (Oliveira et al., 2009). The sportsman's performance has also been associated with blood

pressure, oxygen intake rate, aerobic capacity and so on (Zambak, 2019). In the exercise phases, increasing metabolism and energy consumption needs the cardiovascular system to send O_2; while people with normal to high aerobic fitness levels can intake normal levels of O_2. Low aerobic fitness levels will have fewer O_2 levels and therefore pulse. In literature, reaching the maximum O_2 pulse while exercising in the high test rate as a career or long period can lead to cardiovascular problems (Bansal et al., 2012; Cohen-Solal et al., 1997; Laukkanen et al., 2006; Lavie et al., 2004). However, we believe that people who focus on exercises against weight based training can reach maximum effort, which can cause clinical problems and less metabolic stress known as O_2 pulse in $A_{T,}$ which can justify the level of important of fitness levels. In this study, the O_2 pulse in A_T and maximum exercises notifies the aerobic fitness, which is to be contrasted investigated.

MATERIALS AND METHODS

We have begun this study with 20 healthy male volunteers. Before the volunteers participated in the study, they read and signed the voluntary consent form taken from the local ethics committee (10.03.2011-05/05-sayı:76). The volunteers who joined the study are age in an average of 20.4 ± 0.3, with height average 183 ± 1.6 cm and weight 75 ± 1.1 kilograms and body max index (BMI) 22.3 ± 0.4 km/m^2 are found.

There was a different parameter to the joining criteria of the volunteers. These are between 18 and 25 years old young and healthy volunteers were chosen. The volunteers had known acute or chronic (metabolic, cardiovascular, breathing, skeleton and muscular, etc.) illnesses. The volunteers did not consume cigarette, drugs and alcohol. The body max index norm level 18 to 25 kg/m^2 were preferred. All volunteers before exercising the body composure in the early hours between 8 to 10 were checked by a BİA test on foot with Tanita, TBF Body Composition Analyses TBF-300 Japon (Kaya and Ozcelik, 2005). The exercise was tested in 22°C temperature in the laboratory. All volunteers joined electromagnetic bike with an ergometer increasing weight exercise test (Ozcelik et al., 2004). This protocol began the test in 4 min with 20 W increase in the warming up period as volunteers reached a steady-state balance without being nervous when the pressure at the second phase was reached. In this period, the volunteers avoided problems and nervousness as changes in lungs gas parameter, especially calculating A_T, can lead to wrong conclusion, hence this was tested with precaution (Ozcelik et al., 1999). In pressure period workforce computer control increased as 15 W/min as the volunteer pedalled until they reach the maximum point of exercise. In this point the pressure was reduced 20 W/min as a resting period at the end of the test. In the exercise phases, the heart rate pump level 12 chest electrode was measured pulse by pulse.

The volunteers parameter turbine volume meter were measured. The volunteers change parameter breath by breath metabolic gas analyzed were measured. At the point where the volunteers reached their maximum effects in exercise, the O_2 intake level is known as VO_{2max}. At this point the reached heart rate was measured as the highest heart rate. Calculating A_E the V-slope method was measured as non-invasive. The technique identifies the CO_2 (VCO_2) and O_2 (VO_2) levels of intake relations and metabolism anaerobic at the point of threshold which produces lactic acid from bicarbonate as a result. This technique is used in other lung gas change parameter by using A_T calculation in testing. These technique V_E/VO_2 levels and tidal ending partial O_2 pressure increase can be observed as V_E/VCO_2 and tidal partial CO_2 pressure change was the factor (Algul et al., 2017; Whipp et al., 1986).

As our findings, the average standard deviation (±SD) was given. Paired t-test and person correlation analysis data analyzing the usefulness of the data was used. $P<0.05$ is chosen.

RESULTS

The maximum work rate of volunteers was 225 ± 4 W and the A_T strength level was 135 ± 4 W as our findings. The work rate at the A_T occurred at 60% of maximal exercise capacity. O_2 uptake at maximal exercise (VO_{2max}) was 3.08±0.6 l/min and at the A_T was 1.89 ± 0.04 l/min. Volunteers A_T and maximum exercise capacity for each kg of body waight was 1.812 ± 0.06 W/min/kg and 3.00 ± 0.08 W/min/kg, respectively. Heart rate at the aximal exercise and at A_T were 186 ± 1.6 and 140 ± 1.7 beat/min, respectively.

The volunteer O_2 pulse at the A_T varied between minimum of 9.6 ml/beat and maximum 15.83 ml/beat and averaged at rate of 13.49 ± 0.3 ml/beat. Maximum exercise O_2 pulse value of minimum 14.78 ml/beat and maximum 18.65 ml/beat and an average 16.53 ± 0.31 ml/beat was obtained. Volunteers O_2 pulse in A_T rate maximum was approximately 82% of volunteers maximum rate of work rate and maximum O_2 rate held in between a positive correlation of $R = 0.75184$ ($P < 0.05$) (Figure 1). O_2 rate in A_E pulse rate and per kg work production capacities in between held positive correlation $R = 0.68811$ ($P < 0.0001$) was found (Figure 2).

Volunteer O_2 pulse valve each per kg body weight had become a standard rate in A_T and a maximum exercise rate of 0.181 ± 0.006 ml/beat/kg and 0.221 ± 0.005 ml/beat/kg was found. Bodyweight per O_2 pulse rate was accepted as a fitness observation per each kg of bodyweight work rate capacity A_T $R=0.84253$ ($P < 0.0001$) and maximum exercise usable correlation $R= 0.73812$ ($P < 0.0001$) was found (Figure 3).

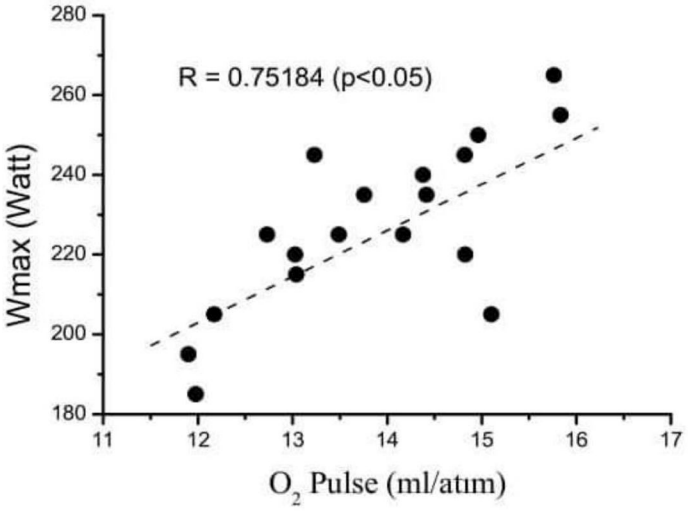

Figure 1. The correlation analysis of maximal work rate and O_2 pulse at the anaerobic threshod in study group.

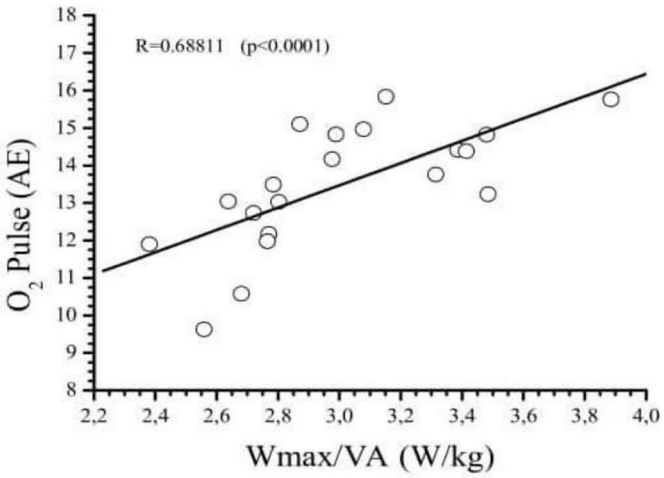

Figure 2. The correlation analysis between maximal work capacity for each kg body weight and O_2 pulse at the anaerobic threshold (A_T) for all subjects.

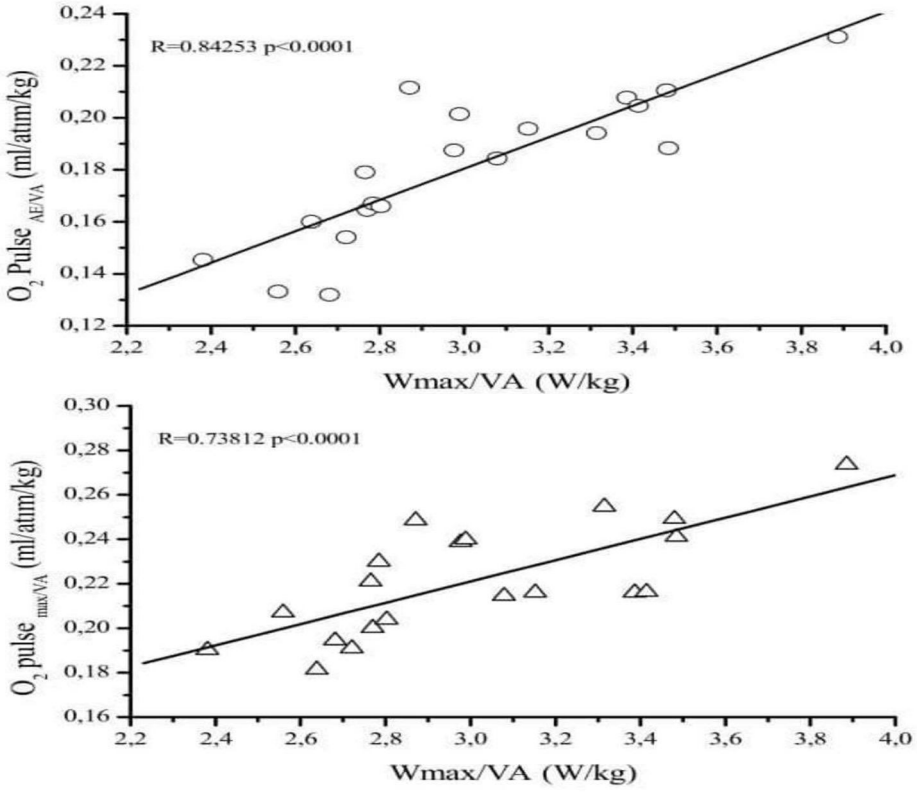

Figure 3. The correlation analysis between f work production capacity for per kg body weight at the anaerobic threshold (upper graph), and at the, at the maximal exercise and O_2 pulse values (below graph), for all subjects.

DISCUSSION

In this study , the volunteers A_T was observed at 60% of maximal work rate that is accepeted as a normal standard (Wasserman et al., 2012; Ozcelik et al., 2004). The work production capacity for each kg of body weight at maximal exercise (3.0 W/kg) and at the A_T (1.8 W/kg) was found to be in normal ranges (Ozcelik et al., 2004).

The subjects O_2 uptake levels for each kg of body weight at the maximal exercise and at the A_T was found to be 41 and 25 ml/dk/kg, respectively which is shown to be in normal range (Wasserman et al., 2012).

During an incremental exercise test, the O_2 pulse rate at maximal exercise performance varied among the subjects but it averaged at a value of 16.53 ml/beat. In the literature, it has been shown that O_2 pulse below 12 ml/beat indicates higher risk of death (Oliveira et al., 2009).

O_2 uptake levels at the A_T are used as an important prognostic level in clinical science (Wasserman et al., 2012; Kunutsor et al., 2017; Justino et al., 2018; Bortolini et al., 2009). In this study, it is an indicator of cardiovascular disease (Wasserman et al., 2012; Cohen-Solal et al., 1997; Lavie et al., 2004). O_2 intake shows that the disparity between the cardiac output artery and venous blood. O_2 pulse shows that O_2 quantity which is taken O_2 in each pulse. The high of this level is very important prognostic levels for us (Laukkanen et al., 2006). During exercise intake O_2 (Ozcelik et al., 2002) and the speed of heartbeat (Ozcelik et al., 2004) shows linear rising parallel to rising work power. Also, during exercise O_2 pulse level rises with the O_2 intake and O_2 pulse volume. As O_2 intake level, O_2 pulse level does not rise linearly against rising pressure. İn this study, in A_T O_2 pulse maximal exercise of O_2 pulse level is about 82%. In other words, 82% O_2 pulse level usage is provided in 60% exercise capacity. It is shown that while doing an exercise test against rising pressure, there is no nonlinear cardiac output dynamic (Stringer et al., 2005). During intake volume exercise, there is difference among studies; some studies shown decrease (Proctor et al., 1998), some studies plateau (Hagberg et al., 1985), while some of them rising (Gledhill et al., 1994) during the exercise. The increased intensity left ventricular diameter will either remain the same or decrease (Pokan et al., 2000; Rowland et al., 2000). Study on the O_2 pulse value against the increasing weight exercise test also showed an increase (Oliveira et al., 2011). During exercise arterial and venous O_2 pulse value show stroke volume. For these reasons, the volunteer heart rate change in volume is an important factor that effects the value. In the works, the patients who have left ventricular function disorder experiences a decrease in O_2 pulse (myocardial ischemia or infarcts). For this reason O_2 pulse especially in the lack of heart functioning patients are an important factor to clarify mortality (Lavie et al., 2004; Laukkanen et al., 2018; Lim et al., 2005).

In the evaluation of Aerobic fitness, the criteria and O_2 pulse relations are evaluated in maximum exercise and A_E named correlation gathered. In this work, we aimed at finding out the point of exhaustion before the activity of aerobic metabolism of our volunteers reach the O_2 pulse value in the A_E. Each kilograms per work strength capacity shows a meaningful correlation (Figure 3).

A regular sign of A_E disorder is a prognostic factor which is used as an important factor (Agostini et al., 2013; Wasserman et al., 2012). In this work, an important prognostic agent A_E and also O_2 pulse value shows importance (Figures 1 to 3). While fitness level increases, the O_2 pulse in the A_T value shows a linear increase. O_2 pulse value in A_T and maximum value per kilograms body weight is standardized to show fitness valve in a high-level meaningful correlation. As known, heart rate volume and body built have a relation which probably connects O_2 pulse (Collis et al., 2001; Simone et al., 1997).

In this work, the main limiting factor was to pick healthy volunteers. Where unfit volunteers and fit volunteers O_2 pulse in A_T value is shown, prognostics of the situation can actively be shown.

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