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.

Accepted 7 February, 2020

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 $135 \pm 4$ W and $225 \pm 4$ W, respectively. $O_2$ pulse was found to be $13.49 \pm 0.3$ ml/beat at $A_T$ and $16.53 \pm 0.31$ 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-sayi:76). The volunteers who joined the study are age in an average of $20.4 \pm 0.3$, with height average $183 \pm 1.6$ cm and weight $75 \pm 1.1$ kilograms and body max index (BMI) $22.3 \pm 0.4$ km/m² 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/m² were preferred. All volunteers before exercising the body composure in the early hours between 8 to 10 were checked by a BIa test on foot with Tanita, TBF Body Composition Analyses TBF-300 Japan (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 $CO_2$ (V$CO_2$) 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$E$/V$CO_2$ 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 $3.08 \pm 0.6$ l/min and at the $A_T$ was $1.89 \pm 0.04$ l/min. Volunteers $A_T$ and maximum exercise capacity for each kg of body weight was $1.812 \pm 0.06$ W/min/kg and $3.00 \pm 0.08$ W/min/kg, respectively. Heart rate at the aximal exercise and at $A_T$ were $186 \pm 1.6$ and $140 \pm 1.7$ 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 $13.49 \pm 0.3$ ml/beat. Maximum exercise $O_2$ pulse value of minimum $14.78$ ml/beat and maximum $18.65$ ml/beat and an average $16.53 \pm 0.31$ 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 $0.181 \pm 0.006$ ml/beat/kg and $0.221 \pm 0.005$ 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).
DISCUSSION

In this study, the volunteers $A_T$ was observed at 60% of maximal work rate that is accepted 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; Cohen-Solal et al., 1997; Lavié 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. In 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 kilogram 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.

REFERENCES


Kaya, H., and Ozcelik, O. (2005). Determining the change of body


