VALIDITY OF THE CONCONI TEST IN ESTIMATION OF ANAEROBIC THRESHOLD DURING CYCLING

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VALIDNOST CONCONI-JEVOG TESTA U PROCENI PRAGA ANAEROBNOG METABOLIZMA PRILIKOM VOŽNJE BICIKLA

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ABSTRACT
This study was designed to assess the validity of Conconi’s method, by means of heart rate and lactate threshold measurements to predict anaerobic threshold. The results presented in this paper, clearly demonstrate significant difference between anaerobic threshold values obtained by means of Conconi’s test (Conconi’s threshold) and anaerobic threshold values obtained by direct lactate blood concentration measurement (lactate threshold) in the subjects underwent a 10 min warm-up. At the same time, the Conconi’s threshold values were higher comparing to lactate threshold values, indicating overestimation of anaerobic threshold obtained by means of Conconi test. Also, our results indicate that Conconi’s test in practise, can be useful tool for quick, non-invasive approximation of training process effects on the anaerobic threshold, as much as our results show higher anaerobic threshold values in the group of well trained subjects. The significance of proper warm-up protocol for anaerobic threshold estimation by means of Conconi’s test is also shown in this paper.

INTRODUCTION
Anaerobic threshold (AT) is considered as an important variable in the field of physiology due to its ability to closely predict actual performance in endurance events. Conconi et al. (1) introduced in early eighties a new method for non-invasive determination of anaerobic threshold in runners. Results from this study shows linear relationship between heart rate and running speed at submaximal levels but a plateau in heart rate at the high running speeds. These investigators reported that the deflection point of the heart rate (HR)-running speed relationship occurs at the same speed as the lactate threshold (LT). Since then, the most common approach in non-invasive determination of AT is based on such defined strong relationship between HR deflection point and LT, as indicators of AT (1-8). These investigators also reported that their method is applicable to different endurance sports, such as cycling, race walking, rowing, skating and swimming (2, 7-10).

Still Conconi’s method is controversial for at least two reasons (11). First, many physiologists reported that during incremental maximal exercise HR reaches plateau in only certain percentage of subjects (12-17). Second reason for estimation of Conconi’s method validity is based on the reports that HR deflection point overestimates directly measured LT (17-19).

This study was designed to assess the validity of Conconi’s method, by means of HR and LT measurements to predict AT. The aim of this study is to determine whether Conconi’s method results using relationship between HR deflection point and LT can help in determination of AT in cycling tests.

SUBJECTS AND METHODS
This study was performed at Faculty of Sports and Physical Culture University of Niš, and Medical Faculty University of Kragujevac, Serbia, during time period from September to December 2006. All tested subjects were healthy women, ages ranged from 18 to 28 years. Medical observations (such as ECG, heart rate, arterial pressure, work activities, smoking habits, etc.) were made before testing, during test period and 24 hours after testing, by medical doctor.

In all investigated subjects anaerobic threshold (AT) was estimated by means Conconi’s test (1, 8). It means that heart rate/load relationship was determined in subjects by measuring the heart rate (HR) while the subject under study progressively increased its load. The HR/load relationship is the curve which was in part linear and in the part curvilinear. The HR at which the linearity of the HR/load relationship is lost has been called the deflection point or anaerobic threshold. The anaerobic
threshold (AT) is defined as the highest VO2 beyond which lactate begins accumulation in the blood causing a metabolic acidosis.

Anaerobic threshold for lactate concentration (LT) was measured from the blood lactate concentration/load relationship, at the same meaning as described above for HR/load relationship.

All investigated subjects were classified in four experimental groups:

**Group 1** - nine untrained subjects with previously performed warm up protocol just before starting Conconi’s test.

**Group 2** - nine well trained subjects with previously performed warm up protocol just before starting Conconi’s test.

**Group 3** - seven untrained subjects without previously performed warm up protocol just before starting Conconi’s test.

**Group 4** - seven well trained subjects without previously performed warm up protocol just before starting Conconi’s test.

The warm up protocol in the first two groups was performed by cycling at the load of 20W and increasing the load for 15 W at each minute until 50% of maximal heart rate (HRmax) was reached. Maximal heart rate (HRmax) for investigated women was calculated from relation (15, 20, 21):

\[ HR_{max} = 220 - \text{age of a woman} \]

The heart rate (HR) was measured at rest (before test starting) and then during the test at each lap time (or at each increase of load). HR was measured by means of pulse meter (Polar 610i).

Blood lactate concentration was also measured at rest and than during the test at the same way as HR. Blood lactate concentrations were measured from the blood samples (third finger puncture) by means of lactate analyzer (Accutrend lactate Mannheim) (5, 13, 22).

For the Conconi’s test we used bicycle-ergometer (Ketlter ergometer AX1). During the test protocol (described later) the successive increase in load is expressed in power unit (W).

In our investigation, the Conconi’s test was performed through two protocols. In the first protocol the Conconi’s test was applied to subjects without previously performed warm up protocol. The test have been started at 20 W load and than have been increased for 15 W at each minute (lap time). In this protocol we had 8 to 12 lap times. The heart rate was continuously measured during the test and data were then transferred to the original software for the estimation of the anaerobic threshold (Software of Stretch system for biomechanical and functional tissue investigation, developed in collaboration between our Laboratory and Centre for Scientific Research of Serbian Academy of Science and Arts and tested by Faculty of Mechanical Engineering University of Kragujevac).

In the second protocol the Conconi’s test was applied to subjects with previously performed warm up protocol described above. After that, the Conconi’s test was performed at the same way as described in the first protocol.

All investigations were performed according to the ethical standards of the local Ethics Committee and the Helsinki Declaration.

**Statistical analysis**

Data are presented as means ± S.E.M. (standard error of the mean) and analyzed using Student’s t-test: where p value of <0.05 was considered as statistically significant.

**RESULTS**

As described above in „Subjects and methods“ sections, all tested subjects were healthy women (total number was 32) ages ranging from 18 to 28 years. Medical observations were made before testing, during test period and 24 hours after testing, by medical doctor. There were no adverse events in all tested subjects during the observed period.

In the first experimental group anaerobic threshold (AT) was estimated by means of Conconi’s test. In this experimental group all investigated subjects (n=9) were untrained persons and all of them underwent a 10 min warm-up at approximately 50% of HRmax. The values of AT is marked as „CT“ (Conconi’s threshold). Within the applied protocol (described in section „Subjects and methods“), successive blood samples have been taken for lactate measurement, one for each increase of load. A total number of loads for each of subjects were ten. Blood lactate concentration over the 4 mmol/l was considered as AT and this values is marked as „LT“ (lactate threshold).

The mean value for CT in the first group was 162.6±5 bpm while, at the same time, the mean value for LT was 145.6±3.36 bpm (figure 1). Our results show statistically significant difference between CT and LT values (t=2.822, DF=16, *p<0.05), with higher AT values obtained by means of Conconi’s test.

![Figure 1. Conconi’s threshold (CT) and lactate threshold (LT) values in untrained subjects with previously performed warm up protocol (values are means of X±SE, t=2.822, DF=16, *p<0.05)](image-url)

In the second experimental group all investigated subjects were well trained persons and all of them underwent a 10 min warm-up at approximately 50% of HRmax. The „CT“ and „LT“ marks have the same meaning as described above.
The mean value for CT in the second group was 178.67 ± 2.74 bpm while, at the same time, the mean value for LT was 161.11 ± 4.51 bpm (figure 2). Our results show statistically significant difference between CT and LT values (t = 3.326, DF = 16, p < 0.01), with higher AT values obtained by means of Conconi’s test.

Further statistical analysis shows significant difference between CT values obtained in the first and in the second group (t = 2.819, DF = 16, p < 0.05). In addition, there is the same difference between LT values in these groups (t = 2.758, DF = 16, p < 0.05).

In the third experimental group all investigated subjects were well trained persons and they did not undergo a warm-up protocol. The "CT" and "LT" marks have the same meaning as described above.

In this experimental group, it was not possible to obtain the CT values, because the HR deflection point simply, does not exist. On the other hand, the mean value for LT was 159.43 ± 4.23 bpm.

In the fourth experimental group all investigated subjects were untrained persons and they also, did not undergo a warm-up protocol.

In this experimental group, again, it was not possible to obtain the CT values, from the same reasons as in the third experimental group. The mean value for LT in this group was 142.17 ± 3.45 bpm.

Further statistical analysis show significant difference between LT values obtained in the third and in the fourth group (t = 3.167, DF = 12, p < 0.05).

**DISCUSSION**

The results presented in this paper, clearly demonstrate significant difference between AT values obtained by means of Conconi’s test (CT) and AT values obtained by direct lactate blood concentration measurement (LT) in the subjects who underwent a 10 min warm-up. At the same time, the CT values were higher comparing to LT values, indicating overestimation of AT obtained by means of Conconi test. These results are in accordance with some literature data (17-19). In opposite, there are other literature data indicating a good correlation between CT and LT values (2, 7-10). The possible explanation of this discrepancy may lay in a different test (experimental) protocols, presumable for lactate blood concentration measurements (11). Nevertheless, our results confirm the fact, that Conconi’s test is, at least, suggestive of LT.

On the other hand, our results show significant difference between CT values obtained in the first and in the second group with higher values in the group of well trained subjects (second group). In addition, there is the same difference between LT values in these groups. These results confirm the well known fact (may say “physiological dogma”) that physical activity (training process) significantly affect the body fitness, including anaerobic capacity. But, beside that, our results indicate that Conconi’s test in practise, can be useful tool for quick, non-invasive approximation of training process effects on the AT, in as much as, our results show higher AT values in the group of well trained subjects (second group).

In the third and fourth experimental groups we investigated the trained and untrained subjects but, they did not undergo a warm-up protocol. In both groups it was not possible to obtain the CT values, because the HR deflection point simply, does not exist. These results indicate the significance of proper warm-up protocol for AT estimation by means of Conconi’s test. Proper warm up increases body temperature thereby accelerating the metabolic processes and optimizes muscular, cardiovascular and metabolic adaptations to exercise. Actually, warm up is designed to prepare the body for the ensuing sporting activities and to optimize performance (3, 13).

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