CURENT PHYSICAL PROTOCOLS OF INVASIVE AND NONINVASIVE DETERMINATEING OF ANAEROBIC THRESHOLD DURING CONCONI TEST

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(Original scientific paper)

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Abstract

The heart rate and blood lactate responses on the court enable a detailed estimation of the working regime (metabolic zone) in which an athlete is trained, which is not possible to estimate only on the basis of the heart rate. These parameters are measured at rest, during the exercise (lactates are measured after each work interval), and in recovery. In the end one gets curves which represent a metabolic profile of each individual. Our sample comprised of 10 active female football players and 8 active female handball players who gave their written consent to take part in this research. To determine the statistical significance of differences between the researched groups a method of multivariate analysis of variance (MANOVA), on a multivariate level, and a univariate analysis of variance (ANOVA), on a univariate level, were used. Research results obtained lead us to conclude that between the subjects of the first and the second group there is no difference in numeric values of the heart rate at rest and different levels of workload, nor there is any difference in the lactate level at rest, in workload and in recovery, except for the values of heart rate in the first workload of 50W. Generally speaking, research results show that both group subjects display the same functional abilities.

Keywords: *heart rate, lactates, female football, female handball, functional abilities, multivariate analysis of variance*

INTRODUCTION

Many physiologists report that there is a linear heart rate relationship during an incremental maximum exercise test and workload. This linearity is lost with the high intensity of exercises. Breaking point is on the level of anaerobic threshold (ANP). The moment when the heart rate does not follow the increasing workload, and the curve turns to the right, is called a deflection point. Having in mind that workloads below the threshold (dominant aerobic), on the threshold (aerobic-anaerobic) and above the threshold (dominant anaerobic) stimulate different metabolic processes. Heart rate values in certain zones of intensity are extremely important in determining the training intensity. Heart rate enables precise determination of the workload intensity only up to the anaerobic threshold. Such workloads have reversible effects on the heart thus strengthening the myocardium by decreasing the heart rate at rest, and increasing the efficiency on a submaximal workload (greater workload-lower values of HR) (Đurašković, 2002). This is the basis of the Conconi test. Heart rate and blood lactate responses on the court enable a detailed estimation of the working regime (metabolic zone) in which an athlete is trained, which is not possible to estimate only on the basis of the heart rate. These parameters are measured at a rest, during exercise (lactates are measured

after each work interval) and in recovery. In the end one gets curves as a metabolic profile of each individual. These curves are varied and heavily depend on the type of workload. Actually, the workload determines which parameter is to be observed and monitored as an indicator of the improvement rate. (Fratrić F., 2006).

During the prolonged continuous work that engages several muscle groups (running, cycling), besides the lactate, it is important to monitor the heart rate and consumption of V02 max. In endurance sports heart rate and the level of blood lactate should be checked every 4 weeks. There were attempts to quantify the point where the curve of heart rate bends to the right. Numerous studies have shown that quantification of this point is far more exact when determined on the basis of the lactate curve. (Fratrić F., 2006).

John A. Vachon et al (John A. Vachon, 1999) investigated the validity of the heart rate deflection as a predictor of the lactate threshold during various Conconi test running protocols. In the conclusion of this study it is found that the HR deflection point is not an adequate predictor of the lactate threshold.

Grazzi, Casoni,Mazzoni, Uliari, & Conconi (2005). confirmed the validity of the Conconi test and HR deflection for the determination of the anaerobic threshold. The authors compared two versions of the Conconi test, of Conconi, Grazzi, Cason, Guglielmini, Borsetto, Ballarin, Mazzoni, Ptracchini, & Manfredini (1996) and Grazzi, Alfieri, Borsetto, Casoni, Manfredini, Mazzoni, & Conconi (1999), on the one side, and Ozcelik and Kelestimur (2004), on the other side, by monitoring three important parameters (method used for the increased workload, warm-up procedure, method used for HR deflection point determination). Ozcelik test protocol (Ozcelik & Kelestimur, 2004) was performed on cycle ergometer in costant rhythm while the Conconi test regulates the workload increment by the increased pedalling frequence. Conconi et al. (1996) and Grazzi et al. (1999) have pointed out that this test follows the physiological demands appearing during the incremented repetitive activities (running, walking, cycling, swimming).

Adequte warm up increases body temperature and thus speeds up metabolic processes and metabolic adaptation to testing procedure (Bishop D., 2000, Amann M., 2004). Four minute low intensity warm up method (20 W) was used by Conconi et al., 1996 and Grazzi et al., 1999. It turned out that it's been failed to introduce the testing subject into the adequate warm up, so the subject could not show his/her full aerobic work in the test. The third point, considered by the authors, is the method used to identify the heart rate break point (the heart rate deflection point). Objective mathematical methods avoid subjective interpretations during this test (Conconi et al. 1996; Grazzi et al., 1999). In the study of Ozcelik & Kelestimur (2004) the heart rate deflection point was detected in 6 out of 16 tests on which their study is based.

Reliability and validity of the modified Conconi test was the research focus of the group of authors led by Čelik, O., Kosar. S. N., Korkusuz. F. & Bozkurt. M. (2005). On a sample of twenty-eight oarsman they administered three tests in three separate days. The third test was a Conconi test with the incremented workload on ergometer when the level of blood lactate was measured. The results show that the mean power output (PO) scores for the CT, CTR and ILT were 234.2 ± 40.3 W. CRT- 232.-i.39.7W and ILT= 229.7±39.6 W, respectively. The mean HR values at the AT for the CT, CTR and ILT were 165.4±11.2b.min. 160.4±T0.8b.min. and 158.3±8.8b.min., respectively. Interclass correlation coefficient (ICC) analysis indicated a significant correlation between all three tests.

Validity of HR deflection point was investigated by the Conconi test in cycling (Borgois, Coorevits, Danneels, Cambier, & Vrijens, 2004) on a sample of eleven cyclists. A correlation between HRDP and the level of lactate was investigated. It was found that the lactate threshold appeared earlier than HRDP and it was concluded that determination of HRDP in the Conconi test was not valid for the determination of the anaerobic threshold.

Reliability of the Conconi test in determination of the anaerobic threshold (Carev, 2002) was investigated on 22 cyclists (l1 men and 11 women). Mean values for the heart rate at AT were 157.3 b.min for the Conconi test and 163.3 b.min. for the V-slope method. Because there was no significant difference in the two methods, the author recommends the Conconi test as a practical tool for AT determination.
Grazzi et al. (2005) have confirmed validity of

the Conconi test and HR deflection point for the estimation of the anaerobic threshold. They have compared two versions of the Conconi test, Conconi et al. (1996) and Grazzi et al. (1999), on the one hand and Ozcelic and Kelestimur (2004) on the other hand, by considering three important points (method used to increase power output, the warm-up procedure, method used to identify the heart rate break point).

Bodner & Rhodes (2000) reviewed previous research on the heart rate deflection point determination. They have compared the Conconi test to other similar tests only to determine that the heart rate deflection point is highly dependent on the type of the protocol used, but not all studies report reproducibility of HRDP and the lactate anaerobic threshold. The HRDP has a potential to be used not only for a training regulation purposes, but also clinically, as a parameter of the workload intensity for cardiac rehabilitation.

The research problem of this study is to determine the heart rate frequency and the level of the blood lactate during the Conconi test on cycle ergometer in football and handball female players on the federal competition level.

METHODS

Subject sample

The research sample comprised of 10 top-rated, regular federal level competition, active, female football players and 8 female handball players who gave their consent prior to the onset of this study.

Variable sample

For the purpose of this research a 13 variables were measured. The variables were designated as follows: (FPUMI) heart rate at rest in min., (FPUOP1) heart rate in the first minute of the test, (FPUOP2) heart rate in the second minute of the test, (FPUOP3) heart rate in the third minute of the test, (FPUOP4) heart rate in the fourth minute of the test, (FPUOP5) heart rate in the fifth minute of the test, (FPUOP6) heart rate in the sixth minute of the test, (FPUOP7) heart rate in the seventh minute of the test, (FPUOP8) heart rate in the eighth minute of the test, (FPUOP9) heart rate in the ninth minute of the test, (FPUOP10) heart rate in the tenth minute of the test. (FLAKMI) blood lactate at rest, (FLAKTE) blood lactate in the workload, (FLAKOP) blood lactate in recovery.

Blood lactate was measured in zero minute, before the test, at the end of the workload, and 10 minutes after the test. The heart rate was measured at every lap time during each change of workload. The workload was dosed in Watts. The heart rates were measured by pulsemeter "Polar". The duration of the test was measured by the pulsemeter.

The Conconi test is a very comfortable noninvasive method for measuring the anaerobic threshold (AT) (Conconi et al., 1996). According to the Conconi's protocol subjects undergo a 10 minute warm-up at 50% of the HR reserve, upon the load is increased by 15 W every minute. Then, subjects perform a continuous ride on a bicycle ergometer for 12 minutes, starting at the load of 25W and finishing when the subject stops cycling because of the pain. HR was recorded continuously at 5 second intervals with use of the Polar watch; the data were later downloaded to a computer for further analyses. The Polar technology needs minimum eight lap times for the software analysis, graphs display and AT point determination.

Blood samples were taken from subjects' finger, first at rest, then at the moment of test finish, and the third measurement was performed ten minutes after the rest. Blood lactate concentrations were determined using the automated lactate analyzer (Accutrend Laktate Mnanhame).

Data processing

To determine the differences, an adequate statistical procedures were used to commensurate with the set of research problem.

The data were processed and analyzed by means of the software program "Statistica 6". Basic statistical parameters were calculated: MV-mean value, SD-standard deviation, MIN - minimal values and MAX - maximal values, and R – range. To determine the statistical significance of differences between the groups, a method of multivariate analysis of variance (MANOVA), on a multivariate level, and univariate analysis of variance (ANOVA), on a

univariate level, were used.

RESULTS

The results shown in Tables are displayed in the logical order (Tables 1. - 4.). Values of the heart rate and lactate at rest, in workload and at recovery in football female players (first group) and handball female players (second group), are shown in Tables 1. and 2.

The values of the heart rate at rest, under workload and in recovery in female football players (the first group) are shown in the Table 1. The results show that the average values of the heart rate at rest in female football players were 73.70 beats/min (the values ranged from 60 b/min to 82 b/min, which is the range of 22 b/min. The values of the heart rate at the end of the test were 170.80 b/min (ranging from160 b/min to182 b/min). Calculated maximal values of heart rate for the given age were (220-g.s) out of 200. The average values of the lactate at rest in female football players were 1.20

Table 1. Basic statistical parameters of heart rate at rest, in different workloads and in recovery in female football players

	Mean	Min	Max	Range	ST
FPUMI	73.70	60.00	82.00	22.00	7.83
FPUOPl	95.60	79.00	115.00	36.00	9.68
FPUOP2	109.50	96.00	135.00	39.00	11.67
FPUOP3	119.00	100.00	143.00	43.00	11.44
FPUOP4	124.60	108.00	146.00	38.00	10.72
FPUOP5	132.30	115.00	157.00	42.00	11.82
FPUOP6	141.20	121.00	161.00	40.00	11.04
FPUOP7	148.40	126.00	170.00	44.00	11.80
TPUOP8	157.00	137.00	174.00	37.00	10.29
FPUOP9	164.80	150.00	181.00	31.00	9.88
FPUOP10	170.80	160.00	182.00	22.00	8.51
FLAKMI	1.20	1.00	2.30	1.30	0.40
FLAKTE	5.02	1.20	10.20	9.00	2.54
FLAKOP	3.22	1.30	8.20	6.90	1.98

Table 2. Basic statistical parameters of heart rate at rest, in different workloads and in recovery in female handball players

	Mean	Min	Max	Range	ST
FPUMI	68.25	66.00	72.00	6.00	2.25
FPUOPl	106.25	96.00	117.00	21.00	7.01
FPUOP2	116.50	107.00	127.00	20.00	6.41
FPUOP3	125.13	109.00	140.00	31.00	9.86
FPUOP4	134.50	120.00	150.00	30.00	9.59
FPUOP5	141.63	122.00	158.00	36.00	11.73
FPUOP6	151.00	130.00	170.00	40.00	13.48
FPUOP7	158.88	134.00	177.00	43.00	14.21
TPUOP8	164.63	140.00	181.00	41.00	13.86
FPUOP9	172.75	156.00	188.00	32.00	12.07
FPUOP10	173.75	158.00	184.00	26.00	9.71
FLAKMI	1.36	1.00	2.10	1.10	0.42
FLAKTE	7.61	3.50	12.50	9.00	3.09
FLAKOP	4.80	1.90	7.20	5.30	1.86

mmol/l (from 1-1.30 mmol/1), average values of the lactate in the end of the Conconi test were 5.02 mmol/l (ranging from 1,20-10.20 mmol/l).

The values of the heart rate at rest, under different workload and in recovery in female handball players (the second group) are shown in the Table 2. The results show that the average values of the heart rate at rest in female handball players were 68.25±2.25 beats/min (the values ranged from 66 b/min to 72b/min 60 b/min, which is the range of 6 b/min). The values of the heart rate at the end of the test were 173.75±9.71 b/min (ranging from 158 b/min to 184 b/min).The average values of the lactate at rest in female football players were 1.20 mmol/l (from 1-1.30 mmol/1), average value of the lactate in the end of the Conconi test were 4.80 mmol/1(from 1.90 mmol/l to 7.20 mmol/l.

Table 3. Multivariate analysis of variance between female football players and female handball players (MANOVA)

Wilks Lambda	F	Effect	Error	P
0.007	89.68	16	1	0.083

The results of the multivariate analysis of variance (Table 3.) between the female football player subjects and female handball player subjects show that there is no statistically significant difference between the groups in the researched area (p .083). Due to this fact there is no need to use other statistical methods. However, we give the difference between the groups defined by the ANOVA method.

Table 4. ANOVA

	Group I Mean	Std.Dev.	Group I I Mean	Std.Dev.	JF	D
FPUMI	73.70	7.832	68.25	2.252	3.595	0.076
FPUOP1	95.60	9.675	106.25	7.005	6.801	0.019
FPUOP2	109.50	11.674	116.50	6414	2.301	0.149
FPUOP3	119.00	11.441	125.13	9.862	1.435	0.248
FPUOP4	124.60	10.721	134.50	9.592	4.153	0.058
FPUOP5	132.30	11.823	141.62	11.734	2.783	0.115
FPUOP6	141.20	11.043	151.00	13.480	2.882	0.109
FPUOP7	148.40	11.796	158.87	14.207	2.928	0.106
FPUOP8	157.00	10.296	164 63	13.866	1.798	0.199
FPUOP9	164.80	9.875	172.75	12.068	2.369	0.143
FPUOP10	170.80	8.509	173.75	9.706	0.472	0.502
FLAKMI	1.20	0.400	6	0.437	0.676	0.423
FLAKTE	5.02	2.540	7.61	3.094	3.820	0.068
FLAKOP	3.22	1.98	4 80	1.863	2.978	0.104

On an univariate level the obtained results in the researched area of the heart rate at rest and under workload and the level of lactate at rest, and under workload, and in recovery show that there is statistically significant difference only in the variable FPUOPI (heart rate on the first level of workload) p=0.01.

DISCUSION AND CONCLUSION

The values of the heart rate and the lactate at rest, under workload and in recovery in female football players (the first group) and female handball players (the second group) are shown in Tables 1. and 2. The results show the presence of great range between the minimal and maximal heart rate which in turn points to the inhomogeneity of the female football players group whose standard deviation was 7.83 beats/min. In female handball players, a small range between the minimal and maximal heart rate, points to the homogeneity of this group whose standard deviation was 2.25 beats/min.

Workload through this test was between 80% to 91%, so with this workload range the subjects were expected to enter the anaerobic threshold, and in most subjects it did happen with the deflection point.

The female football players group, which at the end of the test displayed the value of 1.20 mmol/1, did not reach the anaerobic threshold, thus for them this test was not anaerobic sensitive. In the contrary, those subjects whose lactate values were 10.20 mmol/l have already entered the anaerobic threshold so the Conconi test was sensible enough for them. Taking into consideration that the anaerobic threshold is reached on the blood lactate level of 4 mmol, its values should be monitored every three minutes, with a purpose to avod too small or too big workload in the test, due to the fact that the anaerobic threshold in the Conconi test is reached earlier with the values of the lactate than with the heart rate deflection point.

In the light of all aforementioned one can conclude that between the first and the second group subjects there is no difference between the heart rate at rest and in different levels of workload, nor there is any difference in the level of the blood lactate at rest, in workload and in recovery, except for the values of heart rate in the first workload of 50 W. This evidently leads to a conclusion that both groups of subjects are of the same functional abilities.

By analyzing of the obtained results we can conclude that the numeric values of the heart rate at rest are statistically significantly lower in female handball players. This can be explained by the fact that this group has a longer sports training experience and the higher rank of competition in the Challenge cup. Heart rates during the workload have average lower values on all levels of workload in female football players. This can be accounted for by a better adaptation of the cardio-vascular system to rapid increase of workload and later reaching of the anaerobic threshold.

Heart rate values in the end of the test in female football players were lower compared to the values found in female handball players. This does not mean that the female handball players have shown better results because the essence of the test is to reach the anaerobic threshold on as much higher heart rate as possible, and at the same time, to reach the lactate values of 4 mmol/l as late as it's possible, at the end of the test. Female handball players finished their test with high heart rates and with significantly higher values of the blood lactate.

The average values of the level of lactate at rest, under workload and in recovery are lower in female football players. The statistically significant differences were not found in any of the analyzed level. Normal lactate values range from 1 to 1.7 mmol/1. Minimal values of the blood lactate in both samples were within the referential values, but maximal values were higher than the average ones. Lower values of the blood lactate at rest points to the fact that an athlete is fully recovered from the previous workload. On the contrary, if the athlete takes up next training with the increased values of the blood lactate there is a chance of sustaining sports injuries. Therefore, the results obtained in this research can help to shape the training process so that by one noninvasive method one can determine the anaerobic threshold and thus to individualize the training process. In sports such as football and basketball this method can help in correcting the functional abilities of the players and thus avoid the overloading and enhance reaching the optimal conditioning.

Tables 3. and 4. show the results of the multivariate and univariate analyses of variance between the female football players and female handball players. On the univariate level the researched variables heart rate at rest, and in workload and the blood lactate in rest, in workload and in recovery, show statistically significant difference only in FPUOP1 variable (heart rate on the first level of workload). Namely, female football players have statistically lower heart rates with the workload of 50 Watts in comparison to the female handball players. This single variable cannot individually influence the existence of the differences in the researched area.

On the basis of the research conducted on a sample of 10 female football players and 8 female handball players the following conclusions can be drawn:

1. Research results of heart rate at rest and in different workloads during the Conconi test performed on cycle ergometer show that the numerical values of the heart rate in workload and in recovery are lower in female football players when compared to female handball players. The obtained differences are not statistically signi-

ficant. Statistically significant difference was determined only in the values of the heart rate at rest.

1. Average values of the blood lactate at rest, in workload and in recovery are lower in female football players when compared to the female handball players. This is not a statistically significant difference.

2. On the basis of the obtained results we can draw a conclusion that the researched samples of the female football players and female handball players are of the same functional abilities.

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СОВРЕМЕНИ ФИЗИКАЛНИ ПРОТОКОЛИ НА ИНВАНЗИВНОТО И НЕИНВАНЗИВНОТО ОДРЕДУВАЊЕ НА АНАЕРОБНИОТ ПРАГ ВО ТЕКОТ НА CONCONI ТЕСТОТ

УДК: 796.332.015.574
(Оригинален научен труд)

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Апстракт

Целта на истражувањето беше да се прикаже значењето на современите протоколи за одредување на анаеробниот праг на инванзивната и неинванзивната метода во текот на Конкони (CONCONI) тестот. Пулсот и лактатите на терен, овозможуваат детална проценка на режимот на работата (на метаболичката зона) во која спортистот тренира, што не е можно само врз основа на вредностите на пулсот. Овие параметри се мерат во мирување, во текот на оптоварувањето (на лактатите по секој интервал на работата) и по опоравувањето. На крајот се добиваат криви линии, како физиолошко-метаболички профил за секоја индивидуа. Истражувањето е спроведено на 10 фудбалерки и 10 ракометарки кои доброволно ја прифатија оваа метода на испитување. За утврдување на разликите меѓу фудбалерките и ракометарките, применета е мултиваријантна анализа на варијансата (MANOVA). Врз основа на добиените резултати констатирано е дека меѓу фудбалерките и ракометраките не постои разлика во фреквенцијата на пулсот во мирување и на различно ниво на оптоварување, како и во нивото на лактатите во мирување, оптоварување и опоравување, освен во вредностите на пулсот при првото оптоварување од 50 W. Според тоа, утврдено е дека фудбалерките и ракометарките имаат исто ниво на функционални способности.

Клучни зборови: *фреквенција на срцето, лактати, фудбалерки, ракометарки, функционални способности, мултиваријантна анализа на варијансата*

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