42 - CARDIORESPIRATORY AND METABOLIC RESPONSES OF ATHLETES OF DIFFERENT MODALITIES OF THE UNISC ATHLETICS TEAM.

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INTRODUCTION

The application of tests for functional assessment of high-performance athletes focus in the cardiorespiratory performance, therefore the more precise result would be given through the application of a direct test, via an ergospirometry, mainly when using ergometers that are most similar to the movements of the sport practiced in order to maximize the performance related to cardiorespiratory and metabolic responses.

The cardiorespiratory test or ergospirometry assesses the cardiovascular, lungs and metabolic responses during the physical exertion, analyzing the interactions among the systems to capture, transport and metabolization of Oxygen (O2), what is important to identify the energy production at rest and during physical effort, besides the description of the elimination of carbon dioxide (CO2) produced. In these tests the variables analyzed include the airflow (respirometry) combined with measurements of respiratory gases (oxygen and carbon dioxide). Thus, the test provides accurate information about the maximum oxygen consumption (VO2max), which represents the aerobic power of the individuals and has great clinical and sportive use (YAZBEK et al., 2001).

Therefore, the ergospirometry provides the determination and monitoring of respiratory, metabolic and cardiovascular variables during the exercise, bringing information about the integrity and performance of the systems involved in the transportation of gases as well as their adaptations during the performance of an exercise. It is a method that adds quality to the diagnosis of physical aptitude besides allowing monitoring the training of the athletes with greater scientific accuracy respecting the biological individuality of the subject (NETO, 2001). Another contribution of this evaluation is the identification of respiratory modifications enhanced by the stress imposed during the stress test (SERRA, 1997).

For Lopes and Porcaro (2007) the great advantage of ergospirometry is the possibility to monitor the physiological responses, providing security and accuracy in the results , in addition, it is a non-invasive procedure that evaluates the physical performance and the functional capacity of an individual or athlete (YAZBEK et al., 2001).

Given the contribution of the ergospirometry assessment, it integrates the parameters of assessment proposed in the project “Correlation between the blood biochemical profile and performance of running athletes in the ergospirometry test of Bruce and in specific tests using infrared spectroscopy”, of which the present article is an excerpt. It is thus proposed to describe the cardiorespiratory and metabolic performance of the athletes of the team of the University of Santa Cruz do Sul (UNISC) in ergospirometry test using the Bruce Protocol, emphasizing the physiological responses and considering the characteristics of the sport practiced as part of the specific objectives of this project.

MATERIALS AND METHODS

The methodology consisted of analytical cross-sectional descriptive study with a quantitative methodological design. The sample was composed of a group of 12 athletes of the Athletics team of UNISC, of different modalities (sprinters, middle-distance runners and runners), being six of the male gender. These athletes have voluntarily joined the study upon the signature of term of informed consent. This study is part of the project “Correlation between the blood biochemical profile and performance of running athletes in the ergospirometry test of Bruce and in specific tests using infrared spectroscopy” proposed and approved by the Ethics Committee in the protocol 2146/08.

Data collected consisted of anthropometric, ergospirometry variables and serum biomarkers of these athletes. Despite the importance of the other variables studied, this presentation will be focusing on the following anthropometric data: weight, height, body mass index (BMI) and fat percentage (%F); in the ergospirometry the volume of oxygen consumption (VO2), carbon dioxide (VCO2), respiratory quotient (RQ); and in the serum biomarkers the blood lactate (BL).

It was recommended to the subjects a light diet and rest in the 24h prior to the test, being initially submitted to an anthropometric assessment, blood pressure and resting heart rate. In the sequence the athlete was positioned on the treadmill (ergometer), being connected to the spirometry system (respiratory gas analysis). After the beginning of the test on the treadmill, blood from fingertip was collected every three minutes until the end of test on a way similar to the one done in resting. Also during the test the heart rate was verified every 20 seconds with a digital frequency meter and blood pressure checked every 3 minutes with a mercury sphygmomanometer.

In anthropometric dimension the body composition was evaluated using the Body Mass Index (BMI-kg/m2), calculated by the ration weight(kg)/height(m2), classifying the result according to the World Health Organization (BOUCHARD, 2003). The %F was obtained by the sum of skinfolds (ΣSM), by measuring with a Lange skinfold caliper. To estimate the body density it was used Jackson and Pollock and to calculate the Fat Percentage it was used the Siri equation observing the classification of Pollock and Wilmore (2003).

Related to the ergospirometry, the Bruce protocol was used in the treadmill and a gas analyzer TEEM 100, evaluating the cardiorespiratory performance from the value of oxygen consumption (VO2), carbon dioxide(VCO2), respiratory quotient (RQ), heart rate(HR) and blood pressure (BP).

To evaluate the metabolic profile, a blood collection was done in the pre and post-test (brachial vein), being verified from frozen plasma samples the levels of blood lactate (BL). The peripheral venous blood sampling was done in brachial veins, stored in vacutainer to obtain the plasma and in other flask without anticoagulant, to obtain serum. Two portions of blood of 5µL and 10 µL from the fingertip were simultaneously collected. The collection of the peripheral blood in the post-test was done after 10 minutes of the end of the ergospirometry. All the samples were properly stored and later analyzed through standard biochemistry techniques and infrared spectrometry with Fourier transform.

The data entered was compiled in electronic spreadsheets (Excel, Microsoft Office 2007) and analyzed in the

Statistical Package for Social Sciences for Windows (SPSS – version 18.0), using descriptive statistics with data for mean and standard deviation, being applied for gender as well as for modality.

DISCUSSION AND RESULTS

In Table 1 it is possible to observe the anthropometric characterization variables of the sample studied, where the athletes with average age of 20.83 and 17.50 years obtained results of BMI of 22.68 + 2.26 kg/m2 and 20.38 + 3.16 kg/m2 and the percentage of fat of 8.26 + 3.60 % and 18.19 + 3.53 %, respectively in the male and female genders. These results are similar to the ones found in other studies described below. Siqueira, et al. (2009), in a study with twenty male runners with average age of 35.5±10 years found values of BMI of 21 ± 1.2 kg/m2. Whereas the study done with 26 male runners done by Guglielmo, et al. (2005), found a fat percentage of 6.6 ± 3.1 %. Related to females, Nunes et al. (2009), in studies done with 112 indoor soccer players with age of 22.1 ± 5.4 years, found a BMI of 22.3±1.9 kg/m2 and fat percentage of 23.2 ± 5.1 %.

Table 1. Anthropometric characterization of the studied group.

Variables	Athletes	
	Males (n=06) $\bar{x}$ ± sd	Females (n=06) $\bar{x}$ ± sd
Age (years)	20.83 ± 5.53	17.50 ± 1.38
Weight (kg)	69.04 ± 12.59	54.95 ± 10.54
Height (m)	1.74 ± 0.08	1.64 ± 0.06
BMI (Kg/m²)	22.68 ± 2.26	20.38 ± 3.16
% Fat	8.26 ± 3.60	18.19 ± 3.53

BMI = Body Mass Index; %F = Fat percentage; $\bar{x}$ ± sd = mean ± standard deviation.

In the evaluation of anthropometric parameters it was taken into account the %F because, according to Deng et al. (2001), the BMI does not consider the distribution of body fat, being possible the generation of an inappropriate result in athletes who many times have a BMI > 25 kg/m² and a fat percentage of 10-15%. For this group of individuals with homogeneous characteristics, BMI classification distortions can occur due to high muscle mass which increases BMI values overestimating adiposity (WITT; BUSH, 2005). It is important to consider the anthropometric characteristics because some factors may imply in different physiological responses to the exercises when differed by gender being them the proportion and body composition, muscle characteristics, aerobic capacity among others.

The ergospirometry assessment observed in Table 2, attempts to differ the consumption of oxygen according to the training. It is possible to observe higher values of oxygen consumption (VO2) in athletes who participate in competitions predominantly aerobic when compared to athletes of anaerobic competitions, with average of maximum VO2 of 49.85 and 41.81 ml/Kg/min, respectively.

Table 2. Comparative of maximum VO_2 differed according to the type of training.

		VO_2 ml/kg/min					
Training	Athlete	Rest	3'	6'	9'	12'	15'
Aerobic	01	3.01	16.06	17.07	24.90	32.93	46.99
	02	2.40	15.90	22.44	28.32	39.00	57.52
	03	1.74	24.40	25.93	37.69	41.18	50.98
	04*	6.19	16.12	16.40	25.47	27.19	40.58
	05	0.20	9.16	12.95	20.72	16.93	53.19
Mean	-	**2.71**	**16.33**	**18.96**	**27.42**	**31.45**	**49.85**
Anaerobic	**Athlete**	**Rest**	**3'**	**6'**	**9'**	**12'**	**15'**
	06	2.71	11.92	17.48	24.39	39.43	-
	07	7.67	12.51	20.90	30.93	49.70	-
	08	0.12	5.93	11.48	15.93	36.30	-
Mean	-	**3.50**	**10.12**	**16.62**	**23.75**	**41.81**	-

* athlete 4 reached more tree stages with, respectively, 51.08, 54.53 and 65.32 of VO_2 max

Related to the ergospirometry parameters, the results suggest that athletes with specific training for aerobic work had higher values of maximum VO2, indicating a better capacity to capture, transport and use oxygen when compared to athletes of speed/explosion. It meets the claims of Thomas (2007), when points out that the performance of an athlete is strongly related to his/her metabolic condition. These results still reflect the adaptation of the cardiorespiratory system as well as the adaptation at a tissue level of the athletes; being the maximum VO2 the component of aerobic aptitude what best represents this capacity (FURTADO et al., 2004). Another aspect seen in the results of this study is the progressive increase in th eak in the moment of maximum intensity of the activity, data corroborated by Freitas (20e capture of atmospheric oxygen, proportionally to the effort made by the athletes, having its p04). These variations come into agreement with Wilmore and Costill (2001), who reported the adaptations of the respiratory system to the training, causing the human body to adapt to repeated stimuli, making the production of energy efficient reducing the risk of fatigue.

By analyzing the blood lactate, as a metabolic variable, evaluated at rest and after the ergospirometry using the Bruce protocol (Table 3), it is observed that the athletes who participate in modalities with aerobic predominance had 9.23 mmol/dL at the end of maximal exercise test when compared to athletes with anaerobic predominance who obtained an average in the concentration of lactate of 13.64 mmol/dL.

Table 3. Comparative of lactate, differed according to type of training.

Training	Athlete	Pre-test	Post-test
Aerobic	01	0.6654	9.8701
	02	0.9981	8.7611
	03	0.2218	10.2028
	04	2.7725	6.7649
	05	1.109	10.5355
Mean	--	1.15336	9.22688
Anaerobic	06	0.9981	12.3099
	07	1.5526	14.8606
	08	2.1071	13.7516
Mean	--	1.5526	13.6407

The athletes of aerobic resistance prolonged the use of oxidative energy sources reaching a greater number of stages in the stress test (16.8±4.02), simultaneously showing a lower concentration of lactate (9.23±1.53 mmol/dL) when compared to athletes of speed/explosion (12.00±0.00; 13.64±1.28 mmol/dL, respectively for the number of stages and blood lactate), which can be related to the modality practiced, type of training and the individual characteristics of the athletes.

Therefore the results suggest that the athletes who are characterized by speed use more anaerobic energy, have a more pronounced blood acidification, resulting in both from the increased volume of VCO2, as the increase in the blood lactate levels, that when accumulated results in metabolic acidification, contributing to muscle fatigue (OLIVEIRA FILHO; OLIVEIRA, 2007).

The blood acidification resulted from the increase in VCO2, has as an aggregating factor the blood lactate that when accumulated results in metabolic acidosis contributing to muscle fatigue (OLIVEIRA FILHO; OLIVEIRA, 2007), which can be observed in the athletes studied, because they showed significant increases in blood lactate levels. For Barros Neto, Tebexreni and Tambeiro (2001), this metabolic acidosis of the exercise, results from the imbalance between supply and mitochondrial demand of oxygen, increasing the ratio pyruvate/lactate.

Table 4 shows the physiological response found in the execution of the test by the athletes through the respiratory quotient (RQ), index obtained from the comparative parameter of VCO2/VO2, which can indicate the prevailing energy substrate to carry out each stage of the stress test. It can be observed that both groups of athletes (with aerobic and anaerobic training) reached a RQ higher than "1" (RQ>1) in the last stage of the test (15º and 12º minute, respectively).

Table 4. RQ comparative, differed according to type of training.

RQ							
Training	**Athlete**	**Rest**	**3'**	**6'**	**9'**	**12'**	**15'**
Aerobic	01	0.93	0.80	0.85	0.88	1.03	1.00
	02	1.09	0.75	0.78	0.83	0.88	0.99
	03	0.88	0.97	1.04	1.07	1.11	1.11
	04*	1.09	0.98	0.97	1.01	1.01	1.05
	05	1.00	0.83	0.83	0.85	0.85	0.93
Mean	--	**1.00**	**0.87**	**0,89**	**0.93**	**0.98**	**1.02**
	Athlete	**Rest**	**3'**	**6'**	**9'**	**12'**	**15'**
Anaerobic	06	1.15	0.90	0.88	0.96	1.10	-
	07	0.92	0.83	0.90	0.98	1.06	-
	08	1.00	0.79	0.81	0.91	0.95	-
Mean		**1.02**	**0.84**	**0.86**	**0.95**	**1.04**	-

* athlete 4 reached more tree stages with, respectively, 1.02, 0.97 and 1.01 of QR.

From the analyzed results it can be concluded that the athletes who practice modalities predominantly aerobic (long duration and low intensity) showed higher values of VO2 and remained in the aerobic range (RQ<1) at later stages, indicating a better cardiorespiratory capacity.

The results point out the effects of training over the efficiency in the use of metabolic pathways, characteristics of physical activity that promote physiological and metabolic adaptations, increasing physical abilities and optimizing cardiorespiratory responses.

CONCLUSIONS

Observing the results obtained in the evaluation of the athletes in the ergospirometry of Bruce, it was possible to highlight the importance that this evaluation can have in the monitoring of the athletes in training in different sports areas. Especially in sports characterized in demanding from the athlete a high capacity to supply oxygen and nutrients in great amounts to keep the aerobic metabolism for longer and avoid fatigue.

Athletes participating in activities predominantly aerobic showed a better performance during the test in terms of VO2 and test duration; this fact is associated to a cardiovascular adaptation to the endurance type of training, which raises the volume of cardiac filling (diastolic volume) and the contraction strength through physiological myocardial hypertrophy. The athletes of aerobic activities also presented the higher maximum VO2 of the test, as well as a reduced accumulation of blood lactate at the end of the ergospirometry and remained in the aerobic range (RQ<1) at later stages, indicating a better cardiorespiratory capacity.

The results found are consistent with those in the literature and the athletes who participate in competitions predominantly aerobic were the ones who showed a greater global performance, fact which is associated to the cardiorespiratory adaptations to the chronic training in physical exercise of dynamic resistance.

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CARDIORESPIRATORY AND METABOLIC RESPONSES OF ATHLETES OF DIFFERENT MODALITIES OF THE UNISC ATHLETICS TEAM.

ABSTRACT

The application of tests for functional evaluation of high-performance athletes is focused on cardiorespiratory fitness. It is proposed, to describe the cardiorespiratory and metabolic performance of athletes in cardiopulmonary exercise test, by the Bruce Protocol, comparing physiological responses, considering the characteristics of the sport practiced. The methodology consisted of an analytical cross-sectional descriptive study, with quantitative methodological design, in which twelve athletes from different athletics modalities were evaluated in 2008, six of them were males. The athletes were evaluated by anthropometric assessment, focusing on data for body mass index and fat percentage, and cardiopulmonary exercise test, by the Bruce Protocol on treadmill, evaluating cardiorespiratory performance from the oxygen volume consumption (VO2), carbon dioxide (VCO2), respiratory quotient (RQ), blood lactate (BL), heart rate (HR) and blood pressure (BP). The results showed that athletes with predominantly aerobic training had higher values of VO2 maximum (54.80±7.00) when compared with athletes of speed / explosion (41.81±7.00), which it was also found in RQ. Moreover, in aerobic training athletes, there was the realization of a greater number of stages in the stress test and lower lactate concentration, when compared with speed training athletes. From the analyzed results it can be concluded that athletes that practice predominantly aerobic modalities showed higher values of VO2 and remained in the aerobic range (RQ<1) at later stages, indicating an improved cardiorespiratory fitness. The results showed the effects of training on the efficient use of metabolic routes, characteristics of physical activities that promote physiological and metabolic adaptations, increasing physical capacity and optimizing the cardiorespiratory responses.

KEY WORDS: exercise test, athletes, energy metabolism.

RÉPONSES CARDIO-RESPIRATOIRES ET MÉTABOLIQUES DES SPORTIFS DE DIFFÉRENTS MODALITÉS DE L'ÉQUIPE D'ATHLÈTISME DE L'UNISC.

RÉSUMÉ

L 'application des tests pour l'avaliation fonctionnel des athlètes de haut niveau se concentre sur la capacité cardio-respiratoire. Il est donc proposé, de décrire les performances cardio-respiratoires et métaboliques des athlètes pendant l' épreuve d'effort cardio-pulmonaire, en comparant les réponses physiologiques, compte tenu des caractéristiques de la méthodologie du sport pratiqué. La méthodologie a consisté d'une analyse transversale analytique descriptive avec un dessin méthodologique quantitative dans laquelle ont été submis pour avaliation douze athlètes en 2008, dans différents formes d'athètisme, et étant six personnes du sexe masculin..Les athlètes ont subi une avaliation anthropométrique, en se concentrant sur les donnés d'indice de masse corporelle et pourcentage de graisse, dans l'épreuve d'éffort cardio-respiratoire, en utilisant le protocole de Bruce sur un tapis roulant ergométrique, en évaluant des performances cardio-respiratoires du volume de la consommation d'oxygène (VO2), le dioxyde de carbone (VCO2), le coeficient respiratoire (QR), lactate dans le sang (LA), fréquence cardiaque (FC) et la pression artérielle (PA). Les résultats ont montré que les athètes ayant une formation essentiellement aèrobique étaient des valeurs plus élevés de VO2 max (54,80+ 7,00) par rapport à des athlètes de vitesse/explosion (41,81 + 7,00), qui ont également été trouvé dans le QR. Encore, dans les athlètes d'endurance aèrobique, il a été obsevé un plus grand nombre d'étapes dans le test d'effort et une concentation moins élevé de lactato, en comparaison avec les athlètes de la vitesse. À partir des résultats analysés on peut conclure que les athlètes qui pratiquent des modalités essentiellement aérobiques montrent des valeurs plus élevées de la VO2 et sont restes aussi dans la gamme aèrobique (QR<1) dans les étapes ultérieures, indiquant une meilleure condition physique cardio respiratoire. Les résultats montrent les effets du entraînemment sur l'utilisation efficace de voies métaboliques, mettant en valeur des capacités physiques et en optimisant les réponses cardio-respiratoires.

MOTS-CLÉS: Test d'effort, athlètes, métabolisme énergétique.

RESPUESTAS CARDIORRESPIRATORIAS Y METABÓLICAS DE ATLETAS DE DISTINTAS MODALIDADES DEL EQUIPO DE ATLETISMO DE UNISC.

RESUMEN

La aplicación de testes para evaluación funcional de atletas de alto rendimiento tiene como foco la capacidad cardiorrespiratoria. Se propone así, describir el desempeño cardiorrespiratorio y metabólico de atletas en testes ergoespirométricos, por el Protocolo de Bruce, comparando respuestas fisiológicas, considerando las características del deporte practicado. La metodología ha consistido en un estudio trasversal analítico descriptivo con diseño metodológico

cuantitativo en que fueron sujetos doce atletas evaluados en el año de 2008, de distintas modalidades del atletismo, siendo seis del sexo masculino. Los atletas realizaron evaluación antropométrica, enfocando datos de índice de masa corporal y porcentual de grasa, y el test ergoespirométrico, a través del protocolo de Bruce, en estera ergométrica, evaluando el desempeño cardiorrespiratorio a partir del volumen del consumo de oxígeno (VO2), dióxido de carbono (VCO2), cociente respiratorio (QR), lactato sanguíneo (LA), frecuencia cardíaca (FC) y presión arterial (PA). Los resultados apuntan que los atletas con entrenamiento predominantemente aeróbico obtuvieron valores más elevados de VO2 máximo (54,80±7,00), cuando comparados con los atletas de velocidad/explosión (41,81±7,00), lo que también fue encontrado en el QR. Todavía, en atletas de resistencia aeróbica, se observó la realización de un mayor número de estagios en el test de esfuerzo y menor concentración de lactado cuando comparados con atletas de velocidad. A partir de los resultados analizados se puede concluir que los atletas que practican modalidades con predominancia aeróbica presentaron mayores valores de VO2 así como se quedaron en la faja aeróbica (QR<1) en estagios posteriores, indicando una mejor capacidad cardiorrespiratoria. Los resultados apuntan los efectos del entrenamiento sobre la eficiencia en el aprovechamiento de las rutas metabólicas, características de actividades físicas que promuevan adaptaciones fisiológicas y metabólicas, potencializando capacidades físicas y optimizando las respuestas cardiorrespiratorias.

PALABRAS CLAVE: prueba de esfuerzo, atletas, metabolismo energético.

RESPOSTAS CARDIORRESPIRATÓRIAS E METABÓLICAS DE ATLETAS DE DIFERENTES MODALIDADES DA EQUIPE DE ATLETISMO DA UNISC

RESUMO

A aplicação de testes para avaliação funcional de atletas de alto rendimento tem como foco a capacidade cardiorrespiratória. Propõe-se assim, descrever o desempenho cardiorrespiratório e metabólico de atletas em testes ergoespirométricos, pelo Protocolo de Bruce, comparando respostas fisiológicas, considerando as características do esporte praticado. A metodologia consistiu de um estudo transversal analítico descritivo com desenho metodológico quantitativo em que foram sujeitos doze atletas avaliados no ano de 2008, de diferentes modalidades do atletismo, sendo seis do sexo masculino. Os atletas realizaram avaliação antropométrica, enfocando dados de índice de massa corporal e percentual de gordura, e o teste ergoespirométrico, através do protocolo de Bruce, em esteira ergométrica, avaliando o desempenho cardiorrespiratório a partir do volume do consumo de oxigênio (VO2), dióxido de carbono (VCO2), quociente respiratório (QR), lactato sanguíneo (LA), frequência cardíaca (FC) e pressão arterial (PA). Os resultados apontam que os atletas com treinamento predominantemente aeróbico obtiveram valores mais elevados de VO2 máximo (54,80±7,00), quando comparados com os atletas de velocidade/explosão (41,81±7,00), o que também foi encontrado no QR. Ainda, em atletas de resistência aeróbica, observou-se a realização de um maior número de estágios no teste de esforço e menor concentração de lactato, quando comparados com atletas de velocidade. A partir dos resultados analisados pode se concluir que os atletas que praticam modalidades com predominância aeróbica apresentaram maiores valores de VO2 bem como permaneceram na faixa aeróbica (QR<1) em estágios posteriores, indicando uma melhor capacidade cardiorrespiratória. Os resultados apontam os efeitos do treinamento sobre a eficiência no aproveitamento das rotas metabólicas, características de atividades físicas que promovam adaptações fisiológicas e metabólicas, potencializando capacidades físicas e otimizando as respostas cardiorrespiratórias.

PALAVRAS-CHAVE: teste de esforço, atletas, metabolismo energético.