CONDITIONALITY OF MAXIMUM OXYGEN UPTAKE OBTAINED BY DIFFERENT EXERCISE MACHINES WITH TRAINING LOAD SETUP USING GROSS MOTOR SKILL TESTS

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Abstract

The aim of this study was to determine the conditionality of relative maximum oxygen uptake obtained (R VO_2max) by using three different exercise machines with training load setup (treadmill, cycle ergometer and Orbitrek elliptical trainer) while utilizing a gross motor skill test. In accordance with the study aim, a sample of 19 female students was used. A progressive exercise protocol was applied until the exhaustion of participants had set in. Relative maximum oxygen uptakes obtained from utilized exercise machines were set as dependent variables for a multiple regression analysis with forward algorithm of variable selection. The following gross motor skill tests were set as independent variables: side steps (MKUS), hexagon test (HEX), standing long jump (MSDM), throwing a medicine ball (MBML), number of push-ups performed until exhaustion set in (MSKL), number of sit-ups in 60 seconds (MTRB), balance on two feet with closed eyes (MBAP2Z), balance on one foot with open eyes (MBAU10), arm plate tapping (MBTAP) and foot taping (MBTAN).

Results indicate statistically significant ($p<0.01$) and relatively strong ($R^2=0.65$-0.92) predictive power of the selected gross motor skill variable set (additionally reduced by forward variable selection algorithm for entry into a model) and unambiguously show that a set of applied motor skill variables can be used in scientific and professional practice as a good predictor of the relative maximum oxygen uptake.

Keywords: relative maximum oxygen uptake, Orbitrek, cycle ergometer, treadmill, regression analysis

Introduction

Diagnostic procedures in sports are carried out with the aim of determining the athlete's initial state, evaluating the effects achieved in individual sports preparation cycles and planning and programming further training process course. Modern training process diagnostics represents a series of procedures which identify, evaluate and explain individual characteristics of an athlete by testing or measuring certain traits and abilities. The complete diagnostic procedure should include measurement and evaluation of morphological, functional, biochemical, biomechanical, motor, mental and social characteristics of the athlete and of his or her specific abilities and proficiencies which enable successful performance of technical and tactical elements. Functional diagnostics provides a detailed overview of the current state of the individual and the entire team. It also enables the observation and control of the training process, and the option of making comparisons to other teams. Moreover, the evaluation of functional abilities can provide data on specific physiological and biochemical reactions during training and competitive activities in a particular branch of sports (Meyer et al., 1996). The most frequently used aerobic energy capacity assessment parameters in scientific and professional practice are the absolute and relative maximum oxygen uptake (VO_2max, VO_2max /kg), whereas lactate concentration in blood is the most frequently used parameter in anaerobic capacity assessment (Svedahl & MacIntosh, 2003; Christopher & Rhodes, 1993). The most frequently used training load setup exercise machines are the cycle ergometer and the treadmill, even though lately specific ergometers for individual sports (rowing, kayaking, cross-country skiing...) which truly reproduce the dynamic movement stereotype specific for each sport are also increasingly used. The test is generally performed until the exhaustion of the participant sets in, unless there are contraindications or limiting factors (Rowland, 1996). In addition to the two standard training load setup exercise machines, an Orbitrek exercise machine (thus far rarely used as a measurement instrument in sports scientific and professional practice) was used to evaluate functional characteristics of students in this research. Therefore, the aim of the research was to determine and explain the correlation of a set of gross motor skill variables and the relative maximum oxygen uptake, measured on three different training load setup exercise machines.

Method

The participant sample comprised 19 female students of the Faculty of Kinesiology at the University of Split who were tested on 3 different exercise machines: Orbitrek exercise machine, cycle ergometer and a treadmill. In so doing, relative maximum oxygen uptake variables were measured on each individual exercise machine using a progressive exercise protocol, until participant exhaustion set in. The participants were also evaluated in 14 gross motor skills tests: side steps (MKUS), hexagon test (HEX), standing long jump (MSDM), medicine ball throw (MBML), tapping with hands and feet (MKRBNR), push-ups (MSKL), number of sit-ups in 60 seconds (MTRB), standing lengthwise on both feet on a balance bench with closed eyes (MBAP2Z), standing lengthwise on one foot on a balance bench with open eyes (MBAU10), arm plate tapping (MBTAP) and foot taping (MBTAN),

Initially, all variables were subjected to the test of normal distribution by means of a Kolmogorov-Smirnov test, and descriptive statistical parameters (namely, arithmetic mean, standard deviation, minimum and maximum results) were calculated. Multiple regression analysis and the utilization of a *forward* variable selection algorithm for entry into a model enabled a separate analysis of relative maximum oxygen uptake dependence on motor skill variables on all observed exercise machines. Multiple correlation coefficient (R), multiple determination coefficient (R^2) and the associated significance were calculated.

Results and Discussion

Table 1 contains descriptive statistics results of observed motor skill variables and the relative maximum oxygen uptake on different training load setup exercise machines.

***Table 1** Descriptive statistic parameters of the maximum oxygen uptake variables on all 3 observed exercise machines and motor skill variables (AM - arithmetic mean, Min - minimum result, Max – maximum result, SD – standard deviation, KS-p – empirical significance of the Kolmogorov-Smirnov test)*

	AM	Min	Max	SD	KS-p
R VO_2max **-O**	42.93	30.72	52.5	7.28	p > .20
R VO_2max **-B**	39.88	29.62	53.7	7.01	p > .20
R VO_2max **-P**	46.17	34,35	64.7	7.80	p > .20
MKUS	9.76	8.14	11.0	0.69	p > .20
HEX	11.37	7.60	14.5	1.41	p > .20
MSDM	1.99	1.70	2.2	0.14	p > .20
MBML	8.41	6.70	10.0	1.01	p > .20
MKRBNR	9.30	6.00	14.7	2.24	p > .20
MSKL	19.95	10.00	31.0	7.66	p > .20
MTRB	40.00	20.00	58.0	9.44	p > .20
MBAP2Z	4.20	1.88	10.6	2.47	p < .15
MBAU10	5.76	1.98	20.1	4.57	p < .20
MBTAP	38.58	35.00	42.0	2.48	p > .20
MBTAN	47.00	39.00	68.0	6.55	p > .20

It is important to point out that all variables have a distribution for which it can be said it does not deviate significantly from the normal distribution (Table 1).

Moreover, by taking standard deviations and minimal and maximum results of observed variables into consideration, it can be noted that the female student sample used was relatively heterogeneous.

Table 2. Regression analysis results when utilizing a forward variable selection algorithm for entry into a model for the criterion variables of maximum relative oxygen uptake on all observed exercise machines. (Regression coefficients assigned to standardized variables – Beta, significance of beta coefficients – p, multiple correlation coefficient – R, multiple determination coefficient – R^2, multiple correlation coefficient significance– p)

	R VO_2max Orbitrek		R VO_2max Cycle ergometer		R VO_2max Treadmill	
	Beta	**p**	**Beta**	**p**	**Beta**	**p**
Intercept						
MKUS	0.58	0.01			0.59	0.19
HEX	-0.44	0.04	-0.33	0.11		
MSDM	0.24	0.17			0.47	0.01
MBML	0.50	0.02	0.52	0.04	0.25	0.11
MKRBNR	-0.33	0.04				
MSKL			0.21	0.23		
MTRB	0.77	0,01	0.33	0.13	0.89	0.00
MBAP2Z	0.81	0.00			0.51	0.00
MBAU10	-0.20	0.20			0.55	0.00
MBTAP	-0.58	0.01				
MBTAN	0.27	0.10			0.17	0.23
R	0.96		0.80		0.92	
R^2	0.92		0.65		0.84	
p	0.00		0.01		0.00	

It is important to note that in order to get a clearer picture of the correlation between observed variables a *forward* variable selection algorithm for entry into a model (Jelaska, Erceg & Kuna, 2011) was used. When viewing table 2, it can be observed that the maximum oxygen uptakes on all exercise machines were determined by motor skills ($p<0.01$, $R^2=0.65-0.92$). Therefore, we can conclude that VO_2max is highly determined by predictors arising from the motor skill set. Table 1 shows that the participants had the highest maximum oxygen uptake levels scores on the treadmill, a bit lower scores on the Orbitrek exercise machine, and the lowest ones on the cycle ergometer, which almost completely coincides with previous research results (Sedlock, 1992; Mays et al., 2010). In addition to that, results from table 2 indicate that the maximum oxygen uptake while exercising on Orbitrek statistically significantly affects as much as 7 out of 11 predictor variables, namely the assessment variables: strength of the torso (MBML, MTRB), agility (MHEG, MKUS), coordination (MKRBNR) movement frequency (MTAP) and balance (MBAP2Z). Previously obtained results are to be expected considering the Orbitrek operating mode - the elliptic movement dynamic itself requires good coordination at high frequencies. On the treadmill, 4 out of 11 predictors statistically significantly indicate the maximum oxygen uptake: both balance assessment variables, MBAP2Z and MBAU10, as well as the body and torso strength assessment variables, MTRB and MSDM. It is obvious that balance plays an important role at the treadmill, probably because running on the same spot feels somewhat unnatural, and because of this, processes for maintaining balance are additionally activated. Only one variable statistically significantly influences maximum oxygen uptake on the cycle ergometer, and that is the shoulder girdle and torso strength assessment variable, MBML. The differences and similarities between the exercise machines can be defined within the scope of their specificities, i.e. movements carried out during the performance of an exercise. Whereas Orbitrek and cycle ergometer require strength of the torso which is extremely important in order for task execution to be economical and continuous, the treadmill requires a highly developed balance as opposed to the other two exercise machines. The difference between Orbitrek and cycle ergometer exercise machines is most evident in coordination and hand movement frequency: Obitrek is more demanding in these aspects. This was to be expected, since Orbitrek exercise actively utilizes arms, and the movements themselves are much more complex than those used during cycle ergometer exercise.

Modern sports technologies assuredly aim to develop functional abilities of athletes, so there is need for the improvement of training process modality and methods which would then improve these required properties. One of the possible approaches to satisfying high standards is the option of using training load setup exercise machines in an advanced manner, as kinesiological operators. It needs to be emphasised that the main limitation to this research is a relatively small sample as opposed to the number of variables measured, as well as a relatively heterogeneous participant sample that obscured certain results. For future research it would be wise to homogenize the participant sample in order to facilitate interpretation of results and increase the deduction capability.

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