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Maximal oxygen uptake ($\dot{V}O_{2\ max}$) in young trained and untrained boys. Methodological case study

Maksymalny pobór tlenu ($\dot{V}O_{2\ max}$) u młodych trenujących i nie trenujących chłopców. Metodologiczne studium przypadku

INTRODUCTION

There are many laboratory and outdoor tests more or less objectively determined maximal oxygen capacity expressed in maximal oxygen uptake ($\dot{V}O_{2\ max}$). It is known that $\dot{V}O_{2\ max}$ is the most objective parameter of fitness level and exercise capacity. All methods used to estimating $\dot{V}O_{2\ max}$ can be divided into two groups: direct or indirect methods. First group amounts incremental exercise test named "tests until refuse" with using expiratory gas analyser. In the second group we can find some submaximal exercise tests (for example Physical Working Capacity- PWC 170, Test Astrand-Ryhming etc.). Many authors showed that indirect methods are not as much precise as direct one. It is very expressive especially in researching with group of children's [Astrand and Rodahl 1986, Laskowski 1994]

Due to this our purpose was to examine maximal oxygen uptake in young trained and untrained boys with using different kind of methods and comparison results.

MATIRIALS

Twenty nine healthy boys age 12-13 years old trained soccer (n=15) and untrained (n=14) volunteered for this study. Table 1 illustrate the characterisation of the examined groups.

Table 1. Anthropological characteristics of the examined groups

	Age [year]	Height [cm]	Weight [kg]	BSA [m^2]	BMI [$kg.m^{2\ -1}$]
untrained boys n=14	12,6 ± 0,2	155 ± 4,8*	43,6 ± 5,2*	1,4 ± 0,1	18,2 ± 1,2
trained boys n=15	12,8 ± 0,2	161,9 ± 5,9	48,6 ± 5,0	1,5 ± 0,1	18,5 ± 1,5
		P< 0,01	P< 0,05		
Values are means ± SD, n - no. of subject, * Difference from trained boys (as determined by paired *t*-test) BMI – body mass index, BSA – body surface area					

METHODS

Each subject performed two cycloergometer exercise tests. First one is standard submaximal test PWC 170 (two 5 min bouts of exercise, first with load 1,0W · kg^{-1} and the second 1,5W · kg^{-1}) where the formula is:

$$\dot{V}O_{2\,max}\,[ml \cdot min^{-1}] = 1{,}7 \times PWC_{170}\,[kGm \cdot min^{-1}] + 1240$$

The second one is an incremental exercise test. We purpose following workload protocol as a modifications of well known protocol for adults (Suchanowski, 1993). This test started at 5 min reference phase at a power output of 1,0W · kg^{-1} (for untrained) and 1,5W · kg^{-1} (for trained) with a pedalling rate 50 rev · min^{-1}.Than the load output followed by increases amounting 15W per every 1 min until the subject refuse to continue exercise. Table 2 illustrate the workload protocol. During this test we measured: VO_2, VCO_2, minute lung ventilation (MV), heart rate (HR), anaerobic threshold (AT), respiratory exchange ratio (RER) and $\dot{V}O_{2\,max}$. We used expiratory gas analyser Oxycon Pro of Jaeger and computer program Breath-by-Breath.

Table 2. Characteristics of workload protocol in cycloergometer incremental exercise test with pedaling frequency 50 rev per min in untrained and trained boys

Test Phase	Untrained		Trained	
	Time [min]	Load	Time [min]	Load
Resting	3	no load	3	no load
Reference	5	1,0W · kg^{-1}	5	1,5W · kg^{-1}
Test	Until refuse	15W per every 1 min	until refuse	15W per every 1 min
Recovery	5	no load	5	no load

RESULTS

The present study investigated that the maximal oxygen uptake was significantly higher in both group of boys when we used indirect method (PWC 170) than when we measured it in direct one (incremental exercise). Table 3 illustrate differences between $\dot{V}O_{2\,max}$ values in both methods.

Table 3. Maximal oxygen uptake ($\dot{V}O_{2\,max}$) in different kind of methods

	Indirect method PWC 170		Direct method incremental exercise test	
	$\dot{V}O_{2\,max}$ [L.min^{-1}]	$\dot{V}O_{2\,max}$ [ml.kg^{-1}.min^{-1}]	$\dot{V}O_{2\,max}$ [L.min^{-1}]	$\dot{V}O_{2\,max}$ [ml.kg^{-1}.min^{-1}]
untrained boys n=14	2,39 ± 0,2*$^{\$}$	54,5 ± 4,2*$^{\$}$	1,93 ± 0,3*	44,3 ± 5,5*
trained boys n=15	2,71 ± 0,3	58,9 ± 5,2$^{\#}$	2,54 ± 0,4	55,2 ± 4,1
	P<0,01	P<0,02	P<0,01	P<0,05

Values are means ± SD, n - no. of subject,
* Difference from trained boys (as determined by paired *t*-test)
$^{\#}$ Difference from direct method *P<0,01* (as determined by paired *t*-test)
$^{\$}$Difference from direct method *P<0,05* (as determined by paired *t*-test)

In group of untrained boys $\dot{V}O_{2\,max}$ (expressed in L.min^{-1} and ml.kg^{-1}.min^{-1}) was significantly higher (P<0,05) when we estimated it in indirect method from measurement in direct one. We also showed significantly (P<0,05) difference in trained group but only when $\dot{V}O_{2\,max}$ was expressed in ml.kg^{-1}.min^{-1}.

DISCUSSION

It is known that children's predispositions in aerobics sports are natural a little bit higher then in adults. It's due to the fact that children can quickly adapt their oxidative metabolism meet the higher energy requirements and hence, have a lower need for nonoxidative metabolism even in the high-intensity exercise.(Hebestreit at al.1998; Hargrereaves 1995; Williams at al. 2001). Metabolic responses to heavy exercise are different in children, adolescents and adults. In particular, children have lower anaerobic performance compared with adults (Armon at al.,1991; Erikson 1980). However, the

most important and the major factor which could describe physical efficiency is maximal oxygen uptake ($\dot{V}O_{2\,max}$).

In this study we examined maximal oxygen uptake in young trained and untrained boys with using different kind of methods and compared the results. We showed that indirect method which we used to estimated $\dot{V}O_{2\,max}$ was not as precise as direct one. The results of $\dot{V}O_{2\,max}$ from PWC_{170} are too much higher contrary to results from incremental exercise.

Due to this our purpose was to used (if it is only possible) direct methods with suggested workload protocol. This method with using cycloergometer is really save for researched subject and could give us many interesting and important factors as well as in subaximal or maximal phase of incremental exercise (for example: VO_2, VCO_2, minute lung ventilation (MV), heart rate (HR), anaerobic threshold (AT), respiratory exchange ratio (RER) and measurement of $\dot{V}O_{2\,max}$. This is very important especially when the data from researching are needed to planning the training program for young athletes.

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STRESZCZENIE

Maksymalny pułap tlenowy jest niewątpliwie najlepszym wskaźnikiem wydolności fizycznej. W niniejszej pracy przebadano pod kątem wartości $\dot{V}O_{2\,max}$ dwie grupy chłopców trenujących (piłka nożna) oraz nie trenujących stosując dwie odmienne metody badań, a następnie porównano wyniki. Stwierdzono, iż wyniki uzyskane z próby pośredniej (PWC_{170}) znacząco zawyżają wartości $\dot{V}O_{2\,max}$. w stosunku do pomiaru tego parametru w próbie bezpośredniej (test" do odmowy"). Autorzy niniejszej pracy, oparciu o uzyskane wyniki, sugerują, aby o ile jest to możliwe (nie ma przeciwwskazań) w badaniach wydolnościowych dzieci stosować próby bezpośrednie. Przy zastosowaniu cykloergometru i proponowanego protokołu obciążeń takie próby wysiłkowe są w pełni bezpieczne. Szczególnie jest to wskazane w badaniach dzieci trenujących, gdzie uzyskane wyniki często służą do planowania procesu treningowego.

ABSTRACT

In this study we examined maximal oxygen uptake in young trained and untrained boys with using different kind of methods and compared the results. We showed that indirect method which we used to estimated $\dot{V}O_{2\,max}$ was not as precise as direct one. The results of $\dot{V}O_{2\,max}$ from PWC_{170} are too much higher contrary to results from incremental exercise.

Due to this our purpose was to used (if it is only possible) direct methods with suggested workload protocol. This method with using cycloergometer is really save for researching subject and could give us many interesting and important factors as well as in subaximal or maximal phase of incremental exercise (for example: VO_2, VCO_2, minute lung ventilation (MV), heart rate (HR), anaerobic threshold (AT), respiratory exchange ratio (RER) and measurement of $\dot{V}O_{2\,max}$. This is very important especially when the data from researching are needed to planning the training program for young athletes

The Ethical Committee at the Medical University of Gdańsk approved this study