ASSESSMENT OF NERVOUS-MUSCULAR SYSTEM'S POTENTIALS OF CYCLIC KINDS OF SPORTS SPORTSMEN

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Abstract. *Purpose:* to work out and substantiate methodic of assessment of nervous-muscular system's potentials of elite sportsmen, representatives of cyclic kinds of sports. *Material:* in the research sportsmen of cyclic kinds of sports (n = 28) participated. Testing was conducted with the help of ergometer of bicycle type. *Results:* we present methodic of assessment of nervous-muscular system's potentials of elite sportsmen with the help of surface electromyography. It was found that sportsmen with high aerobic potentials reach second electromyography threshold with power of work, corresponding, in average, 80.5% VO_2 max. We also found confident correlation ($r=0.59$, $p\leq0.05$) between maximal concentration of blood lactate and maximal amplitude of electromyogram. *Conclusions:* application of our approaches permits to assess reserve potential by type of muscle fibers, which influence on sportsman's bent to certain kind of motor functioning. The worked out assessment system permits to determine contribution of different motor units' types in achievement of required parameters of work.

Key words: muscle fibers, electromyography, threshold of anaerobic metabolism, anaerobic.

Introduction

Functional potentials of sportsmen's nervous-muscular system (NMS) are one of the most important factors, which influence on of sports' functioning results. In spite of sufficient quantity of scientific data [1, 2, 5, 12, 18] the problem of control and assessment of NMS functional potentials as main component of sportsman's motion functional system has not been studied properly.

As on to day in sports practice, for assessment of NMS such methods as dynamometry and electro-neuro-myography are used [1 – 3, 17]. However, such approach is insufficient for complex assessment of this system's functional potentials. Development of methods and approaches to assessment of NMS reserves is an important problem of sports science. As per modern ideas "functional reserves" are regarded as potentials of organ or system to strengthen appropriate functioning with maximal mobilization (i.e. in conditions of maximal shifts in homeostasis) [4]. Accordingly, functional potentials of sportsman's NMS reflect maximal range of this system's shifts for achievement of certain result of muscular functioning.

We have analyzed potentials of electromyography (EMG) (as method of NMS assessment), based on registration and analysis of muscles' or nervous electric activity [2]. In modern sports practice the method of surface electromyography (SEMG) is widely used and it permits to simultaneously register total electric activity of different muscular groups. So, with the help of different SEMG parameters inter-muscular and in-muscular coordination are assessed; muscular fatigue and activation of different motor units' types are differentiated and etc. [1, 5, 11, 17].

Analysis of recent data [13, 14, 16] and our own researches [8, 9] permitted to determine purposefulness of SEMG application for assessment of NMS functional potentials in cyclic kinds of sports sportsmen.

Hypothesis: application of surface electromyography under increasing load permits to find threshold changes of electromyogram, which are conditioned by recruiting of different types of muscle fibers. Appearing of second electromyography threshold reflects switching in of glycolitic muscle fibers in total effort and, therefore, it is connected with prevalence of anaerobic energy supply mechanism. By values of power and oxygen consumption at level of electromyography thresholds it is possible to assess reserve potentials of different muscle fibers' types: oxidative, transitive and glycolitic.

The purpose of the research is to work out and experimentally prove methodic of assessment of nervous-muscular system's potentials of elite sportsmen, representatives of cyclic kinds of sports.

Material and methods

Participants: the research was fulfilled on the base of State Research Institute of Physical Culture and Sports and 28 elite sportsmen of cyclic kinds of sports (academic rowing - n=18, triathlon - n=4, light athletic – n=6) participated. The sportsmen's age was 23.4 (4.8), height – 194.7 (6.8) and weight – 93.0 (7.5)

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Procedure: testing was fulfilled with ergometer of bicycle type Monark Ergomedic 894 and stipulated work under constant increasing load: duration of every step was 3 minutes (by Machado F. A. 2013). The work was fulfilled up to reaching of oxygen maximal consumption (VO_2 max). Ergometric testing envisaged keeping of constant rotations' value – 80 r.p.m., initial power was 78 W; further it increased by 23.6 W.

Registration of external breathing and gas metabolism parameters was realized with gas analyzer "Oxycon Mobile" (Jeager, Germany). We carried out analysis of the following indicators: oxygen consumption VO_2, $ml \cdot min^{-1} \cdot kg^{-1}$;% VO_2max; ventilation equivalent by oxygen $VEVO_2$. Lactate concentration in mixed capillary blood was measured at the end of every load step with the help of bio-chemical analyzer "Dr. Lange" (Germany).

Under testing load we registered electric activity of the most engaged in work muscular groups with the help of portable electromyography device "MegaWin ME6000" (Mega Electronics Ltd, Finland) according to recommendations of V.N. Komantsev (2006).

In the article we present analysis of amplitude mean values, root mean square of eloctromyogram (rmsEMG) m. Vastus Lateralis with discreteness of 10 seconds. We studied threshold changes of electromyogram (EMG) – first and second electromyography thresholds ($EMGT_1$ and $EMGT_2$). In detail methodic of electromyography study is given in our previous publications [8, 9].

Threshold of anaerobic metabolism (TAM) was differentiated by appearing of ventilation (VT) and lactate thresholds (LT) [6].

Statistical analysis of data was carried out with the help of Excel 2007 and Statistica 6 programs. The samples of the data were checked for normality of distribution. For determination of confidence and significance of correlations between two parameters we used Spearman's correlation analysis. For determination of confidence of differences between two connected samples we used non parametrical criterion of Wilkinson. Determination of confidence of differences between two groups was fulfilled by criterion of Kholmogorov- Smirnov.

The research procedure was fulfilled in compliance with principles of all medical researches, mentioned in Helsinki Declaration, 2008.

Results of the researches

In our present research we compared the values of load power (W) and oxygen consumption (VO_2, $ml \cdot min^{-1} \cdot kg^{-1}$) at level of maximal oxygen consumption (VO_2max) and at reaching $EMGT_2$ by elite sportsmen with different aerobic potentials: first group included sportsmen with high aerobic potentials and the second included the rest of sportsmen (see table 1). Distribution of sportsmen by groups was fulfilled in compliance with such indicators as W and VO_2 at level of TAM. By modern opinions [6, 7] such indicators reflect sportsmen's aerobic potentials.

Table1. Power and oxygen consumption at TAM levels, $EMGT_2$ and VO_2max in sportsmen with different aerobic potentials (X±δ, n = 28)

Parameters		1 group (n = 8)	2group (n = 20)
Wmax, W		366. 6 ± 29.4	339.6 ± 38.1
VO_2max, $ml \cdot min^{-1} \cdot kg^{-1}$		47.2 ± 5.7	48.3 ± 8.4
TAM	W, W	284 ± 33.9	209 ± 57.1*
	VO_2, $ml \cdot min^{-1} \cdot kg^{-1}$	41.5 ± 5.0	32.7 ± 7.45*
$EMGT_2$	W (W)	294.1± 20.4	241.2 ± 36.0*
	W,%	80.5 ± 4.3	70.8 ± 6.5*
	VO_2, $ml \cdot min^{-1} \cdot kg^{-1}$	38.4 ± 7.4	34.8 ± 6.7*
	VO_2,%	80.9 ± 9.5	72.2± 8.4*

*differences are confident at $p \leq 0.05$

As we can see in table 1 in first group sportsmen VO_2 and W at level of $EMGT_2$ are confidently higher. As it is known [7], maximal potential of oxidative muscle fibers (1st type) manifests exactly at reaching TAM. Thus, values VO_2 and W of load at $EMGT_2$ level reflect aerobic ability of muscles. Therefore, by indicators of load power and oxygen consumption at reaching $EMGT_2$ we can assess reserve potentials of oxidative muscle fibers. By results of

this research we worked out scale of muscles' aerobic potentials' scale, depending on VO_2 and W when reaching $EMGT_2$ (see table 2).

Table2. Integral assessment of muscles' aerobic potentials of elite sportsmen, considering power and oxygen consumption at $EMGT_2$

Level of muscles' aerobic potentials	VO_2,%	W,%
High	≥ 80.7	≥ 81.0
Above average	73.4 – 80.6	74.3 – 80.9
Average	66.1 – 73.3	67.7 – 74.2
Below average	≤ 66.0	≤ 74.1

In order to work out methodic of assessment of glycolitic muscular fibers' functional potentials we analyzed changes of EMG amplitude after reaching $EMGT_2$.

We analyzed correlation between maximal concentration of lactate in blood and changes of electromyography amplitude. In modern opinions level of sportsman's anaerobic potentials is characterized just by value of maximal concentration of lactate in blood [12].

With the help of correlation analysis we found confident ($p \leq 0.05$) correlation between maximal concentration of lactate in blood and increase of EMG amplitude EMG (%) after reaching $EMGT_2$ ($r = 0.50$) [as well as EMG maximal amplitude (mcV)] ($r = 0.59$).

We compared two groups of sportsmen, depending on maximal concentration of lactate in blood. First group included sportsmen with high anaerobic potentials (maximal lactate concentration in blood - 14.0 ± 2.5 $mmol.l^{-1}$); second group included the rest of sportsmen. Using Kholmogorov-Smirnov's criterion, we compared EMG amplitude in both groups after reaching $EMGT_2$ (see table 3).

Table 3. Values VO_2, W, EMG amplitudes (Amax) and EMG amplitudes' increment after reaching $EMGT_2$ (ΔA) in sportsmen with different anaerobic potentials (n = 18, X±δ)

Parameters		1 group(n =10)	2 group (n =8)
La, $mmol \cdot l^{-1}$		14.0 ± 2.5	8.8 ± 1.3*
Wmax, W		332. 5 ± 29.1	349.0 ± 38.7
VO_2max, $ml \cdot min^{-1} \cdot kg^{-1}$		51.1 ± 10.7	48.7 ± 4.8
Amax, mcV		654.6 ± 164.4	452.5 ± 97.0*
Δ A	A, mcV	371.6 ± 127.2	213.5 ± 99.7*
	A,%	54.9 ± 6.1	43.4 ± 5.3*

*differences are confident at $p \leq 0.05$

As we can see in table 3 two groups confidently ($p \leq 0.05$) differ by a number of parameters. So, for sportsmen with better anaerobic potentials higher values of maximal EMG amplitude (mcV), ENG amplitudes' increment (ΔA, %) after reaching of $EMGT_2$ is intrinsic. As it is known [5, 16, 19], increase of load power after reaching $EMGT_2$ is possible only at the account of new glycolitic muscle fibers' involvement with further synchronization of already working motor units. So, duration of sportsman's work after reaching $EMGT_2$ will depend to large extent on reserve potentials of glycolitic muscle fibers.

Therefore, reserve potentials of glycolitic muscle fibers can be assessed by the value of maximal amplitude of electromyogram and by increment of EMG amplitudes after reaching $EMGT_2$. By results of our research we worked out integral assessment of muscles' anaerobic abilities (see table 4).

Table 4. Integral assessment of muscles' anaerobic abilities, depending on EMG amplitudes' increment (ΔA, %) **after reaching**

Level of muscles' aerobic potentials	ΔA,%
High	≥ 53.5
Above average	43.7 – 53.4
Average	33.9 – 43.6
Below average	≤ 33.8

Discussion

By results of experimental researches we worked out and experimentally tested system of assessment of NMS functional potentials, which includes differentiation of anaerobic threshold; assessment of reserve potentials of oxidative and gycolitic muscle fibers.

By results of this and our previous works [8, 9], when comparing load power and oxygen consumption (VO_2) at TAM level and with reaching $EMGT_2$, we found rather high correlation between the following: VO_2 and power of load at reaching $EMGT_2$ and LT ($r = 0.72 – 0.93$, $p \leq 0.05$) and VT ($r = 0.79 – 0.93$, $p \leq 0.05$). It serves as the base for application of electromyography method for TAM differentiation at reaching $EMGT_2$. These results are in agreement with the data of Moritani T. [19], C. T. Candotti [10], Zuniga J. M. [20], who determined correlations between aerobic-anaerobic transition of energy supply by changes of muscles' electric activity.

Results of our research and the researches of A. Lucia [14], F. Hug [13] showed the presence of two electromyography thresholds ($EMGT_1$ and $EMGT_2$). The authors explain the presence of two thresholds in elite sportsmen by their ability to switch in work different types of muscle fibers (transitive and glycolitic) in response to increase of load's intensity up to definite level. The authors explain that recruiting of new motor units (especially quickly contracting: of 2nd and 3rd type) is conditioned by mechanisms of fatigue of local and general genesis. The found, as a result of researches, scientific data became a basis for working out of methodic of reserve potentials' assessment; of different by type muscle fibers with the help of surface electromyography.

Appearing of $EMGT_2$ witnesses about fatigue progressing in working motor units, which is accompanied by many quickly contracting (glycolitic) muscle fibers' involving in work for maintaining of proper effort. Thus, we chose the values of load power and oxygen consumption at $EMGT_2$ as criteria for assessment of muscles' aerobic abilities: i.e, functionaly potentials of oxidative muscle fibers.

Results of C. J. De Luca [11], S. Green [12], J. Maestu [16] witness that the higher is the quantity of active quickly contracting (2nd and 3rd type – glycolitic) muscle fibers are, the quicker EMG amplitude increases. It conditions increase of anaerobic energy supply contribution. Therefore, significant increment of EMG amplitude after reaching $EMGT_2$ is conditioned by ability of nervous muscular system to switch in work great number of quickly contracting muscle fibers as well as synchronization of motor units and high reserve potentials of quickly contracting muscle fibers. So we chose value of EMG increment after reaching $EMGT_2$ as criterion for assessment of functional potentials of glycolitic muscle fibers and their anaerobic abilities.

Basing on results of previous works of modern authors [10, 13, 14, and 18] and our own researches we, for the first time, worked out the methodic of NMS assessment with the help of surface electromyography data, taken under loads of increasing power in elite sportsmen. Application of our approaches permits to assess reserve potential of different by type muscle fibers. Sportsman's bent to definite kind of motor functioning depends on it. The main advantage of the worked out assessment system is possibility to determine contribution of different motor nits' types in achievement of desired working parameters.

In our research the question about other possible factors' (except recruiting of different types of muscle fibers and fatigue progressing) influence on surface electromyogram changes under maximal loads remains unsolved. It requires further study and can be used in perfection of already worked out methodic of sportsmen's NMS assessment.

Conclusions

The research resulted in working out and experimental testing of NMS functional potentials' assessment, which includes: determination of anaerobic threshold by appearing of $EMGT_2$; assessment of reserve potentials of oxidative muscle fibers by power level of work and oxygen consumption at $EMGT_2$; assessment of reserve potentials of glycolitic muscle fibers – by EMG amplitudes' increment after reaching $EMGT_2$.

This methodic of NMS functional potentials' assessment is recommended to implement in stage-by stage and current control of functional state of cyclic kinds of sports sportsmen.

The prospects of further scientific researches imply study of factors, influencing on changes of surface electromyography in different muscle groups under maximal load of special orientation.

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Conflict of interests

The author declares that there is no conflict of interests.

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