



The performance indicators of elite athletes aged 15-16 in sports-related activities

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Dr. Hab., **K.G. Zelenskiy**¹

Dr. Hab., Professor **G.N. Ponomarev**²

Dr. Hab., Professor **V.F. Kostyuchenko**³

PhD, Professor **V.D. Zverev**³

¹Stavropol State Pedagogical Institute, Stavropol

²The Herzen State Pedagogical University of Russia, St. Petersburg

³Lesgaft National State University of Physical Education, Sport and Health, St. Petersburg

Corresponding author: ardf_zelenskii@mail.ru

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Abstract

Objective of the study was to pinpoint the characteristics of the athletic performance of adolescents aged 15-16 in sports radio direction finding during the process of energy provision for muscular activity in the context of aerobic-anaerobic transition.

Methods and structure of the study. The research was conducted in Kislovodsk in November 2023, during the training camps. The participants were 12 members of the Russian youth national team in the age group of 15-16 years, including one Master of Sports, eight Candidates for Master of Sports, and three athletes with first-category status.

During the experiment, a treadmill test was performed. The participants performed muscle work with gradually increasing load until they reached exhaustion. Breathing was monitored to measure the concentration of oxygen and carbon dioxide in nanometers, while heart rate and lactate levels in the blood were also determined.

Based on the collected data, the aerobic and anaerobic thresholds were calculated, expressed in terms of running speed, oxygen consumption per minute, and heart rate.

Results and conclusions. It was discovered that the lactate levels in the blood of skilled athletes aged 15-16 who participate in sports radio direction finding are within the expected range and are equal to 2,4 mmol·l⁻¹ at the aerobic threshold and 4,3 mmol·l⁻¹ at the anaerobic threshold. The average speed at the anaerobic threshold is 3,01 m·s⁻¹, at the anaerobic threshold – 4,02 m·s⁻¹, and at the maximum power consumption – 4,71 m·s⁻¹.

The most informative indicators in sports radio direction finding for skilled athletes aged 15-16 are the oxygen consumption at the anaerobic threshold, the speed at the anaerobic and maximum power consumption thresholds.

Keywords: sports radio direction finding, maximum oxygen consumption, aerobic threshold, anaerobic threshold, lactate, pulmonary ventilation, oxygen pulse.

Introduction. Physical performance is manifested in various forms of muscular activity. In turn, functional capabilities determine the level of physical performance. That is why information about physical performance and, in particular, about the functional capabilities of athletes are necessary components of the management of the process of sports training in sports radio direction finding [2].

Important objective factors that determine physical performance and functional capabilities of an athlete include, among other things, the power, capacity and efficiency of the mechanisms of aerobic and anaerobic energy supply. That is why, in a narrower sense, physical performance is considered as the functional state of the cardiorespiratory system [3]. The main factor of physical performance is considered to be the indicator of maximum aerobic power - maximum

oxygen consumption ($\dot{V}O_{2\max}$ or $VO_{2\max}$). However, for a more complete assessment of the state of the cardiorespiratory system, it is also important to have data on the functional state of aerobic and anaerobic processes. In endurance competitions, including when covering a competitive distance in sports radio direction finding, performance is determined not only by the aerobic power ($\dot{V}O_{2\max}$) of the athlete, but also by the ability to use a larger share of aerobic performance (% of $\dot{V}O_{2\max}$) for a sufficiently long time and thereby maintain the distance speed. It follows that to assess the athlete's performance, it is necessary to determine the threshold of anaerobic metabolism (AnT), which is characterized by the ratio of aerobic and anaerobic energy production.

For the most complete disclosure of the aerobic-anaerobic transition, the aerobic threshold (AeT) is



determined, which denotes the upper limit of the process of aerobic energy supply and the anaerobic threshold (AnT), characterized by the onset of a pronounced upward deviation of the lactate curve and other indicators of external respiration. An important indicator characterizing the efficiency and effectiveness of the cardiorespiratory system during physical exertion is the oxygen pulse indicator, which reflects the amount of oxygen transported to the tissues consuming it (including muscles) during one heartbeat [1]. Determining these indicators is a necessary condition for assessing the impact of training loads on the athlete's body and dosing their volume and intensity during sports training.

Objective of the study was to pinpoint the characteristics of the athletic performance of adolescents aged 15-16 in sports radio direction finding during the process of energy provision for muscular activity in the context of aerobic-anaerobic transition.

Methods and structure of the study. The scientific work involved 12 young men, members of the Russian youth national team in sports radio direction finding aged 15-16 (1 - Master of Sports, 8 - Candidate Master of Sports, 3 athletes of the 1st category). The study was conducted in November 2023 in the conditions of a training camp in Kislovodsk.

The test was conducted using the Treadmill H/P Cosmos Quasar. When performing the work, the angle of inclination on the treadmill was 1%. Muscle work was performed with a stepwise increasing load until «failure». The initial running speed corresponded to $2.5 \text{ m}\cdot\text{s}^{-1}$, with a subsequent increase in speed at each step by $0.5 \text{ m}\cdot\text{s}^{-1}$. The duration of each step is 3 min.

During the entire testing period, as well as during the recovery period, air was sampled to measure the

concentration of oxygen and carbon dioxide in it, and heart rate was determined. Analysis of inhaled and exhaled air was performed using a Metalyzer 3B-R2 automatic gas analyzer (Cortex, Germany). Based on the data obtained, oxygen consumption ($\dot{V}\text{O}_2$) and $\text{VO}_{2\text{max}}$ ($\dot{V}\text{O}_{2\text{max}}$), lung ventilation ($\dot{V}\text{E}$) ($\text{l}\cdot\text{min}^{-1}$), and carbon dioxide excretion ($\dot{V}\text{CO}_2$) were determined.

The values of the aerobic (AeT) and anaerobic (AnT) thresholds were determined, expressed as running speed ($\text{m}\cdot\text{s}^{-1}$), the level of minute oxygen consumption ($\dot{V}\text{O}_2 - \text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, % of $\dot{V}\text{O}_{2\text{max}}$) and heart rate (min^{-1}). Heart rate (min^{-1}) was recorded using a Polar heart rate monitor. Before testing and 10 s before the speed increase at each stage, capillary blood was taken to determine the lactate concentration (La , $\text{mmol}\cdot\text{l}^{-1}$). The concentration of lactate in the blood was determined using the EKF Biosen C_Line analyzer.

Determination of aerobic performance, including threshold values of aerobic-anaerobic metabolism was carried out by analyzing the dynamics of indicators by finding the «inflection» points of the ventilation parameter curves, heart rate, as well as the dynamics of lactate accumulation in the blood.

Oxygen pulse (OP - O_2 pulse) was defined as the ratio of the volume of oxygen consumption ($\dot{V}\text{O}_2$) to the heart rate (HR) and was expressed in milliliters per contraction ($\text{ml}\cdot\text{beat}^{-1}$). In order to determine the influence of various indicators of aerobic and aerobic-anaerobic performance on the sports results in sports radio direction finding among young men aged 15-17, two control runs were held in the conditions of training camps, one in the sprint and one at the classic distance in the range of 3.5 MHz.

In the sprint, the distance was 2 km. Athletes searched for seven radio transmitters, which operated in the mode of – 12 seconds of work, 28 seconds of

Localization criteria of aerobic and aerobic-anaerobic performance indicators of qualified athletes aged 15-16 years in sports radio direction finding ($\pm \sigma$)

Indicator	Localization criteria		
	AeT	AnT	$\dot{V}\text{O}_2 \text{ max}$
Oxygen consumption ($\dot{V}\text{O}_2$), $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$	$37,0 \pm 1,3$	$47,8 \pm 2,5$	$54,4 \pm 4,8$
HR, min^{-1}	$158,1 \pm 11,2$	$182,5 \pm 6,1$	$194,8 \pm 6,4$
Blood lactate concentration (La), $\text{mmol}\cdot\text{l}^{-1}$	$2,4 \pm 0,8$	$4,3 \pm 0,7$	$7,5 \pm 1,1$
Lung ventilation ($\dot{V}\text{E}$), $\text{l}\cdot\text{min}^{-1}$	$62,1 \pm 13,1$	$98,8 \pm 19,5$	$132,5 \pm 16,7$
Running speed (V), $\text{m}\cdot\text{s}^{-1}$	$3,01 \pm 0,28$	$4,02 \pm 0,30$	$4,71 \pm 0,28$
$\dot{V}\text{O}_2$ from $\text{VO}_{2\text{max}}$ ($\dot{V}\text{O}_{2\text{max}}$), %	$68,9 \pm 6,6$	$85,7 \pm 5,2$	100,0
Oxygen pulse (O_2 pulse), $\text{ml}\cdot\text{beats}^{-1}$	$14,7 \pm 2,2$	$16,3 \pm 1,9$	$17,3 \pm 1,6$
Weight, kg	$62,5 \pm 9,2$		
Height, cm	$178,2 \pm 5,3$		



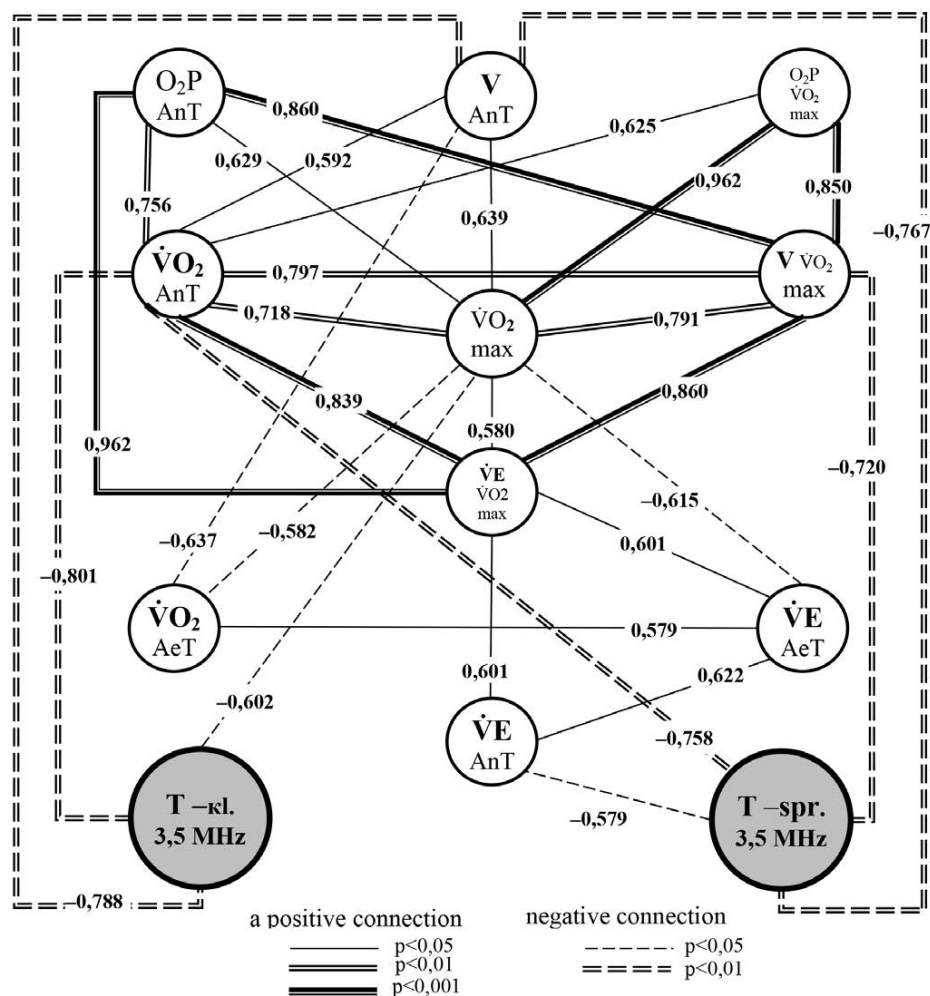
pause. The average time to cover the distance in the sprint was $-17.10 \pm 0.16, 0$.

At the classic distance, the effective length of the track was 6 km. Athletes searched for five radio transmitters, operating in the mode of -1 min of work, 4 min of pause. The average time to cover the distance was $-35.34, 0 \pm 0.11, 0$.

Results of the study and discussion. The results obtained during the testing are presented in the table.

It was found that in qualified athletes aged 15-16 years in sports radio direction finding the $\dot{V}O_{2\max}$ index ($\dot{V}O_{2\max}$) corresponds to $54,4 \pm 4,8$ ml·kg⁻¹·min⁻¹ with a heart rate of $194,8 \pm 6,4$ min⁻¹. At the $\dot{V}O_{2\max}$ level, the pulmonary ventilation indices ($\dot{V}E$) are localized within $132,5 \pm 16,7$ l·min⁻¹, oxygen pulse (O_2 pulse) – $17,3 \pm 1,6$ ml·beats⁻¹, blood lactate concentration (La) – $7,5 \pm 1,1$ mmol·l⁻¹. Running speed (V) is equal to $4,71 \pm 0,28$ m·s⁻¹. At the aerobic threshold (AeT), the concentration of lactate in the blood (La) is $2,4 \pm 0,8$ mmol·l⁻¹. Oxygen consumption ($\dot{V}O_2$) at AeT is $37,0 \pm 1,3$ ml·kg⁻¹·min⁻¹,

which corresponds to 68,9% of $\dot{V}O_{2\max}$. In this case, the heart rate is localized at the level of $158,1 \pm 11,2$ min⁻¹, pulmonary ventilation ($\dot{V}E$) is $62,1 \pm 13,1$ l·min⁻¹, oxygen pulse (O_2 pulse) is $14,7 \pm 2,2$ ml·beats⁻¹. Running speed (V) at AeT is $3,01 \pm 0,28$ m·s⁻¹. The upper limit of the aerobic-anaerobic transition (anaerobic threshold - AnT) is characterized by the following parameters. The concentration of lactate (La) in the blood is $4,3 \pm 0,7$ mmol·l⁻¹, with a heart rate of $182,5 \pm 6,1$ min⁻¹. Running speed (V) at AnT is $4,02 \pm 0,30$ m·s⁻¹. Oxygen consumption ($\dot{V}O_2$) is 85,7% of $\dot{V}O_{2\max}$ with a value of $47,8 \pm 2,5$ ml·kg⁻¹·min⁻¹. The ventilation rate of the lungs ($\dot{V}E$) is $98,8 \pm 19,5$ l·min⁻¹, oxygen pulse (O_2 pulse) is $16,3 \pm 1,9$ ml·beats⁻¹. The test results show that athletes aged 15-16 have quite high oxygen consumption rates at the aerobic-anaerobic transition boundary (85% of $\dot{V}O_{2\max}$), which is a high indicator of aerobic performance. However, despite the fact that the athletes under study have quite high sports titles (MS) and ranks (CMS), they still have not yet reached the proper level



Correlation graph characterizing the interrelations of cardiorespiratory system parameters and their influence on the sports result in the disciplines of «sprint» and «classic» in sports radio direction finding in qualified athletes aged 15-16 years. Explanation of symbols in the text



of functional development corresponding to adult athletes. It can be assumed that the high percentage of oxygen consumption (relative to $\dot{V}O_{2\max}$) at the AnT level in young men aged 15-16 is due to a lower activity of the glycolysis enzyme, phosphofructokinase, relative to adult athletes [3]. A correlation analysis was conducted to determine the influence of various functional indicators of the cardiorespiratory system at the aerobic (AeT) and anaerobic (AnT) thresholds on the result of passing a competitive distance in sports radio direction finding in young men aged 15-16, as well as their interrelationships. The intercorrelation matrix obtained as a result of data processing made it possible to identify relationships at the reliability level from $p < 0,05$ to $p < 0,001$ (see the figure).

The analysis of intercorrelations showed that when covering a distance in a sprint, the following factors have a strong reliable effect on the result (time) (T – 3.5 MHz sprint): the speed of movement of the athlete at the level of AnT (VAnT) ($r = -0,767$; $p < 0,01$), the speed of movement at the level of $\dot{V}O_{2\max}$ ($r = -0,720$; $p < 0,01$) and oxygen consumption at the level of AnT ($\dot{V}O_{2\text{AnT}}$) ($r = -0,758$; $p < 0,01$).

When an athlete runs a distance in the «classics», a close reliable relationship ($p < 0,01$) with the result (time) (T – class. 3,5 MHz) is observed with oxygen consumption at the level of AnT ($\dot{V}O_{2\text{AnT}}$) ($r = -0,801$) and the speed of movement at the AnT level (VNP) ($r = -0,788$; $p < 0,01$). The analysis of intercorrelations showed that the most important and informative performance criteria for qualified athletes aged 15-16 years in sports direction finding are oxygen consumption at the AnT level ($\dot{V}O_{2\text{AnT}}$), running speed at the IPC level ($\dot{V}O_{2\max}$) and ventilation (VE) at the IPC level ($\dot{V}O_{2\max}$) (see Figure). The $\dot{V}O_{2\text{AnT}}$ index has a strong reliable association with lung ventilation (VE) at the level of MPC ($\dot{V}O_{2\max}$) ($r = 0,839$; $p < 0,001$), with MPC ($\dot{V}O_{2\max}$) ($r = 0,718$; $p < 0,01$), with running speed (V) at the level of MPC ($\dot{V}O_{2\max}$) ($r = 0,797$; $p < 0,01$) and oxygen pulse (OP) at the AnT level ($r = 0,756$; $p < 0,01$). In addition, there is an average significant association ($p < 0,05$) with running speed at the AnT level ($r = 0,592$) and oxygen pulse (OP) at the MPC level ($r = 0,625$). Running speed (V) at the MPC level ($\dot{V}O_{2\max}$), except with $\dot{V}O_{2\text{AnT}}$, closely correlates with lung ventilation (VE) at the MPC level ($\dot{V}O_{2\max}$) ($r = 0,860$; $p < 0,001$), with MPC ($\dot{V}O_{2\max}$) ($r = 0,791$; $p < 0,01$), with oxygen pulse (CP) at the AnT level ($r = 0,860$; $p < 0,001$) and at the MPC level ($\dot{V}O_{2\max}$) ($r = 0,850$; $p < 0,001$). In turn, the lung ventilation index (VE) at the $\dot{V}O_{2\max}$ level, in addition to running speed at the $\dot{V}O_{2\max}$ and $\dot{V}O_{2\text{AnT}}$

levels, has a strong association with OP at the AnT level ($r = 0,962$; $p < 0,001$), an average association with $\dot{V}O_{2\max}$ ($r = 0,580$; $p < 0,05$), with VE at the AnT level ($r = 0,601$; $p < 0,05$) and with VE at the AeT level ($r = 0,601$; $p < 0,05$). It should also be noted that with all these indicators, there is a different, from moderate to strong, reliable relationship with the MPC index ($\dot{V}O_{2\max}$) (see Figure).

Conclusions. The results obtained in the course of the study showed that the concentration of lactate (La) in the blood of qualified athletes aged 15-16 in sports radio direction finding at aerobic and anaerobic thresholds is localized within the generally accepted limits and equals, respectively, 2,4 and 4,3 mmol·l⁻¹, and at a heart rate of 158 min⁻¹ – AET, 182 min⁻¹ – AnT. It is noted that individual indicators may differ significantly from the average values. Thus, in the course of the study it was established that with AET the minimum and maximum La indicators in the blood were, respectively, – 1,8 and 3,1 mmol·l⁻¹, with AnT – 3,4 and 5,5 mmol·l⁻¹. This factor must be taken into account when dosing the intensity of training loads. It was determined that the average running speed at the AET level in 15-16 year old boys is 3,01 m·s⁻¹, at the AnT level – 4,02 m·s⁻¹, at the MPC level – 4,71 m·s⁻¹. It was established that the most informative performance criteria in sports radio direction finding in qualified athletes aged 15-16 are the oxygen consumption indicators at the AnT level, running speed at the MPC level, and lung ventilation at the MPC level. In addition, the oxygen consumption indicators at the AnT level, the athlete's speed at the AnT and MPC levels have a direct impact on the results of passing distances in sprint and «classic».

References

1. Zakharevich A.L., Marchenko D.S., Titova E.M. Prakticheskiye aspekty stress-testa s gazoanalizom sportsmenov razlichnykh vidov sporta. Practical guide. Minsk: RNPTS sporta publ., 2022. 36 p.
2. Zelenskiy K.G., Ponomarev G.N. Issledovaniye zon intensivnosti pri prokhozhenii klassicheskoy distantsii v sportivnoy radiopelengatsii yunoshami 13-14 let. Teoriya i praktika fizicheskoy kultury. 2018. No. 12. pp. 57-59.
3. Tikhvinskiy S.B., Bobko Ya.N. Opredeleniye, metody issledovaniya i otsenka fizicheskoy rabotosposobnosti detey i podrostkov. Detskaya sportivnaya meditsina. S.B. Tikhvinskogo, S.V. Khrushcheva [ed.]. Moscow: Meditsina, publ. 1991. pp. 259-273.