Physiological and motor characteristics of long distance running depending on the level of preparedness

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Abstract

Objective of the study is to substantiate the relationship between the physiological and motor characteristics of long-distance running and the growth of sports achievements.

Methods and structure of the study. The study involved 20 students involved in athletics and qualifying for long-distance running (group A (n=10) – II adult category, group B (n=10) – I adult category and above). The experiment used running tests on a treadmill, during which a complex of cardiorespiratory, metabolic and motor characteristics were recorded. Long-distance running is characterized by maximum mobilization of body systems. The study made it possible to establish that an increase in most of the studied physiological indicators indicates an increase in the functional capabilities of those involved, and with an increase in the preparedness of athletes, the energy cost of running decreases and the ratio of aerobic and anaerobic components of energy supply changes towards an increase in the share of the anaerobic component.

Results and conclusions. The maximum values of a number of physiological parameters recorded during the 3000 m run were compared with the corresponding data obtained in tests on a treadmill, which made it possible to determine maximum aerobic and anaerobic capabilities. An increase in most of the studied indicators indicates an increase in the functional capabilities of the body of those involved. During the study, the following pattern was revealed: with increasing fitness of athletes, energy consumption during running decreases, and the ratio of aerobic and anaerobic energy supply modes changes towards an increase in the share of the anaerobic component.

Keywords: *athletes, running, physiological functions of the body, motor functions of the body, energy supply.*

Introduction. The study of physiological and motor functions directly in the process of performing physical exercises is one of the promising directions in assessing the special performance of those involved in physical culture and sports. The information obtained under such conditions makes it possible to judge the gradients of the functions under consideration, the individual maximum level of physical fitness and performance, as well as the ability to maintain this level.

It is believed that running is one of the most popular, but also quite complex types of physical activity [3, 63 p.; 6, 82 p.]. Running is included not only in the school and university curriculum, but also in the list of exercises for performing the All-Russian Physical Culture and Sports Complex «Ready for Labor and Defense» (VFSK «GTO») [2, 15 p.; 5, 39 p.]. Many scientific studies have been devoted to the study of physiological and motor characteristics in running, including long-distance running, but in almost all of them only one or two functional characteristics are studied, most often heart rate (HR) [3, 64 p.; 5, 38 p.; 9, 14 p.].

Objective of the study is to substantiate the relationship between the physiological and motor characteristics of long-distance running and the growth of sports achievements.

Methods and structure of the study. The study involved 20 students involved in athletics and qualifying for long-distance running. The students were divided into 2 groups depending on their level of pre-

paredness: group A – II adult category (n=10); group B – I adult category and above (n=10). In the preparatory and competitive period from 2021 to 2023, using running tests on a treadmill, maximum aerobic performance was determined in subjects of both groups (test with a stepwise increasing speed from 4 m/s to 6 m/s, the increase occurred every 2 minutes by 0,5 m/s) and anaerobic capacity (uphill run test, elevation angle 3°, speed decreased from 6,5 m/s to 6 m/s). In both tests, the athletes under study continued to move until failure. A distance of 3000 m was chosen as the distance under study [7].

During running, a complex of cardiorespiratory, metabolic and motor characteristics was recorded: oxygen consumption (VO_2), carbon dioxide emission (VCO_2), minute pulmonary ventilation (VE), oxygen pulse (O2p), carbon dioxide excess ($ExCO_2$), oxygen debt (O_2 debt), depth (D) and frequency (RR) of breathing, heart rate (HR), step frequency (SF), step length (LS) [1; 4; 8].

Results of the study and discussion. The maximum values of a number of physiological indicators recorded during the 3000 m run were compared with the corresponding data obtained in tests on a treadmill, which made it possible to determine maximum aerobic and anaerobic capabilities (Table 1).

During the study, it turned out that most of the considered indicators in the 3000 m run reach the values recorded in the treban tests. High values of Exc CO-2max and oxygen debt indicate that long-distance running takes place under conditions of significant O_2 deficiency, which indicates the intensity of anaerobic glycolytic processes. VO_2 consumption reached its maximum at approximately 3–4 minutes, remaining constant throughout the entire distance.

Analysis of the results obtained revealed the following dynamics: during the first 2–3 minutes of running, heart rate increases to 180±5,8 beats/min, and VE increases to 90±10,2 l/min, while this phenomenon is not associated with a change in speed movements. Long-distance running is characterized by maximum mobilization of the body's functional systems that ensure performance at this level. High values of both aerobic and anaerobic metabolism indicate the activation of both sources of energy supply.

Comparative data for a number of physiological and motor indicators recorded during the 3000 m run at different stages of preparation are given in Table. 2. They indicate that not all of the indicators under consideration change with the growth of sports results at a given distance.

As can be seen from table 2, no significant increase in VO2max is observed. There is a tendency towards a restructuring of the structure of external respiration due to a slight increase in RR and GD at RRmax. The maximum indicators of oxygen utilization (% O_2) and carbon dioxide emissions (% CO_2) remain practically unchanged.

Despite the improvement in sports results, only a slight change in the maximum indicators of SN and DS

Table 1. Comparative data of maximum cardiorespiratory and metabolic parameters recorded in the 3000 m run and special tests on the treadmill

Indicators	Indicators of maximum aerobic capacity (stepwise increasing speed test)	Indicators of maximum anaerobic capacity (uphill running test)	Indicators recorded in the 3000 m run	Level of statistical significance of differences (P)	
				between 1 and 3	between 2 and 3
VO_2 (ml/min-kg)	69,7±1,2	–	68,8±0,9	>0,05	–
VCO_2 (ml/min-kg)	76,8±1,6	–	72,8±1,3	<0,001	–
VE (l/min)	128,8±2,7	–	123,4±3,0	<0,001	–
GD (% of vital capacity)	44,4±1,3	–	45,1±1,3	>0,01	–
RR (breaths/min)	63,4 ±1,2	–	62,0±1,8	>0,05	–
GD at RR (% of vital capacity)	39,8±1,2	–	39,7±1,7	>0,05	–
Heart rate (bpm)	194±1,2	178±1,3	192±1,6	>0,05	<0,001
O_2p (ml/beats/kg)	0,369±0,007	0,364±0,007	0,374±0,006	>0,05	<0,01
Exc CO_2 (ml/kg)	26,0±1,4	21,0±1,5	22,6±1,0	<0,001	>0,05
O_2 debt (ml/kg)	–	1,8±63	130±7,5	–	<0,01
BRS (step/s)	3,14±0,05	–	3,2±0,03	>0,05	–

Table 2. Maximum values of physiological and motor indicators when running 3000 m at different stages of preparation in the annual cycle (preparatory - competitive periods)

Indicators	Preparatory period	Competitive period	p
t run 3000 m (min)	9.32,0±9,1	9.13,0±8,8	<0,05
VO_2max (ml/min-kg)	68,4±1,3	69,4±1,0	>0,05
VCO_2max (ml/min-kg)	69,0±1,4	76,7±1,7	<0,05
VEmax (l/min)	118,1±2,6	132,1±3,9	<0,05
O_2 debt (ml/kg)	115,2±6,4	147,9±2,3	<0,05
Exc CO_2max (ml/kg)	19,9±1,2	26,0±0,9	<0,05
RRmax (breaths/min)	60,9±2,5	63,6±2,4	<0,05
GDmax (% of vital capacity)	46,6±2,3	45,6±2,1	>0,05
HD at RRmax (% of vital capacity)	39,2±1,6	40,3±1,9	>0,05
Heart ratemax (bpm)	190,5±1,8	190,8±2,3	>0,05
O_2p (ml/stroke/kg)	0,372±0,008	0,376±0,008	<0,05
% O_2	4,9±0,07	4,81±0,13	>0,05
% CO_2	4,4±0,9	4,46±0,11	> 0,05
ChSh at max LSh	3,08±0,4	3,14±0,04	<0,05
LSh at max ChS	159,4±9,6	173,0±3,5	<0,05
HR max (step/s)	3,19±0,05	3,21±0,05	<0,05
LH max (cm)	178±3,2	178±3,5	>0,05
ChSh (average)	3,11±0,04	3,16±0,02	>0,05
DS (medium)	169,1±2,1	172±2,3	<0,05

was revealed. The data obtained indicate that changes in the stride structure to maintain increased running speed mainly follow the path of increasing the average values of SN and DS due to a longer retention of high values of SN and DS. With an increase in sports performance at a distance, VEmax significantly increases, which is primarily associated with a change in the breathing structure: an increase in RRmax and GD at RRmax. There is a significant increase in p VCO2max, Exc CO_2max and oxygen debt during the competitive period. During the annual training cycle in the preparatory and competitive periods, there are no significant differences in the level of efficiency.

In table Table 3 presents comparative data on some of the studied cardiorespiratory, metabolic and motor indicators in athletes of various levels of prepar-

Table 3. Comparative data of physiological and motor indicators during 3000 m running among athletes in the study groups

Indicators	Group A	Group B	p
t run 3000 m (min)	9.46,0±5,8	8.58,0± 6,4	<0,01
VO_2max (ml/min-kg)	67,6±1,1	70,1±1,2	<0,01
VCO_2max (ml/min-kg)	70,6±1,7	75,6±1,6	<0,01
VEmax (l/min)	126,2±3,4	123,0±4,5	>0,05
RRmax (breaths/min)	63,0 ±1,0	61,4±3,0	>0,05
GDmax (% of vital capacity)	42,7 ±1,1	48,1±2,2	<0,01
GDmax RR (% of vital capacity)	36,4 ±1,2	43,3±1,8	<0,01
Heart ratemax (bpm)	192±1,7	188,6±2,2	>0,05
% O_2max	4,87±0,1	4,84±0,1	>0,05
O2p (ml/stroke/kg)	0,365±0,006	0,383±0,009	<0,01
O_2 debt (ml/kg)	118,6±7	144,1±12,6	<0,01
Exc CO2max (ml/kg)	21,5±1,5	24,3±1,2	<0,05
HR max (step/s)	3,14±0,04	3,26±0,05	<0,05
LW max (cm)	174±2,8	182±3,5	>0,05
LH at max BH (cm)	161±3,6	172±3,9	<0,05
ChS at check DS (step/s)	3,97±0,05	3,14±0,03	<0,05

edness. The growth of most of the indicators under consideration indicates an increase in the functional capabilities of the body systems.

As athletes become more prepared, there is a tendency towards a decrease in the energy cost of running. Also, no significant changes were found in the growth of maximum external respiration performance, but there was a restructuring in the RR/GD ratio. Subjects in group B maintain approximately the same VEmax with a larger GD and a smaller RR. An increase in running speed is accompanied by an increase in SNmax and DSmax; over time, stability of the running step is noted, characterized by long-term maintenance of a high SN at DSmax and DS at CSmax.

Conclusions. Based on the fact that long-distance running is characterized by maximum mobilization of vegetative and metabolic functions, as well as the achievement of maximum levels of aerobic and anaerobic capabilities, an increase in athletic performance was identified at the studied distance (3000 m) during the preparatory-competitive period. In group B athletes, the increase in athletic performance was accompanied to a greater extent by an increase in the level of anaerobic capacity and stabilization of the running stride. An increase in most of the studied indicators indicates an increase in the functional capabilities of the body of those involved. During the study, the following pattern was revealed: with increasing fitness of athletes, energy consumption during running decreases, and the ratio of aerobic and anaerobic energy supply modes changes towards an increase in the share of the anaerobic component.

References

1. Venediktov I.N., Yarchikovskaya L.V., Mironova O.V., Sharonova A.V., Lukina S.M. Povysheniye rabotosposobnosti obuchayushchikhsya metodom reglamentirovannogo upravleniya dykhaniyem [Increasing the performance of students using the method of regulated breathing control]. Teoriya i praktika fizicheskoy kultury. 2023. No. 4. pp. 58-60.
2. Dementyev K.N., Mironova O.V., Tokareva A.V. Metodika podgotovki studentov-yunoshey k sdache norm GTO [Methodology for preparing male students to pass the GTO standards]. Fizicheskaya kultura, sport i zdorovye. 2017. No. 29. pp. 14-17.
3. Demesh V.P., Ustinova O.N., Venediktov I.N., Sergeeva A.G. Programma upravleniya protsessom begovoy podgotovki voyennosluzhashchikh i gossluzhashchikh k vypolneniyu kontrol'nykh normativov [Program for managing the process of running training of military personnel and civil servants to meet control standards]. Teoriya i praktika fizicheskoy kultury. 2021. No. 12. pp. 63-65.
4. Efimova-Komarova L.B., Efimov-Komarov V.Yu., Tokareva A.V. Fizicheskaya kultura. Praktikum po samokontrolyu [Physical Culture. Workshop on self-control]. Study guide. SPb., publ., 2016. 74 p.
5. Mironova O.V., Dementyev K.N., Grigoryev V.I., Pristav O.V. Kompleks GTO kak mobilizatsionnyy instrument kapitalizatsii chelovecheskikh resursov [The GTO complex as a mobilization tool for capitalizing human resources]. Teoriya i praktika fizicheskoy kultury. 2016. No. 9. pp. 39-42.
6. Mironova O.V., Bulavchenko K.V., Sharonova A.V., Kiprushina I.I. Programma trenirovok dlya devushek-pervokursnits, osvaivayushchikh razdel samostoyatelnoy raboty po distsipline «Fizicheskaya kultura i sport» [Training program for first-year girls mastering the section of independent work in the discipline «Physical Culture and Sports»]. Teoriya i praktika fizicheskoy kultury. 2021. No. 12. pp. 82-83.
7. Plotnikova S.S., Kovshura T.E., Sidorenko A.S., Yarchikovskaya L. V. Korrektsiya tempo-ritmovoy struktury bega na srednive distantsii studentok vuza za schet povysheniya skorostno-silovogo potentsiala [Correction of the tempo-rhythm structure of middle-distance running among university students by increasing speed-strength potential]. Teoriya i praktika fizicheskoy kultury. 2016. No. 11. pp. 60-62.
8. Tokareva A.V., Getman V.D., Efimova-Komarova L.B. Samokontrol i metody otsenki fizicheskogo i funktsionalnogo sostoyaniya studentov [Self-monitoring and methods for assessing the physical and functional state of students]. Study guide. SPbGASU, publ. SPb., 2016. 101 p.
9. Tokareva A.V., Mironova O.V., Moskalenko I.S., Yarchikovskaya L. V., Bolotin A.E. Formirovaniye navykov organizatsii samostoyatelnykh aerobnykh trenirovok u studentov vuzov dlya uspeshnykh rezultatov ekzamenatsionnoy sessii [Formation of skills for organizing independent aerobic training among university students for successful results of the examination session]. Teoriya i praktika fizicheskoy kultury. 2016. No. 9. pp. 12-15.