The impact of peak aerobic capacity on the performance of elite ski racers aged 18 to 20 in competitions at different distances

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Abstract

Objective of the study was to assess the impact of indicators of peak aerobic capacity in elite ski racers aged 18-20 on their performance in key races at different distances during the 2023-2024 ski racing season.

Methods and structure of the study. The research project encompassed 11 athletes, aged between 18 and 20, who were experts in different sports. They had achieved the rank of CMS or MS. The study focused on their maximum aerobic capacity, evaluating their overall physical performance, strength, and the efficiency of their oxidative and lactic acid energy systems.

Results and conclusions. It was discovered that the success of performances at goal-oriented events in cross-country skiing is largely determined by the extent to which the absolute and relative (related to the physical effort exerted) level of maximum oxygen consumption is developed, as well as the intensity of the lactic acid energy system's functioning, which contributes to the overall energy capacity required for muscular activity.

Keywords: *cross-country skiing, highly skilled athletes aged 18-20 years, aerobic performance, power of oxidative and lactic acid energy systems, sports results, different cross-country skiing distances, correlation relationship.*

Introduction. The results of the conducted studies [1, 2] showed that the effectiveness of competitive activity, both for adults and young athletes, significantly depends on the formation of the main energy supply systems (oxidative and lactic acid), the differentiated significance of which (in terms of contribution to the sports result) is determined by the requirements of the specifics of competitive activity [3, 4]. One of the possible areas for improving the training process is the study of correlation relationships and establishing the significance of indicators reflecting the influence of the functional capabilities of the oxidative and lactic acid energy systems on achieving a high sports result, taking into account the specifics of muscle activity [5]. In this regard, for scientifically based management of the training of highly qualified young athletes, specialists need to have information not only on the level of development of the functional capabilities of the oxidative and lactic acid energy systems, but also on the degree of relationship of the selected indicators with the sports result at various distances of cross-country skiing [6, 7].

Objective of the study was to assess the impact of indicators of peak aerobic capacity in elite ski racers aged 18-20 on their performance in key races at different distances during the 2023-2024 ski racing season.

Methods and structure of the study. The solution to the set goal was carried out on the basis of the following research methods: pedagogical; ergometric methods, ensuring the implementation of the test procedure on a running treadmill, mathematical and statistical methods [8].

A feature of the procedure for carrying out a stepwise increasing load was its implementation on a Cosmos Quasar Med running treadmill (Germany) with an initial running speed of 3,0 m/s, at an inclination angle of 1o and a duration of the loading step of 3 minutes,

the increase in load was carried out by increasing the running speed by 0,5 m/s. The choice of the testing protocol (tested when working with highly qualified athletes of national teams) ensured the step-by-step implementation of muscle activity in the range from moderate to submaximal power, ensuring an exit to the maximum level of functioning of the oxidative and lactic acid energy systems [9, 10]. During the test loads, the following indicators were recorded and calculated, which are included in the nomenclature of the 2022 Olympian model characteristics [10]: maximum running speed at failure, maximum oxygen consumption (absolute and relative value), maximum lactate concentration.

During the 2023-2024 sports season, 11 athletes of the Russian junior national cross-country skiing team aged 18 to 20 years, with qualifications from CMS to MS, were observed.

To achieve the stated goal of the study, the magnitude and direction of the correlation coefficients were considered through the nature of the relationship "selected indicator" – "goal-setting significance of the selected competition". That is why, in order to identify the influence of maximum aerobic performance on sports results, the nature of the correlation links between the functioning indicators of the oxidative (VO_{2max}, VO_{2max}/kg) and lactic acid (maxLa) energy systems and their implementation manifestation in the test load (Vmax) and the results of performances at various distances of individual sprint (qualifying races), individual races (10-20 km), skiathlon (20 km) and mass starts (10-50 km) were studied at the following stages of the 2023-2024 annual cycle: at the end of the snowless stage of the preparatory period, including the All-Russian Competitions (ARC) and the Summer Championship of Russia (Arkhangelsk Region, mid-late September), the middle and end of the competitive period, including the II All-Russian Spartakiad of the strongest athletes of Russia (VUSSR, Tyumen, February), the Championship of Russia 19-20 years old (PR19-20, Kirovo-Chepetsk, mid-to-late February), Russian Championship 21-23 years old (PR21-23, Syktyvkar, late February), Russian Championship (Championship of Russia, Arkhangelsk Region, mid-March), Russian Cup Final (FKR, Kirovsk, early April) and Russian Championship 19-20 years old (PR19-20, Monchegorsk, mid-April), the timing of which is associated with reaching the peak level (February, March) at the main starts of the season (VUSSR, PR19-20, PR21-23, Championship of Russia), as well as the LCR races (September) at the end of the snowless stage of the preparatory period and the FKR and PR19-20 years old (April) at the end of the competitive period.

Results of the study and discussion. The following recorded and calculated parameters were used for the correlation analysis: body mass (BM), running speed at work refusal in the step test (Vmax), absolute and relative values of maximum oxygen consumption (VO_{2max}, VO_{2rel}), maximum lactate concentration (maxLa) and sports results at the main starts of the season.

The dynamics of the correlation coefficients of the body mass (BM) indicator, reflecting the current state of the morphological status, is characterized by a predominantly unidirectional by the sign «+» change in the tightness of the relationship in the range from 0,092 to 0,660 (and only at the winter Russian Championships minus 0,234) in the individual sprint, multidirectional by the sign (+/-) from -0,113 to 0,647 in individual races, from -0,256 to 0,014 in the skiathlon and from -0,714 to 0,703 in the mass start. The direction of the peak level of the correlation relationship (Rtk) of the studied indicator with sports results in the individual sprint with the sign «+» falls on the FKR race in Kirovsk (Rtk = 0,610, April), with the sign «-» on the race of the winter Russian Championship in the Arkhangelsk region (Rtk = -0,234, March), in individual races with the sign «+» falls on the FKR race in Kirovsk (Rtk = 0,815, when moving in skating style, April), with the sign «-» on the race of the winter Russian Championship (and summer Russian Championship) in the Arkhangelsk region (Rtk = -0,113 and -0,140, respectively, March and September), in the skiathlon with the sign «+» falls on the race of the winter Russian Championship (Rtk = 0,014, skating style, March), with the sign «-» on the VSSSR race in Tyumen (Rtk=-0,256, February) and in the mass start with a «+» sign falls on the FKR race in Kirovsk (Rtk= 0,703, classic, April), with a «-» sign for the 50 km race in Monchegorsk of the Russian Championship for 19-20 years (Rtk=-0,714, classic, April). The presented dynamics of the correlation relationship indicates the presence of a direct (with a «+» sign) significant influence of MT on the final result in sprint races and a negative relationship with the results in distance activities, which increases with an increase in the length of the distance. The dynamics of the correlation coefficients of the integrated indicator of physical per-

formance (PP), expressed in the maximum running speed «to failure» (Vmax), reflecting the cumulative effect of the degree of formation of the energy supply systems and physical qualities, is characterized by a unidirectional change in the tightness of the relationship by the «+» sign in the range from 0,289 to 0,621 in the individual sprint, from 0,351 to 0,663 in individual races, from 0,532 to 0,805 in the skiathlon and from 0,450 to 0,855 in the mass start. The peak level of correlation relationship (Rtk) with the sign «+» in the individual sprint falls on the FKR race in Kirovsk (Rtk = 0,621, April) and the VSSSR in Tyumen (Rtk = 0,544, early February), in individual races falls on the FKR race in Kirovsk (Rtk = 0,663, when moving in the classic style and Rtk = 0,547, when moving in the skating style, April), at the Winter Russian Championships (Rtk = 0,515, when moving in the skating style), in skiathlon falls on the VSSSR race (Rtk = 0,805, early February), the Winter Russian Championships (Rtk = 0,532, March) and in mass start falls on the FKR race in Kirovsk (Rtk = 0,855, classic, April) and PR 21-23 years (Rtk=0,658, classic, March and in the 50 km race PR 19-20 years (Rtk=0,645, classic, April). The presented dynamics of the correlation relationship indicates the presence of a pronounced tendency to increase the degree of relationship of the Vmax indicator with all types of competitive activity (from sprint to marathon), reflecting the degree of stability of the basic level of PR and the length of competitive distances.

The dynamics of the correlation coefficients of the absolute value of maximum oxygen consumption (MOCabs.), reflecting the degree of development of the power of the oxidative system, is characterized by a unidirectional change in the tightness of the relationship by the «+» sign in the range from 0,446 to 0,579 in individual sprint, from 0.,417 to 0,851 in individual races, from 0,566 to 0,685 in skiathlon and from 0,555 to 0,677 in mass start. The peak level of correlation relationship (Rtk) in individual sprint is reached at the Summer Russian Championships race (Rtk=0,579, September) and the Russian Championships race (Rtk=0,551, April), in individual races it is reached at the Russian Championships race in Kirovsk (Rtk=0,851, when moving in skating style and Rtk=0,635, when moving in classical style, April), at the Winter Russian Championships (Rtk=0,604, classical style), in skiathlon it is reached at the All-Union USSR race (Rtk=0,685, early February), the Winter Russian Championships (Rtk=0,566, March) and in mass start it is reached at the Russian Championships race in Kirovsk (Rtk=0,881, classical style, April) and the 21-23 years old PR (Rtk=0,677, classic, March and in the 50 km race PR 19-20 years (Rtk=0,561, classic, April). The presented dynamics of the correlation relationship indicates the presence of a positive relationship between the power of the oxidative system (VOCabs.) and the results shown in all types of competitive activity (from sprint races to marathons), with a pronounced differentiation into distance races (in intensity, exceeding the level of the anaerobic threshold), in total indirectly indicating not only the high significance of the absolute level of VOC, but also the significance of the overall dimensions of the body, affecting the very level of the power of the oxidative system. The dynamics of the correlation coefficients of the relative value of maximum oxygen consumption (MOCrel.), associated with the degree of development of regulatory mechanisms reflecting the balance of the functional reserve of the oxidative system in relation to body weight, is characterized by a unidirectional change in the tightness of the relationship by the «+» sign in the range from 0,283 to 0,617 in individual sprint, from 0,359 to 0,561 in individual races, from 0,550 to 0,833 in skiathlon and from 0,698 to 0,905 in mass start. The peak level of correlation relationship (Rtk) in the individual sprint is reached at the Winter Russian Championships race (Rtk=0,617, March) and the All-Russian Ski Championships race (Rtk=0,530, early February), in individual races it is reached at the Winter Russian Championships race (Rtk=0,667, when moving in the classic style, March), the Russian Ski Championships race (Rtk=0,561, classic) and the Russian Ski Championships 21-23 years old (Rtk=0,556, classic, February), in skiathlon it is reached at the All-Russian Ski Championships race (Rtk=0,833, early February), the Winter Russian Championships (Rtk=0,550, March) and in mass start it is reached at the Russian Ski Championships race in Kirovsk (Rtk= 0,905, skating style, April), in the 50 km race PR 19-20 years (Rtk=0,715, classic, April) and PR 21-23 years (Rtk=0,712, classic, March). The presented dynamics of the correlation relationship indicates the presence of a strong relationship between the oxidative system power indicator (VOCrel.) and the achieved speed in races in all types of competitive activity, with a pronounced differentiation in races

that fall during the main start period (winter Russian Championship, PR21-23 and PR19-20 years), dominating at distances of the distance type, the result of which is due to the development of the formed functional reserve by physical loads.

The dynamics of the correlation coefficients of the maximum lactate concentration (maxLa in the step test), associated with the intensity of functioning and readiness for implementation activities, reflecting the functional reserve of the lactic acid system, is characterized by a unidirectional change in the tightness of the relationship by the «+» sign in the range from 0,278 to 0,472 in the individual sprint, from 0,257 to 0,684 in individual races, from 0,439 to 0,485 in the skiathlon and from 0.,359 to 0,575 in the mass start. The peak level of correlation relationship (Rtk) in individual sprint is reached at the All-Union Soviet Union races (Rtk=0,472, February) and the winter Russian Championships (Rtk=0,440, March), in individual races it is reached at the PR21-23 races (Rtk=0,684) and PR19-20 (Rtk=0,630, February), at the winter Russian Championships (Rtk=0,582, March), in skiathlon it is reached at the Winter Russian Championships race (Rtk=0,485) and the All-Union Soviet Union (Rtk=0,439, early February), and in mass start it is reached at the Russian Championships race in Kirovsk (Rtk=0,575, April) and PR21-23 (Rtk=0,525, classics, March). The presented dynamics of the correlation relationship indicates the presence of a positive (at the level of «medium» - «high») relationship between the maximum lactate concentration in all types of cross-country skiing with differentiation into races that fall during the period of the main starts (winter Russian Championship, PR19-20 and PR21-23 years), dominating at the distances of individual races and in the mass start, not exceeding the duration of muscle activity of the «large zone of relative power», which places increased demands on the power capabilities of the oxidative and lactic acid energy systems and, as a consequence of this, going above the level of the anaerobic threshold.

Conclusions. The results of the correlation analysis of the studied indicators of maximum aerobic performance and results at the main starts of the 2023-2024 sports season made it possible to establish that the effectiveness of performances at goal-oriented starts (PR19-20, PR21-23, winter Russian Championship) at various distances of cross-country skiing turned out to be significantly dependent on the degree of formation of the absolute and relative (associated with the development of body weight through physical activity) level of maximum oxygen consumption and the intensity of the functioning of the lactic acid energy system, which form the total energy potential, which is a key mechanism for the formation of the functional potential involved in ensuring muscle activity. The obtained results allowed us to establish the following patterns of manifestation of maximum aerobic performance indicators depending on the specifics of the competitive activity of 18-20 year old cross-country skiers:

- in individual sprint, the success of the performance is determined by a high level of development of the power capabilities of the oxidative (VO_{2max}, VO_{2max}/kg) and lactic acid (maxLa) energy systems, with a stable tendency for the final result to depend on the overall dimensions of the athletes' bodies;

- in individual races, the success of the performance is determined by an increased importance of the balance of overall dimensions of the body with the development of the power capabilities of the oxidative (VO_{2max}) and lactic acid (maxLa) energy systems, with a continuing tendency for the final result to depend, as in sprint races, on the overall dimensions of the body (ODB), which affect the formation of the total energy potential;

- in skiathlon, the success of the performance is determined by a high level of balance between the overall dimensions of the body with the development of the power capabilities of the oxidative system (absolute and relative levels of VO_{2max}), with a decreasing significance of the lactic acid system (maxLa) and a pronounced (in relation to individual races) tendency of the final result to depend on the formation of integrative indicators (Vmax) reflecting the level of development of regulatory mechanisms; - in mass start (race with a mass start), the success of the performance is determined by a high level of balance between the overall dimensions of the body with the development of the power capabilities of the oxidative (relative level of VO_{2max}) with a decreasing significance of the absolute level of VO_{2max} and lactic acid (maxLa) energy systems, with a pronounced (even more so in relation to the previously considered races) tendency of dependence on the formation of integrative indicators reflecting the level of development of regulatory mechanisms with a dominant level of the oxidative system (VO_{2max} value reduced to MT).

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