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Original Article

Realization the functional preparedness of the ski athletes under the model conditions of competitive distance

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Abstract
The research is devoted to the definition of functional preparedness of the skiracers in conditions of a laboratory testing and its realization in the conditions that simulate competitively. The purpose of the researchwas to determine the requirements for the functional capacity of the body of the qualified skiracers forachieving a significant sports success. Special working capacity of the ski athletes depends on the level of aerobic and anaerobic power supply capabilities, which together provide the total energy output for overcoming various particles of competitive distance.Special conditions of competitive activity, which must be brought during the planning of the tools and methods of preparation is the presence of climbing of different lengths and steepness.The study showed that the most important component of the sports result in the ski race is the effectiveness of running ski slopes of different lengths and complexity. In the followed conditions, despite the fact that aerobic metabolism in the ski races is the main energy source, however, on an ascent of a certain length and steepness, anaerobic processes prevail which determine the competitive result of a ski athlete.
Key words: ski races, functional capability, breathing, blood circulation, aerobic energy supply, maximum oxygen consumption, glycolysis.

Introduction

Skiing is one of the main kinds of Winter Olympic Games, that determines the high popularity of this sport in the world.At the same time, the gradual growth of sports results, the emergence of new competing disciplines require a constant search for new theoretical and strategical approaches to the system of training high-qualified athletes. It is known that the manifestation of the individual capabilities of athletes in the ski races depends on the level of functional preparedness of athletes, which is conditioned by special conditions of competitive activity, which must be brought during the planning of the tools and methods for their preparation.

Leading ski scientists such asT.I. Ramenska(2002); A.H. Batalov (2002) etalnote that in order to increase the systematic and purposeful functional training of the ski athletes it is necessary to consider, first of all, the metric and time parameters of the competitive loads on various components of relief of distances laid on difficultly crossed terrain.With the growth of the sports and qualifying level of training, ski athletes gradually move to more difficult terrain tracks. Describing the parameters of the complexity of tracks, most authors rightly attribute to the steepness and length of climb, the sum of height differences, the complexity and harmony of the track(Hoffmann M., Clifford P., Gaskills E.,*Garret W.,Kirkendall D, 2000;* A. H. Batalov, 2002; Potor V., Cretu M., Buftea V., Ulareanu M.V., 2018).

In the ski races, climbing is an element of the track, where even a slight advantage can significantly improve the competitive result. The total length of the climb reaches 50% of the length of the distance and to overcome them, athletes spend 43-51% of all race time.Therefore, the most important component of the sports result in ski races is the effectiveness of running ski slopes of varying lengths and complexity, and although aerobic metabolism during the ski races is the main source of energy, however, the anaerobic processes that determine the competitive result are fully manifested in the rise of a certain length and steepness of the ski athlete (Allen E.,JohnB., 2005; RamenskyaT.I., Geraskin K.M., 2009; Kropta R., Hruzevych I., Bohuslavska V., Galan Y., Nakonechnyi I., Pityn M., 2017).

All climbing on the ski tracks overcome with the maximum possible speed depending on the nature of the energy supply of the body of the ski athletes.Conditional liftings are divided into three groups, therearefollowed: short ones that skiathletes overcome per 18-20 sec, the average that skiathletes overcome per 60-70 sec and long,

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that skiathletes overcome per 150-180 s. According to the time of overcoming and steepness, the energy requirement of the athlete's muscles changes followed: on short ups, the energy demand is mainly provided by the creatine phosphate mechanism of adenosine triphosphoric (ATP) acid resynthesis. For medium lifting, the leading source of ATP resynthesis is glycolysis. On the long, the role of aerobic energy recovery sources is greatly enhanced. At the same time, the total time spent on overcoming these climbs when passing distances are different (M. Hoffmann, P. Clifford, S. E. Gaskill, 2000; T. I. Ramenska, 2002; A. H. Batalov, 2002).

The urgency of the study is due to the search for reserves of improving the performance of competitive activities of ski athletes in this direction, which largely depend on the functional capabilities of the athlete in overcoming the climb of varying complexity.

Purpose of the research

The research is devoted to the definition of requirements for the functional capacity of the body of the qualified ski athletes for its further effective implementation in training and competitive conditions.

Materials & Methods

Participants

20 skiathletes (10 females and 10 males), aged 21-34, with the following qualifications participated in the research, there are: International Class Master of Sport (next – ICMS) –1 person, Master of Sport(next – MS) – 5 persons, Candidate to the Master of Sport (next – CMS) – 14 persons.

Instruments/Procedure

In the laboratory conditions, the research of the characteristics of the reaction of the cardiopulmonary bypass system was carried out using a test with a stepwise increase in load.In the examination of athletes, a specialized ergometer with an enlarged area of the canvas was used, which allows moving on the free-style ski athlete (Fig. 1a), «MetaMax 3B» gas analyzer and «Lactate Scout» lactate meter. The program of laboratory testing included running on skiers to failure with the following characteristics: initial speed was 2,5 $m \cdot sec^{-1}$ (9 $km \cdot h^{-1}$), outlet angle of the canvas was 0º; increasing in the work capacity was achieved by increasing the angle of the canvas track on 1º every 4 minutes of the running.The tests were conducted twice:the first one performedat the beginning (July) andthe second one performed at the end (September) of the special preparatory period.

At the testing of athletes in the conditions of the ski track "Tysovets" (Fig. 1b) athletes overcame a distance of 6 km with a separate start, they are performed: two circles of 3 km. The route included 5 climbs per kilometer, the total ratio of climbing, descending and equal areas was 1: 1: 0.5, respectively.For registration of the indicators, the GPS-navigation system of the telemetric registrar "Polar RS800" ("Polar", Finland) was used, which allowed recording the speed of the athlete's movement and the parameters of the profile of the track (by changing the altitude).On the basis of these indicators were obtained a profile of the track, the speed of the athlete at different distances, the working power.The research of the reaction of the cardiopulmonary bypass system was carried out by «MetaMax 3B» gas analyzer, «Polar RS800» heart rate monitor and «Lactate Scout» lactate meter.

a)

b)

Fig. 1. Research of the characteristics of the reaction of the cardiorespiratory system of ski athletes to special physical activity: running on the ski rollers in the testing conditions (a) and in the conditions that simulate competitive (b)
(pictures performed by authors)

Statistical analysis

To analyze the totality of empirical data at different stages of the studying,we have used methods of mathematical statistics (descriptive statistics, sampling method, non-parametric Wilcoxon criterion, Brave-Pearson correlation analysis, factor,and multiple regression analysis). Material systematization and primary mathematical processing were performed using Statistica 7.0 Integrated Statistical and Graphics Packages (StatSoft Inc., USA, 2007) and Excell 2007 tables editor (Microsoft, USA).

Results

Men who specialize in ski racing and qualify as the CMS, in the test with a stepwise-increasing load, the average power of work (P) was288,2±9,17W(here and next – $\bar{x}\pm\sigma$)during the running with the frequency of movements57,33±8 steps per minute, in the MS and ICMS these indicators were significantly higher: power – 300,7±1,3 W, the frequency was 64,11±1,35 steps per minute. The volumeofbreathperminute (VBM) duringthe working in the CMS has reached 160,1±22,4 $l\cdot min^{-1}$ (MS, ICMS – 187,2±4,2 $l\cdot min^{-1}$), with an increase in breathing frequency up to 55,3±6,9 breathe $cycle\cdot min^{-1}$ (MS, ICMS– 58,1±1,65 breathe $cycle\cdot min^{-1}$) and respiratory volume 2,9±0,3 l (MS, ICMS – 3,5±0,27 l). An assessment of the integral performance of thequalifiedmale ski athletes showed the following values: VO_{2max}– 68,8±5,9$ml\cdot min^{-1}\cdot kg^{-1}$ (MS, ICMS– 75,9±1,7 $ml\cdot min^{-1}\cdot kg^{-1}$), maximum concentration of lactate at the third minute of recovering14,4±4,3 $mmol\cdot l^{-1}$ (MS, ICMS–20,9±1,1 $mmol\cdot l^{-1}$), RQ_{max} – 1,1±0,1 (MS, ICMS– 1,3±0,1).

In women, during the performance of the work registered the following results: in the CMS power of the running was 209,2±16,9 W (MS, ICMS– 236,7±2,1 W), an indicator of tempo was 53,5±6,61 (MS, ICMS– 60,0±1,3) steps per minute. IntheCMSVBMindicatorincreasesto 109,9±12,3 $l\cdot min^{-1}$ (MS, ICMSitwasto134,2±3,0$l\cdot min^{-1}$) at the frequency of breathing 55,4±7,4 breathe $cycles\cdot min^{-1}$ (MS, ICMS– 62,0±1,12 breathe $cycles\cdot min^{-1}$) and respiratory volume 2,0±0,2 l (MS, ICMS– 2,9±0,23 l). VO_2maxattheathletesreached 55,6±5,8 $ml\cdot min^{-1}\cdot kg^{-1}$ (MS, ICMS –65,1±1,3 $ml\cdot min^{-1}\cdot kg^{-1}$), the maximum concentration of lactate at the third minute of recovery, respectively was11,3±3,4 $mmol\cdot l^{-1}$and 16,5±2,8 $mmol\cdot l^{-1}$, HR_{max}– 190,9±11,4 $beats\cdot min^{-1}$ (MS, ICMS– 205,0±2,0 $beats\cdot min^{-1}$), RQ_{max}indicator was 1,1±0,1 (MS, ICMS– 1,2±0,1). Indicators of the concentration of lactate at the levelaerobik threshold (AT_1)in the CMS was2,82±0,50 $mmol\cdot l^{-1}$, at the levelanaerobik threshold (AT_2)same indicator was 4,95±1,45 $mmol\cdot l^{-1}$ (MS, ICMS– 5,71±0,12 $mmol\cdot l^{-1}$).

The obtained results indicate that for athletes who specialize in ski races, a high level of development and implementation of both aerobic and anaerobic mechanisms of energy supply of muscular activity is characteristic, optimization of activity of the cardiopulmonary system.

In the frameworks of the preparatory period, the indicators of functional preparedness received a certain transformation.It was determined to increase the maximum working capacity in the group of females by 6%, in the group of males it was by 11%, the power AT_2in the group of females by 13 %, %, in the group of males it was by 19 %. MaximumVBMincreased by 18% for females, by 5% for males, at the level AT_2same indicator increased responsibly by 25 %and8 %. VO_{2max}in the group of females increased by 12%, and in males group the same indicator increased by 4%, at the levelAT_2same indicator increased responsibly by19 %and 12 %.

During the testing of the implementation of functional capabilities, at the beginning of the preparatory period for the females, the maximum capacity of the work was 383.7 ± 3.2 W, at the end of the preparatory period same indicator was 402.6 ± 7.5 W (as well as it increased by 4.9%).For high-qualifiedfemaleskiathletes, the following values are recorded: VBM – 140,5±17,4 $l\cdot min^{-1}$; VO_2max 4,2±0,3 $l\cdot min^{-1}$ (66,8±5, $ml\cdot min^{-1}\cdot kg^{-1}$); excretion ofthe$CO_2$ – 3,8±0,3 $l\cdot min^{-1}$; respiratory factor was0,9±0,1 c.u.; HR – 195,3±5,3 $beats\cdot min^{-1}$; oxygen pulse was 24,08±8,7 ml $O_2\cdot 1\cdot min^{-1}$.

Males-athletes have the following results:VBM– 190,7±21,3$l\cdot min^{-1}$; VO_2max 5,4±0,6 $l\cdot min^{-1}$; excretion ofthe CO_2 – 5,8±0,7 $l\cdot min^{-1}$; respiratory factor– 1,0±0,1 c.u.; HR – 195,0±5,1 $beats\cdot min^{-1}$; oxygen pulse was27,7±9,6 ml $O_2\cdot 1\cdot min^{-1}$.

Analyzing the data of the performed studies conducted in the field, it can be confirmed that the characteristics of anaerobic productivity of the body of the ski athletes vary in line with the relief of the route (Fig. 3).It was established that the passage with the maximum speed of both main and short ups causes a significant increase in anaerobic body metabolism of athletes. This is evidenced by high values of the ExcCO_2 indicators,especially on the main ascents.

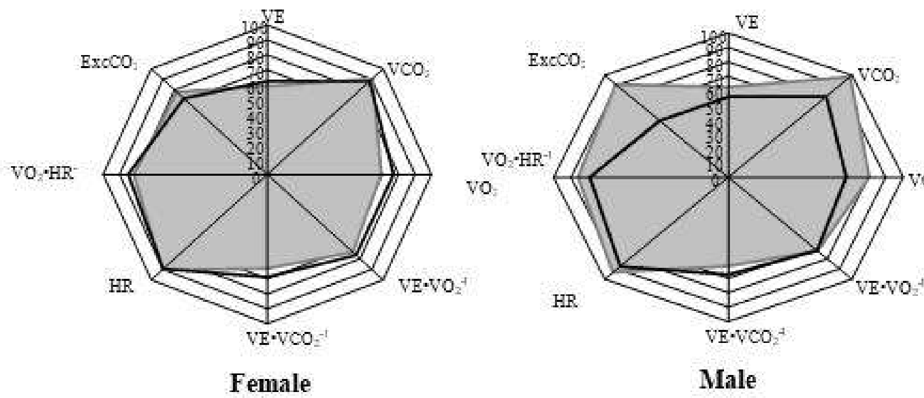

Fig. 3.The voltage level of functional indicators of the skiathletesduring the passing climbing of different steepness:

short lift; main lift.

In the group of thefemales, the speed of overcoming major upsurges by 23% was lower than when passing short ups. Accordingly, the power of the work was less than 13%. Functional parameters were generally higher in overcoming major heights, therearefollowed: the respiratory rate increased by 7,38 %, VBM increased by 5,87 %, VO_2increased by 3,24 %, excretion ofthe CO_2increased by12 %, respiratory factorincreased by 9,4 %, ventilation equivalent for O_2increased by2,65 %, HR increased by 3,45 %, oxygen pulse by the 2,64 %. Ventilation equivalent for CO_2decreased by 7,23 %.

Men overcame the main heights by 16% slower than short, respectively, and the power of work was less by 8.6%. During theovercoming of the main lifts, unlike short, higher were: the frequency of breathing on 3,56 %, VBM on 0,26 %, VO_2on 4,76 %, excretion ofthe CO_2on 10,65 %, oxygen pulse on 5,12 %, HR on 3,95 %, oxygen pulse on 1,45 %. IncreasingoftheO$_2$increase consumption excretion oftheCO$_2$compared toVBMindicating an increasing of the efficiency of the respiratory system during the overcoming the main lift, which also confirms by the decreasing ofthe ventilation equivalent for O_2on 6 % and ventilation equivalent for CO_2on 11,78 %.

It is noteworthy that the females and males ski athletes with a general similarity of the physiological reactions during the overcoming the climb of different steepness, there are also distinctive differences. Males have higher rates than females, an increasing percentage ExcCO$_2$on the main lift (92% and 80% respectively).

If females have a percentage increase oftheVCO$_2$indicator regardless of the steepness of the climb is almost unchanged, then in men, it was higher on the main rise (100% and 82% respectively). That is, the share of anaerobic energy supply in them was greater.

To determine the bioenergy peculiarities of the implementation of the special ability of the qualified ski athletes, a factor analysis of the results was conducted.It was found out that the level of functioning of the cardiorespiratory system of the qualified ski athletes is determined, first of all, by aerobic capacity, possibilities of the apparatus of respiration and blood circulation. So, the absolute and specific indicators of oxygen consumption had the greatest significance ($r = 0,96$; $p<0,05$) and the limit values of the power of work ($r=0,73$; $p<0,05$).

Thus, it can be argued that the manifestation of mechanisms for the implementation of aerobic productivity is associated with speed ofVO$_2$ ($r = 0,96$; $p<0,05$) and the formation and excretion from the the body of theCO$_2$ (VCO_2) – $r=0,79$; $p<0,05$, an appropriate relationship was observed with the respiratory rate ($r=0,98$; $p<0,05$) and $ExcCO_2$ ($r=0,96$; $p<0,05$). That is, the achievement of a high level of performance inskiing is impossible without the implementation of anaerobic possibilities.

It was established that during the overcoming of the competitive distance by the skiathletes, the main source of energy production is aerobic possibilities, the level of implementation of which in the course of work can reach 92-95% of maximum values. At the same time, it was discovered that an important role in the energy supply of the body of ski athletes belonged to anaerobic sources, whose contributions during the overcoming of climbs reached 80%. During the evaluating of the capabilities of the qualified ski athletes at the beginning and at the end of the preparatory period, it was determined that indicator of theVO$_2$on heights increased by 2.8%, and excretion of theCO$_2$(VCO_2)increased by3,5 %, on short lifting the excretion of theCO$_2$decreased by 1,8 %. The highest increasing in the contribution of anaerobic mechanisms to the energy supply of the organism was determined on the main upsurge, as evidenced by the significance VCO$_2$and the excess of excretedCO$_2$ ($ExcCO_2$).

Discussion

The experimental data obtained about the influence of the complexity of the ski tracks on the manifestation of the functional preparedness of the qualified ski racers in the conditions of their training activities have determined the expediency of conducting special studies to identify the effectiveness of modeling their functional preparednessbringing the conditions of competitive activity.

The conducted researches allow asserting, that both aerobic and anaerobic processes of an organism of ski athletes change according to relief of a track. During the overcoming of ascents, anaerobic processes predominate, the intensity of which decreases on descents.The proposed approach to the analysis of the relief of the tracks can diagnose the functional capabilities of the athlete'sbody, to streamline the process of preparation for competitive activities, to closely link it with the structure of athletes' preparedness.

The results of our research supplement the theoretical positions, improving the functional preparedness of ski athletes at different distances (A.H. Batalov, 2002; RamenskyaT.I., Geraskin K.M., 2009; Khmelnytska J.K., 2016). Thus, it is substantiated that the aerobic mechanism of energy supply is the main concern during the ski races, but with the increase in the work capacity, in particular, during the overcoming the climb, the contribution of an anaerobic mechanism increases. The information about the features of the functional reaction of the body of ski athleteson distances and uplifts of varying complexity is supplemented. (Kropta R., Hruzevych I., Bohuslavska V., Galan Y., Nakonechnyi I., Pityn M., 2017; Khmelnytska J.K., 2016) the reasons for their improvement are shown in thus work. Thus, it can be noted that both aerobic and anaerobic processes of the body of ski athletes vary according to the relief of the track. During the overcoming of ascents, anaerobic processes predominate, the intensity of which decreases on descents.

The obtained results confirm the data about the regularities of the process of adaptation of the organism during the annual cycle of training and development of the functional capabilities of skiathletes, provided that the level reached the transition from the preparatory to the special work (Salnykova S., Hruzevych I., Bohuslavska V., Nakonechnyi I., Kyselytsia O., Pityn M., 2017; Potor V., Cretu M., Buftea V., Ulareanu M.V., 2018**),**as well as the structure of special functional preparedness and the role of its components in the development of special endurance (T.I. Ramenska, 2002;J.K.Khmelnytska, 2016).

Conclusions

The structure of the special ability of qualified skiathletes largely depends on the capabilities of the functioning of the cardiorespiratory system, which largely determines the nature of the implementation of energy processes in the passage of the ski tracks of varying complexity, ie a certain ratio of contribution aerobic and anaerobic sources of energy supply, depending on the characteristics of competitive activities.

In plain areas, the current energy exchange of the ski athletes is provided mainly by aerobic sources, as evidenced by the maximum values VO_2max, compensation for acidosis with a relative echoing of the cardiorespiratory system (ventilation equivalent for O_2reaches maximum values). During the passing the main and short ups in the body of athletes most used anaerobic sources of energy formation (their contribution increases to 80%).

The high level of functional preparedness of ski athletes is characterized by a significant increase in the value of powerAT_2 (intheskiathletesofCMSlevelitwas 288,20±9,17 W, in MSandICMS – 300,70±1,30W), higher concentration of lactate in the blood (as the 14,40±1,43 і 20,90±1,10mmol·l^{-1}accordingly) and elevated oxygen pulse (as the 21,81±1,19 і 28,60±1,40мл O_2·1·min^{-1}).

Implementation of the functional potential of the body of the male-athletes in conditions that simulate overcoming the competitive distance, characterized by an increasing of the pulmonary ventilation to 190,7±21,3 l·min^{-1}; consumption of the O_2 – to 5,4±0,6 l·min^{-1}; excretion of the CO_2 – to 5,8±0,7 l·min^{-1}; respiratory factor - to1,0±0,1c.u .; HR – to 195,0±5,1 beats·min^{-1}; oxygen pulse - to 27,7±9,6 млO_2·1·min^{-1}.Functional capabilities of the body of the qualified female ski athletesduring the process of modeling the passing of the competitive distance are characterized by the achievements of pulmonary ventilation to140,5±17,4 l·min^{-1}; consumption of the O_2 – to 3,8±0,3 l·min^{-1} (66,8±5,1 ml·min^{-1}·kg^{-1}); excretion of the CO_2 – to 4,2±0,3 l·min^{-1}; respiratory factor - to0,9±0,1 c.u.; HR – to 195,3±5,3 beats·min^{-1}; oxygen pulse - to 24,08±8,76 мл O_2·1·min^{-1}.

Modeling of the functional capabilities of the ski athletes' body in the process of their preparation for responsible competitions has allowed to develop practical recommendations for the management of the training process, depending on the complexity of the relief of the route and the specifics of the conditions of the competitions.

Conflicts of interest – If the authors have any conflicts of interest to declare.

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