Metrics for comprehensive monitoring that assess the performance of cross-country skiers in sprint races

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Abstract

Objective of the study was to assess the usefulness of step-by-step integrated monitoring metrics in forecasting performance in ski sprints, using the outcomes of the Russian Cup 2023-2024 as a case study.

Methods and structure of the study. The research employed a comprehensive approach, incorporating the analysis of scientific literature, pedagogical assessments, biomedical techniques, and statistical methods. The research was conducted using Python 3.10 in the Google Colab environment, with the aid of regression analysis and the least squares method. The analysis was performed using standard Microsoft Office Excel software.

Results and conclusions. It is revealed that the results of the stage-by-stage integrated control are informative for predicting the performance of cross-country skiers in the winter season. A regression model of the rating points of female athletes in the winter season sprint races has been developed. It was determined that the time to overcome the fourth and fifth test laps of the field test on ski scooters, the time of work on the ski ergometer before the threshold of anaerobic metabolism (PANO), the relative power of work at the last stage of the test on the ski ergometer, the stress level during the response of the glycolytic motor units of the right hand in a state of relative rest limit the performance of athletes in sprinting ski season races.

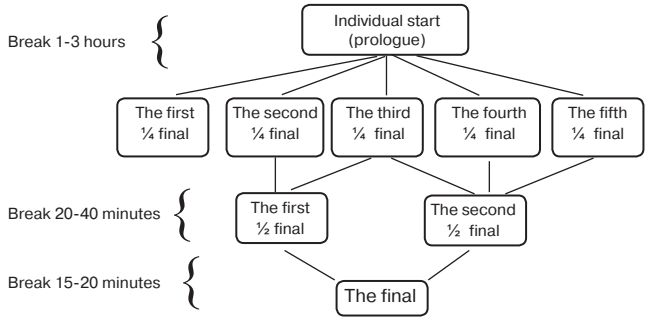
Keywords: *cross-country skiers, preparatory period, field testing, laboratory testing, forecasting, sports performance, regression model, RCCSF rating points, sprint races.*

Introduction. The scientific basis for planning and managing sports activities is forecasting sports performance [2, 3]. The athlete's potential is assessed taking into account current results and their dynamics at the stages of the preparatory and competitive periods.

The sprint race is a separate discipline in the competitive program of female skiers. According to the regulations of the Russian Cross-Country Skiing Federation on rating points, sprint races have a separate rating score. A special feature of the cross-country skiing sprint is the need for the six most successful female skiers to overcome four high-intensity runs. The runs are performed on the same track for ~3-4 hours, with each run lasting ~3 minutes.

The athlete initially participates in an individual time trial (prologue); then the 30 best skiers advance to the quarterfinals (1/4 finals). Unlike the prologue, ¼, ½ and finals are held in the form of elimination runs. The two fastest skiers from each final advance to the next round, with two additional «lucky losers» spots going to the next two skiers (see figure). The duration between rounds in sprint disciplines varies in time (from 15 to 40 minutes), which is shorter than in other cyclic sports [6].

Previously conducted studies reflected the specifics of athlete training methods, tactics for completing «sprints» [7]; the relationship between athlete testing results and FIS points for summer races, with various indicators of competitive activity (time to cover the distance, to overcome individual sections of the distance, speed in the race, athlete's place in the final protocol, etc.) [8]. But the question of which of the indicators of the stage complex control (SCC) limit competitive performance remains insufficiently studied.



Scheme of the sprint discipline in cross-country skiing

Objective of the study was to determine the information content of the indicators of stage-by-stage complex control for predicting performance in ski sprint (using the results of the 2023-2024 Russian Cup as an example).

Methods and structure of the study. The research work was carried out as part of the state work («conducting scientific research») for scientific organizations and higher education institutions subordinate to the Ministry of Sports of the Russian Federation. 30 female cross-country skiers participated in the 2023-2024 season, the age of the athletes was from 19 to 28 years, the qualification of CMS; MS. The staged comprehensive control in the preparatory period was carried out at the training base «Pearl of Siberia» in Tyumen. Field testing on roller skis was carried out according to the standard protocol [4]. In laboratory conditions, the state of the neuromuscular apparatus was assessed using the Chronax-7 device, which allows assessing the latent time of evoked contraction (LTEVC) and the magnitude of the response voltage of motor units (MU) of the muscles of the lower and upper limbs of female athletes [1]. Using a step-increasing load on the Concept2 SkiErg ski ergometer, the strength and aerobic abilities of the shoulder girdle of the athletes were assessed according to the standard testing protocol [5].

Mathematical processing of the research results (132 indicators registered during IVF) was carried out using the Python 3.10 programming language in the Google Colab environment. Regression analysis and the least squares method were used to develop a formula for calculating sprint performance. The Microsoft Office Excel program package was used to calculate the results of field testing for each athlete.

Results of the study and discussion. Competitive performance in sprint races was considered not from the point of view of calculating the actual result of overcoming the race (minutes, seconds, speed), but from the point of view of receiving RCCSF rating points. In our opinion, the position of assessing competitive activity based on rating points is relevant and is of sporting interest to the coaching staff. The athlete receives rating points for her place in the final protocol of each race1. This excludes factors that can significantly affect the time indicator of the race result, but cannot be taken into account when developing a formula predicting the result: sliding conditions, wind strength and direction, humidity, solar activity, quality of snow cover, starting position of the athlete, etc.

132 indicators of the results of the IVF of the preparatory period of ski racers were studied (70 – field test; 62 – laboratory tests). A regression equation was formed to predict the performance. The variables in the equation include the results of the field test on roller skis (2 indicators) and laboratory tests IVF programs (2 indicators) limiting the effectiveness of women's «sprints» in the winter period. The equation for calculating the performance of female cross-country skiers in sprint races during the winter season is as follows:

Sprint points = $591{,}7588-1{,}217205x_1-0{,}033552x_2+3{,}540806x_3-0{,}020716x_4-2{,}470153x_5$,

X_1 – time to complete the fourth test lap in the field test; sec; X_2 – time to complete the fifth test lap in the field test, sec; X_3 – relative work power at the last stage of the step-increasing load on the Concept2 SkiErg ski ergometer, W/kg; X_4 – time spent by the athlete in the step-increasing load on the Concept2 SkiErg ski ergometer until she reaches the individual TAN level, sec; X_5 – tension level at the LTEVC of glycolytic motor units of the right hand in a state of relative rest, before the competitive load, V.

The constants (positive and negative) presented in the equation confirm the logic of using the IVF results in the preparatory period to predict performance in the ski season. Let us consider their practical significance: variable X_1 – with an increase in the time to complete the fourth lap of the field test, the rating points in the race will decrease. On the fourth lap, the athletes reached the TAN level. The higher the lactate threshold, the longer the athlete can work at high intensity. In cross-country skiing sprint races, athletes

[1]Regulations on the rating of Russian ski racers: official website. 2023. Available at: https://flgr-results.ru/attachment/rules/season23-24/Положение_о_рейтинге_сезона_2023-2024.pdf (date of access: 12.08.2024). [Text: electronic].

must demonstrate maximum speed in each of the finals. Variable X_2 - if the time on the fifth lap of the field test increases, the rating points will decrease. The athletes covered this lap in the anaerobic-glycolytic intensity zone. Skiers cover the sprint distance in the race in 2,5-4 minutes, which corresponds to submaximal power work, i.e. the anaerobic-glycolytic energy supply mode, which gives more energy per unit of time than the aerobic one. Variable X_3 - the more steps the athlete completed in the ski ergometer test, the higher the relative power at the last step, which, in turn, will affect the final place in the race. Variable X_4 – the longer it takes the athlete to reach the TAN level, the worse the performance in sprint. Variable X5 – an increase in the threshold of response to the electrical stimulus of fast motor units of the right hand before the load will affect the place in the final protocol, which will be lower. The leading hand during free movement in most skiers is the right [1]. With an optimal state of muscle tone of the upper limbs, athletes in sprint races will be able to realize a greater potential when performing acceleration.

C**onclusions.** The developed regression model of the equation contains constants and variables of the results of field and laboratory testing of the IVF preparatory period, reflecting the physical and functional fitness of female skiers. The indicators limiting the rating points in sprint races are: the time to overcome the test circles of the field test, the time before the onset of the TAN, the relative power of the last (maximum possible) step on the ski ergometer and the level of tension of the response of glycolytic motor units of the right hand. For effective management and correction of the training process, it is worth considering the dynamics of change in the identified indicators, as limiting the final result in sprint races.

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