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Original Article

Combined program for young skiers' special endurance development during the preparatory period of the annual macrocycle

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Abstract:
To increase young ski racers' sports skills, it is necessary to enhance the functional reserves of their cardiovascular system, their physical performance and special endurance, which is important for sports activities. *Research aim* is to test an improved training program for enhancing of ski racers' aged 15-16 physical performance, special endurance and functional reserves of the body. *Research materials and methods*. 24 young men (juniors) aged 15-16 took part in the research project. They were engaged in the «ski racing» group of sports improvement on the basis of the sports school in the Altai region (Russia) 4 times a week for 2 hours. Two groups of young men were examined: control (CG) and experimental (EG). The high-stakes testing of special endurance, physical performance and tolerance of the cardiovascular system to physical activity was carried out at the beginning of the preparatory period of the annual macrocycle and after the end of each training stage: stage I (May-June), stage II (July- September) and stage III (October-December). In both groups, the training program of the federal standard for this sport was used. In EG, training was carried out mainly by a variable method, at the third stage loads with high intensity (3-4 intensity zones) were performed, unlike in CG, where a uniform method was used and loads at the third stage were carried out in 1 and 2 intensity zones. *Research results*. The high-stakes testing results indicate a significantly high increase in the indicators of skiers-racers of EG group physical performance, special endurance and activity of the cardiovascular system, compared with the CG skiers' indicators. *Conclusions.* The program proposed by us to improve ski racers' aged 15-16 special endurance and functional capabilities of the cardiovascular system has shown its effectiveness.
Key Words*:* **cross-country skiing, special endurance, training program, physical activity**

Introduction

The popularity of skiing among the population in various countries is explained by the possibility and accessibility of improving one's physical health and using this active means of recreation to harden the body. Skiing is a means of sports improvement of a person, taking into account its Olympic significance (Kropta et al., 2020). Sports coaches and scientists are faced with the task of finding new and effective methods for optimizing the training process and improving ski training (Agishev et al., 2016). The complexity of the rules and conditions of conduct, the emergence of new kinds of sports racing requires improving sports qualification of skiers' training (Kamaev et al., 2020), the modernization programs of general and special physical training education (Ramenskya, & Geraskin, 2009; Bakhareva et al., 2019).

Research materials are presented in scientific literature sources, which offer various methods and means, the volume and intensity of training loads. To improve athletic fitness and functional one, programs are recommended to improve the efficiency of passing ski trails with different length and complexity of terrain (Ramenskaya, & Geraskin, 2009; Kropta et al., 2017). Experts in the field of cross-country skiing believe that the main source of energy in cross-country skiing is aerobic metabolism (Losnegard, 2019; Andersson et al., 2020). However, during the passage of long steep ascents of the ski distance, this role is performed by the anaerobic mechanism of energy production in the athlete (Khmelnytska, 2016), the level of which decreases during the descent from the mountain. Knowledge of these peculiarities of the skier's metabolism allowed Kropta et al., (2020) to develop practical recommendations for managing the training process depending on the specifics of the terrain at the competition venue.

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There are reports in the literature where performing physical work of a predominantly anaerobic orientation leads to a decrease in the aerobic abilities of the athlete's body. In an annual macrocycle with an increased volume of training with an aerobic type of metabolism, the anaerobic capacity of the athlete's body decreases (Golovachev et al., 2019; Gussakov et al., 2020). Therefore, it seems relevant to search for such training methods, where optimal ratios of volumes of high aerobic and anaerobic work are created. There are scientific papers where the regime of aerobic and anaerobic performance formation is recommended for adult racers at various segments of the ski distance (Losnegard, 2019; Andersson et al., 2020). It is of scientific and practical interest to study the use of variations in the volume of aerobic and anaerobic work at different stages of the preparatory period in the annual macrocycle for young athletes. Information about the study of this issue is limited.

There are scientific papers on the use of training methods to increase ski racers' strength and speed-strength qualities (Kotliar, & Moiseenko, 2017; Kamaev et al., 2020). High-intensity interval training (HIIT) is an effective means to increase an athlete's strength abilities and cardiovascular system reserves (Feito et al., 2018). The effectiveness of highly qualified skiers' training method based on anaerobic glycolysis development is reported by Bakhareva et al. (2021). Special endurance characterizes an athlete's ability to effectively perform work for a long time, is the most significant motor quality in cross-country skiing (Losnegard, 2019; Nakai, 2021) and is interrelated with the quality of the athlete's cardiorespiratory system (Kropta et al., 2020).

In scientific sources (Sheridan et al., 2021; Wong et al., 2021) there is contradictory information about ski racers' special endurance and physical performance development. Landgraff et al. (2021), suggest that the increase in young men's absolute aerobic performance occurs at the age of 13-14. Tomkinson (2011) indicates an age of 15-16. There are different opinions about the use of a combination of loads with different intensities in a training macrocycle increasing ski racers' functional fitness (Losnegard, 2019; Nordhoff, Logdal, 2020). We consider the topic of our research project relevant, because the use of our program in the preparatory period of the annual training macrocycle will increase young ski racers' physical performance, special endurance and ensure the enhance of their sports skills.

Research aim is to test an improved training program for enhancing of ski racers' aged 15-16 physical performance, special endurance and functional reserves of the body.

Material & methods

The research pedagogical project involved 24 young men aged 15-16 (15.4±1.4), who had 1-2 sports degree and 4 times a week for 2 hours engaged in cross-country skiing in the sports improvement group on the basis of the sports school in the Altai region (Russia). Parents' consent to the children's participation in the experiment was obtained. The conducted experiment does not violate the rules and principles of scientific research, which are defined by the Helsinki Declaration of 2008.

Two observation groups were formed: control (CG, n=12) and experimental (EG, n=12). In order to determine the effectiveness of the training process in young men of both groups, a high-stakes test of special endurance, physical fitness and tolerance of the cardiovascular system to physical activity was conducted at the beginning of the preparatory period and after the end of each training stage: stage I (May-June), stage II (July-September), stage III (October-December).

At all three stages of the preparatory period, the dynamics of the athletes' cardiovascular system activity was studied. To do this, the heart rate (HRV) was determined at rest and after 20 squats in 30 seconds (beats/10 s), systolic blood pressure (SBP), mm Hg and diastolic blood pressure, (DBP), mm Hg. The Robinson Index (IR) was calculated in conventional units (Robinson, 1967). The level of EG and CG athletes-juniors' physical performance was determined by the value of the Harvard Step Test index (HSTI, conventional units). To determine the overall endurance level, a cross-country run of 6 km (min/s) was used. During the snowy period of the annual training macrocycle, the level of special endurance was determined by the time of passing the ski distance of 5 km (min/s). The assessment of the intensity of physical activity was carried out in four zones (first, second, third and fourth) depending on the heart rate (HRV).

In both groups, the training program of the federal standard of sports training in «cross-country skiing» (2019) was used. In the training program for EG athletes at all stages of the preparatory period of the annual macrocycle, we used the pedagogical technology «combining methods» for the development of special endurance, which differed from the program for young men from CG, Table 1.

Table 1. Characteristics of training programs for young men of CG and EG

Group	Stage	The content of methods in the program, %	Means	Load volume, км	High-speed work methods	Load intensity zones/ HRV
CG	I	Uniform method - 60.0 Variable (winders) - 10.0 Game, repeat, competitive - 30.0	Cross-country running, cyclocross, step simulation, roller skis	550.0	Uniform - 87.0 Variable - 13.0	1/120-140 2/140-160

	II	Uniform method - 54.0 Variable (winders) - 25.0 Game, repeat, competitive - 21.0	Cross-country running, winders, jumping simulation with sticks, roller skis	1070.0	Repeat -70.0 Variable - 30.0	1/120-140 2/140-160 3/160-180 4/180-195
	III	Uniform - 50.0 Variable (winders) - 50.0	Skiing	820.0	Uniform - 50.0 Variable - 50.0	1/120-140 2/140-160 3/160-180 4/180-200
EG	I	Uniform - 42.0 Variable (winders) - 28.0 Game, repeat, competitive - 30.0	Cross-country running, cyclocross, step simulation, roller skis	555.0	Uniform - 55.0 Variable - 45.0	1/120-140 2/140-160
	II	Uniform - 27.0 Variable (winders) - 54.0 Game, repeat, competitive - 19.0	Cross-country running, winders, jumping simulation with sticks, roller skis	1200.0	Variable - 54.0 Uniform - 27.0 Repeat - 19.0	1/120-140 2/140-160 3/160-180 4/180-195
	III	Uniform - 50.0 Variable (winders) - 50.0	Skiing	820.0	Uniform - 50.0 Variable - 50.0	3/160-180 4/180-200

The digital indicators obtained by us in the pedagogical project were calculated using the Statistica 6.1 software package for Windows.

Results

The analysis of the training programs content for athletes' of the EG and CG training showed that there are differences between the percentages of training methods, volumes and zones of intensity of physical activity at the stages of the preparatory period. At the first stage of the preparatory period, EG athletes used uniform method 1.42 times less, the variable method 2.8 times more than athletes from CG. At the II stage, the uniform method was used 2.0 times less often in athletes of the EG, and the variable method was used 2.2 times more often than in athletes of the CG. The ratio of training methods at stage III did not differ in EG and CG. At all stages of the preparatory period, the same means of training were used in the CG and EG.

The volume of young men's of the CG and the EG physical activity at the I and III stages practically did not differ At the II stage, the total volume of training loads of the EG athletes was 12.0%, more than in comparison with the CG. At the Ist and IInd stages of the preparatory period, the athletes of CG and were in the same zones of intensity of physical activity. At stage III, the load intensity zones differed from each other (Table 1).

The results of the analysis of physical activity distribution by heart rate at the IIIrd stage of the preparatory period indicate that athletes of CG more often trained in the Ist and IInd zones of intensity of physical activity (120-140 and 140-160 beats /min, respectively). EG athletes had a heart rate of 160-180 and 180-200 beats/min, which corresponds to IIIrd and IVth intensity zones, Figure 1.

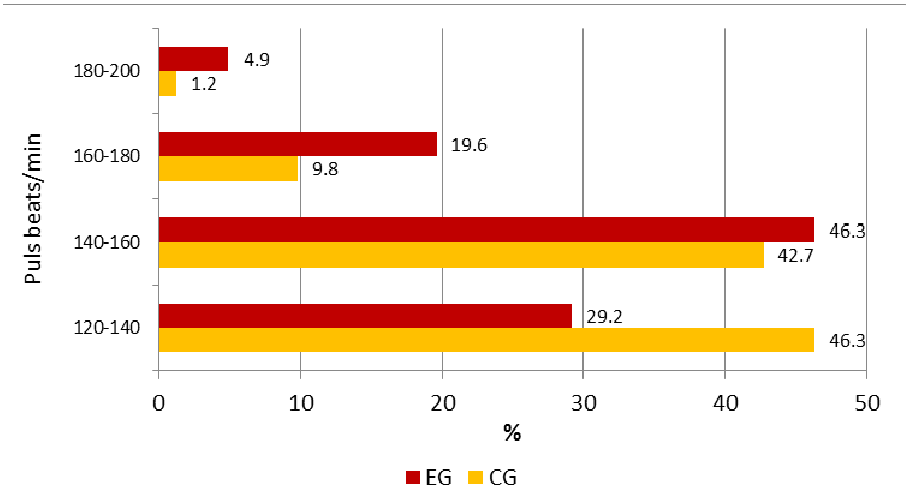

Fig. 1. Distribution of the physical activity volume by heart rate in athletes of CG and EG at the IIIrd stage of the preparatory period

The predominant use of the variable method at different stages of the preparatory period in the annual macrocycle made it possible to increase the intensity of physical load in athletes of the experimental group. One

of the sections of our research project was a test determination of the functional reserves of the cardiovascular system and tolerance to physical loads in athletes of both groups, Table 2.

Table 2. Dynamics of the young men's from CG and EG values of the cardiovascular system in the preparatory period of the annual macrocycle (M ± m)

Tests	Start of the project		Ist stage		IInd stage		IIIrd stage	
	CG	EG	CG	EG	CG	EG	CG	EG
Heart rate (HRV) at rest (beats/10 s)	11.6±0.3	11.5±0.2	11.0±0.11	11.0±0.13	11.0±0.1	10.8± 0.08	10.5±0.12	10.2±0.11
Heart rate (HRV) after 20 squats in 30 s	13.7±0.4	13.6±0.5	13.2±0.2	13.0±0.2	13.0±0.2	12.8± 0.1	13.0±0.2	12.4±0.1
Recovery time after 20 squats, s	57.0±2.1	57.8±2.0	53.2±2.1	52.0±1.8	52.4±1.9	50.4± 1.4	51.2±1.5	48.2±1.2
SBP, mm Hg	112.8±4.4	110.5±4.3	115.5±.4.7	113.7±4.2	114.9±4.3	112.8 ±4.6	119.4±5.2	111.6±4.3
DBP, mm Hg	68.7±2.1	70.5±2.8	70.4±2.7	71.5±2.9	70.2±2.2	71.3± 2.8	72.4±2.0	70.5±2.9
Robinson Index (IR), conventional units	78.5±3.3	76.2±3.2	76.2±3.1	75.0±3.7	75.8±3.2	73.1± 3.1	75.2±3.4	68.3±2.8

We found that the values of heart rate indicators at rest and after «20 squats in 30 seconds» test, the pulse recovery time after exercise decrease in all examined athletes CG and EG at each stage of the preparatory period, compared with the start of the project, $p < 0.05$.

A significant difference between these indicators registered at the end of the IIIrd stage of the preparatory period. At the end of the study, there were no significant changes in the values of systolic and diastolic blood pressure, compared with the beginning of the experiment. At each stage of improving special endurance, all athletes showed a decrease in the value of the Robinson index, which indicates an improvement in the systolic work of the heart muscle, $p > 0.05$.

A significant improvement in the Robinson index was registered only in EG boys at the end of stage IIIrd, $p < 0.05$. Figure 2 shows the dynamics of changes in the values of the cardiovascular system of the CG and EG athletes after the end of the pedagogical experiment, compared with its beginning (%).

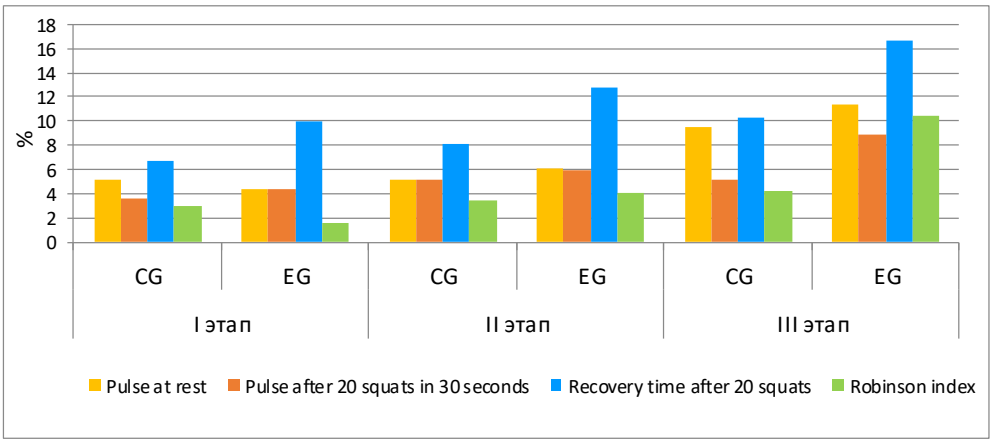

Fig. 2. The increase in the values of the indicators of the CG and EG young men's cardiovascular system at the end of the experiment

The use of the pedagogical technology proposed by us to improve the training process showed an increase in tolerance to physical activity, an increase in young men's of the experimental group special endurance and physical performance of the body, Table 3.

Table 3. Young men's (juniors) of CG and EG control testing of physical performance and special endurance results (M±m)

Tests	Start of the project		I[st] stage		II[nd] stage		III[rd] stage	
	CG	EG	CG	EG	CG	EG	CG	EG
HSTI, conditional units	113.8 ±2.3	112.7 ±2.6	120.5 ±2.8	127.4 ±2.9	122.5 ±2.2	129.6 ±2.5	130.4 ±3.2	139.5 ±3.6
Cross-country run of 6 km (min/s)	24:12 ±0:0.12	24:42 ±0:0.11	24.02 ±0:0.16	24.12 ±0:0.14	23.56 ±0:0.15	23.40 ±0:0.14	23.48 ±0:0.14	23.14 ±0:0.11
Cross-country skiing 5 km (min/s)	-	-	-	-	-	-	17:48 ±0:0.10	16:29 ±0:0.08

It was found that in young men of both groups, the values of the physical working ability (HSTI) and special endurance indicators in the tests «cross-country running 6 km» and «cross-country skiing 5 km» significantly increased at the end of the research project, $p < 0.05$.

The dynamics of the increase in the values of the HSTI and special endurance are illustrated in Figure 3.

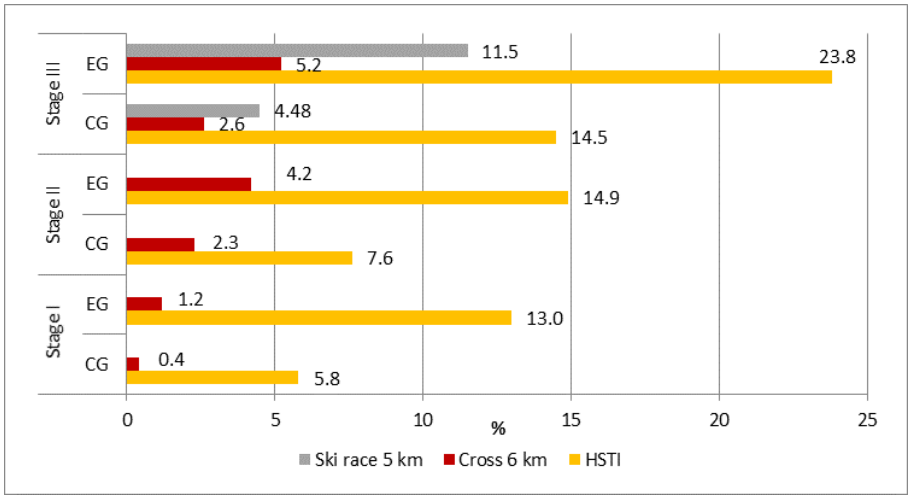

Fig. 3. The increase in the indicators of physical performance and special endurance of juniors of CG and EG

At the end of the project, the increase in the values of the physical fitness and special endurance tests indicators for EG boys turned out to be greater than the increase in indicators in CG, which is a confirmation of the correct choice of the training program for athletes-skiers aged 15-16.

Dicussion

The athletes' in cross-country skiing performance largely depends on the development of physical performance and the level of special endurance. This ensures the performance of sports-specific loads for a long time without the development of a state of fatigue of athletes. The results of our research work confirm the opinion of Andersson et al. ((2020), Nakai (2020), that in the program of the preparatory period of the annual macrocycle, more time should be used for the development of special endurance and physical performance, as a marker of skiers' overall endurance.

In the scientific literature there is a sufficient number of works devoted to improving the training process using various pedagogical technologies, means and methods of training skiers. However, in some scientific sources there are conflicting opinions about the ways of developing special motor qualities and physical performance of skiers of different ages (Sheridan et al., 2021; Wong et al., 2021). Such debatable disputes do not allow the full use of the potential of athletes' training loads. Some authors believe that a significant increase in special endurance occurs at the age of 13-14 (Landgraf et al., 2021), other researchers point to the age of 15-16 (Tomkinson, 2011). The results of our study of the special endurance state confirm the results of the last author.

There is information about a different combination of loads during skiing training sessions. Losnegard (2019) considers aerobic metabolism to be the main source of energy in cross-country skiing and points to the predominant use of aerobic loads with average heart rate values (140-160 beats per minute). The literature provides information on the use of concentrated power loads with a higher heart rate in the sports training of skiers, which improves the explosive work of muscles (Kamaev et al., 2020). Experts in the field of ski racing

believe that the terrain of the track affects the type of metabolism in the athlete's body. The aerobic type of metabolism for energy production prevails on flat areas; the anaerobic type prevails on the ascents (Kropta et al., 2020). In our research project, the boys of the experimental group used a combined method of improving special endurance, which combined aerobic and anaerobic physical activity. The main focus of our program was the third stage of the preparatory period, in which a large amount of physical activity with significant intensity was used, as evidenced by high heart rate indicators in young men. The combined method of forming special endurance in the preparatory and competitive periods is reported by Bakhareva et al. (2019).

In parallel with the development of special endurance and physical performance, functional changes in the human cardiorespiratory system and the formation of tolerance to physical exertion occur. A combined program of training sessions in the preparatory period of the annual macrocycle use in our program led to a significant increase in the physical performance of ski athletes aged 15-16, as evidenced by an increase in the value of the Harvard step test index in the boys of the experimental group by the end of the experiment. The high-stakes testing results at the end of the project showed a significant increase in the athletes' special endurance and functional parameters of the cardiovascular system. A similar correlation of endurance and the state of the cardiovascular system was noted by other experts in the field of sports and physical culture (Ivanyshyn et al., 2019), which are consistent with our data.

The results of testing our program for improving special endurance in the training process of training ski racers aged 15-16 showed a positive effect of using this pedagogical technology. This is evidenced by the reliably high results of the increase in the values of indicators of physical performance, special endurance and cardiovascular system in athletes of the experimental group, compared with the results of young men of the control one.

Conclusions

The proposed program for improving the special endurance of skiers of the experimental group provides for the joint use of aerobic and anaerobic methods of obtaining energy by young athletes in the preparatory period of the annual training macrocycle. A peculiarity of our program is the predominance of a variable training method at all three stages of the preparatory period. At the third stage, the anaerobic mechanism of energy production was accompanied by an increase in heart rate indicators in young men of the experimental group, which correspond to IIIrd and IVth zones of physical activity intensity. Training sessions according to the traditional program in the control group were conducted by a uniform method, on which the load was carried out in Ist and IInd intensity zones.

At the end of the research project, the young men of the experimental group had an increase in the values of special endurance, physical performance, tolerance and functional work of the cardiovascular system indicators significantly more than in the control group of observation.

The approbation of the program proposed by us to increase the special endurance of ski racers aged 15-16 using a combination of aerobic and anaerobic methods, a properly selected ratio of training methods has proved its high effectiveness, compared with the traditional training program for athletes-skiers.

Conflicts of interest. The authors declare no conflict of interest.

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