Proceeding

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Development of special endurance for cross-country skiers of 15-17 years old

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ABSTRACT

Purpose: to devise and prove experimentally a method of objective dosing of training exercises in the development of special endurance among young athletes in cross-country skiing. Materials and methods: the study involved cross-country skiers (15-17-year-old boys). The experiment took place on the basis of the Children's and Youth Sports School (Yakhroma, Russia). The experimental group used the special programs for the development of special endurance along with the generally accepted method. All microcycles in the one-year training cycle were divided into two types: containing special training exercises aimed at developing special endurance and not containing any, as a means of general physical training. Studies of the functional state of athletes were carried out using the diagnostic complex «*Omega Standard*». Results: the athletes of experimental group have significantly higher levels of special endurance. There was a distinct increase in results. Besides, the favourable changes of physiological parameters in the experimental group were proved such as: maximum oxygen consumption (ml/min/kg) from the beginning of the preparatory period to the end of this period increased by 2.8%, it was noted a significant slowing of the heart rate and an increase in stroke volume at rest. Conclusions: in the content of training exercises aimed at developing special endurance in the micro, meso and macrocycle training of cross-country skiers aged 15-17 yr., three variants of microcycles are identified (developing, supporting, restoring). The content of the first two may vary according to the predominant orientation of the training exercise on the basic factor (critical aerobic speed) and the main factors of special endurance (speed and stayer endurance).

Keywords: Cross-country skiing; Structure of the training process; Ski training periods; Special endurance.

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INTRODUCTION

At the present stage of sports development, one of the most important tasks is to develop rational training methods aimed at expanding the functional capabilities of the athletes ' body (Ainegren et al., 2020; Bakhareva et al., 2018; Bjerring et al., 2018).

Achieving high results in cyclic sports, which include cross-country skiing, depends on the level of development of special endurance (Kupriyanov, 2015; Sandbakk & Holmberg, 2017). Special endurance is based on certain physiological mechanisms, the study of which is important in the normalization of loads and monitoring the fitness of athletes. The main indicator of aerobic performance is the maximum oxygen consumption. In the practice of skiing, the relationship between the intensity and heart rate, oxygen consumption and blood lactate values has been established. Physical activity on endurance is associated with significant stresses of the cardiorespiratory system.

The sports readiness of sportsmen increases if the load at all stages of training corresponds to the increasing functional capabilities of the body (Burtscher, 2020; Bjerring et al., 2020; Sanz de la Garza et al., 2016). The dynamics of loads during training is characterized by their gradual increase with a tendency to the maximum possible loads. The physiological meaning of this trend is formulated from a scientific point of view in relation to sports training, expressing it in the «*principle of maximum loads*».

The matter of rational distribution of training loads in the course of one-year and long-term training are of great importance for the development of special endurance in cross-country skiers (Banack et al., 2012; Ohtonen et al., 2013). Therefore, many researchers note that the level of special endurance depends on the volume and intensity of the work done both in one training lesson and during a one-year training cycle (Golovachev et al., 2020; Pellegrini et al., 2013). For cyclical sports related to the duration of motor actions and the development of special endurance, a wave-like change and distribution of loads is more acceptable (Isaev et al., 2016). Sports training in cross-country skiing is characterized by a clearly defined cycle. The principle of Cycling allows you to build a training process based on the need for systematic repetition of the main parameters of training, consistently change tasks, solve problems of appropriate use of means and methods according to their place in the structure of training cycles, adjust and dose loads by volume and intensity. It is necessary to consider any fragment of the training process in its relationship with more or less large forms of the cyclic structure of training. The dynamics of training loads organically combine the gradual and periodic increase (jump) to the maximum values, but this should all be related to the age characteristics and level of fitness of athletes (Burtscher, 2020; Grimsmo et al., 2010; Sadova, 2006).

The body's adaptation to training loads is not straightforward. Rest intervals are necessary for functional and restorative transformations that increase the level of fitness of the athlete the recovery time is longer, the higher the load. Therefore, in the training process, along with rest, temporary changes in loads are necessary, which facilitate the course of biological changes in the body (Shutova & Vysotskaya, 2019).

Purpose: to devise and prove experimentally a method of objective dosing of training exercises in the development of special endurance among young athletes in cross-country skiing.

MATERIALS AND METHODS

Participants

After preliminary testing, two groups of cross-country skiers (15-17-year-olds) with the same level of training and qualification were created: experimental group (N1, n = 22) and control group (N2, n = 22).

Organization of research

The study was carried out during the preparatory and competitive periods at the children's and youth sports school (Yakhroma, Russia). Training and education sessions in both groups were held on certain tracks, the same lubrication of skis, the air temperature is not lower than 15 degrees, the normal condition of the ski track. Athlets of group N2 trained according to the generally accepted method (training plans for children's and youth sports schools). The group N1 used the special programs for the development of special endurance in young ski-racers along with the generally accepted method. All microcycles in the one-year training cycle were divided into two types: containing special training exercises aimed at developing special endurance and not containing any, as a means of general physical training.

Training loads aimed at developing special endurance were divided into six variants according to the predominant effect on individual components of special endurance of skiers-racers (sprint, speed, stayer) and the amount of loads.

The first variant is a microcycle in which the problem of sprint and speed endurance was solving. The content of this microcycle included two or three shock (large) – 90-100% of the training volume, aimed at sprint and speed endurance. The main means were exercises on roller skis and skis on short and medium distances up to 600 meters. The main method of variable and interval loads. For example, several series of 4 × 150 m.; 4 × 200 m.; 3 × 250 m. and so on. These training sessions were key for this microcycle, determining its main focus. The microcycle also used training of a different orientation on speed and strength qualities, but they solved only the problems of maintaining the latter. The method of execution within a series is interval (the duration of active rest between segments in the series is up to 30 seconds), and between series – repeated (active rest is up to 2 minutes).

The second variant of the microcycle - developing speed and stayer endurance. The key training sessions are zones 1 and 2, aimed at speed endurance (volume 90-100%) and 1-2 for stayer endurance, performed by the repeated series method.

Table 1. Distribution of loads in one of the variants of the developing microcycle.

The days of the microcycle	Intensity in % of the competition	Volume of discrete loads (km)	Volume of continuous loads (kg)	Total volume (km)
First	90	3.4	12.0	15.4
Second	90	5.3	10.0	15.3
Third	90	3.5	10.0	13.5
Fourth	70	-	14.9	14.9
Fifth	90	5.8	9.2	15.0
Sixth	90	3.0	12.3	15.3
Seventh	rest	rest	rest	rest
Volume in a microcycle	-	21.0	70.4	89.4

The third microcycle develops stayer endurance. The key training sessions (2-3) are long-distance shock training, which is performed using the repeated method.

The fourth, fifth, and sixth variants of microcycles repeated the first, second, and third variants in the direction of basic training, but differed in that the volume of training loads was average (50-60%) and solved the problem of maintaining special endurance.

The volume of loads per training session with a developing effect ranged from plus / minus 15% depending on the day of the microcycle and the individual condition of athletes (Table 1).

After a day of rest, the relative value of the load was higher, after shock training-less. In microcycles, the task of developing or maintaining special endurance was solved.

In the first case, mesocycles usually included two or three microcycles aimed at developing and maintaining special endurance, and one recovery microcycle (2-4 days). The intensity of loads in the developing microcycle was in the range from 70 to 90% of the competitive speed, and in the supporting one in the range of 70-87% (Table 2).

Table 2. Distribution of loads in one of the variants of the supporting microcycle.

The days of the microcycle	Intensity in % of the competition	Volume of discrete loads (km)	Volume of continuous loads (kg)	Total volume (km)
First	85	2.3	10.0	12.3
Second	85	2.6	10.0	12.6
Third	85	2.3	10.0	12.3
Fourth	70	-	12.0	12.0
Fifth	87	2.3	10.0	12.3
Sixth	85	2.6	8.0	10.6
Seventh	rest	rest	rest	rest
Volume in a microcycle	-	12.1	60.0	72.1

Monitoring of the level of adaptation of athletes to physical activity during the training process was carried out using the diagnostic complex "*Omega Standard*". The respiratory function was assessed using a Bicycle Ergometer test. The heart rate of the tested athletes was continuously recorded using the POLAR heart rate monitor (Finland).

Statistical analysis

Statistical processing of the data was carried out on generally accepted methods of variation statistics with the calculation of average arithmetic, average standard deviation and verification of the results of the study on the reliability of differences at a five percent level of significance. The student's t-criteria was used to evaluate the significance of the differences. Mathematical processing was carried out using the MS Excel 2016.

RESULTS

The amount of work performed in the control and experimental groups was almost the same. Volumes in kilometres for the 6-week cycle were approximately 184 km in N1 and 189 km in N2. Testing at the beginning

and at the end of the experiment showed that a more significant increase in sports results was in N1. The construction of the training process, taking into account the objective dosage of training loads with the development of special endurance among young athletes in cross-country skiing, significantly improved sports results: in 10,000 m skiing the increase in results in group N1 was 3.9% vs 3.2% in N2; in roller skiing 500 m - N1 by 4.0% vs 3.4% in N2 (Table 3).

Table 3. Results of special physical training before and after the experiment.

	Indicators N1 (X ± σ)		**Indicators N2 (X ± σ)**	
	At the beginning of the experiment	At the end of the experiment	At the beginning of the experiment	At the end of the experiment
10 km cross-country skiing (min)	37.06 ± 4.49	36.02 ± 4.63*	38.34 ± 4.32	37.16 ± 4.42
500 m running on roller skis (sec)	78.6 ± 3.2	75 ± 4.3*	77.2 ± 3.8	76.8 ± 3.9

*Note: X–arithmetic mean, σ-mean square deviation; N1-experimental group, N2-control group;*significance of differences (p < .05).*

During the study period, athletes N1 showed favourable shifts in physiological parameters. Analysis of the research results showed that the maximum oxygen consumption (ml/min/kg) from the beginning of the preparatory period to the end of this period increased by 2.8%, there was a certain trend in increasing the maximum oxygen consumption (ml/min/kg) in the competition period by 1.4%. Functional indicators of the heart in athletes at rest decreased by 1.8% by the end of the preparatory period. The lowest values of the heart rate at rest (bpm) was in the competition period, where it was equal to 59.9 ± 2.5 bpm (Table 4).

Table 4. The results of functional indicators of 15-17 year old skiers before and after the experiment.

	Indicators N1 (X ± σ)		**Indicators N2 (X ± σ)**	
	At the beginning of the experiment	At the end of the experiment	At the beginning of the experiment	At the end of the experiment
Maximum oxygen consumption (ml/min/kg)	57.3 ± 3.4	64.7 ± 3.51*	58.9 ± 4.6	63.4 ± 4.23
Heart rate at rest (bpm.)	63.2 ± 4.4	59.9 ± 2.5*	62.7 ± 2.8	63.2 ± 5.2
The heart rate threshold of anaerobic metabolism (bpm.)	166.3 ± 8.1	174.3 ± 5.7*	160.2 ± 9.9	161.4 ± 7.9

*Note: X–arithmetic mean, σ-mean square deviation; N1-experimental group, N2-control group;*significance of differences (p < .05).*

DISCUSSION

The analysis of the literature showed that there are significant differences of opinion and recommendations on the structure of training loads for the development and maintenance of special endurance and on the method of monitoring its condition in skiers-racers 15-17 years old. In the practice of managing the training process, coaches are primarily interested in managing the intensity of training loads and, in particular, its control and planning according to informative indicators (Andreeva, 2000; Nagovitsyn et al., 2017).

In the study by Lunkov (2000), the rational planning of the training of skiers-racers was carried out on the basis of a preliminary in-depth study of the adequacy of reactions to the proposed testing procedures, identifying the factor structure of the functional state at each stage of training. A steady increase in volume

to a certain optimum is a requirement of modern training. By the age of 15-17, the body reaches a significant, but not final, degree of maturity. The profile quality endurance progresses significantly, the results grow, causing dangerous optimism among coaches. It should be remembered that there are still 4 - 5 years before the completion of biological maturation. Therefore, it is necessary to allow the body to realize the natural processes of development by presenting training loads adequate to its capabilities. At the stage of in-depth training, there is a need for ordering, systematization, means and methods, the volume and intensity of loads, alternation of developing and restoring activities.

In the training process in cross-country skiing, the longest in the annual cycle is the preparatory period, which is considered the basis or foundation for the competitive period. Most researchers (Petrov, 2014; Avdeev, 2007) suggest paying close attention to this period.

Ilkin (2013) presents the construction of a training process using an integral method of sports training, which combines aerobic and anaerobic loads in one training session, which are aimed at the simultaneous development of sprint and stayer qualities of athletes. The year-round training process of universal skiers should be built with a combination of sprint and stayer microcycles for the gradual development of endurance and speed qualities in athletes of mass categories. In ordinary microcycles of stayer orientation, we recommend using a uniform training method, with a large amount of load (20 km or more) and an average level of intensity. As the development of general and special endurance, you can use running on lightly crossed terrain in combination with fast walking (10 minutes running + 5 minutes walking), as well as even work on skis and roller skis with an emphasis on long rolling and stable balance.

In the study by Vlasov (1998), it should be noted the construction of training sessions with the use of maximum muscular loads performed by a repeated method. The practical use of this methodology for the development of special endurance of athletes is based on a targeted impact on physical qualities, and with them the energy supply systems that ensure their manifestation. That is why the proposed method is designed for the use of extreme muscle loads throughout all stages of training. In this way, an increase in the effectiveness of competitive activity among athletes who have undergone "*basic*" training can be achieved without increasing the total volume of cyclic load.

The studies by Grachev (2002) were devoted to determining the effectiveness of sequential and parallel training of endurance, speed and strength. The results of the experiment showed that with the same time allocated to the training of endurance, speed and strength of 15-17-year-old athletes, a consistent approach to their improvement was more effective.

CONCLUSIONS

The content of training loads, aimed at the development of special endurance in the micro, meso and macrocycle of training of skiers-racers aged 15–17 years, has been developed. There are three variants of microcycles (developing, supporting, restoring), and the content of the first two can vary according to the predominant orientation of training loads on the basic factor (critical aerobic speed) and the main factors of special endurance (speed and stayer endurance).

The effectiveness of directed training of factors of special endurance of skiers-racers in the preparatory and competitive periods was revealed.

Summing up the results of the pedagogical experiment, it can be noted that directed training for the development of special endurance factors has sufficient effectiveness in the development of special endurance. The training program for athletes of group N1, implemented in the 2017-2019 season, proved to be effective and led to a significant improvement in the sports results of cross-country skiers.

REFERENCES

Ainegren, M., Jensen, K., & Rosdahl, H. (2020). Breathing resistance in metabolic systems: Its effects on pulmonary ventilation and oxygen uptake in elite athletes with high aerobic power. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 234(3), 217-226. https://doi.org/10.1177/1754337120919609

Andreeva, O.V. (2000). Programming of the training process of qualified ski racers on the basis of integrated control (dissertation). Chelyabinsk: Ural State Academy of Physical Culture [in Russia].

Avdeev, A.A. (2007). The training process organization of skiers-sprinters of mass categories during the preparatory period of the annual cycle (dissertation). Saint-Petersburg: Velikiye Luki State Academy of Physical Culture and Sports [in Russia].

Bakhareva, A.S., Isaev, A.P., Erlikh, V.V., & Aminov, A.S. (2018). Hydrostatic pressure as a factor of effective adaptation and improved sport performance of ski racers. Gazzetta Medica Italiana Archivio per le Scienze Mediche 177(3), 30-39. https://doi.org/10.23736/S0393-3660.17.03724-X

Banack, H. R., Bloom, G. A., & Falcão, W. R. (2012). Promoting Long Term Athlete Development in Cross Country Skiing through Competency-Based Coach Education: A Qualitative Study. International Journal of Sports Science & Coaching, 7(2), 301-316. https://doi.org/10.1260/1747-9541.7.2.301

Burtscher, M. (2020). The bi- (or multi-) phasic response of cardiac remodelling to endurance exercise related to the article: From talented child to elite athlete: The development of cardiac morphology and function in a cohort of endurance athletes from age 12 to 18' by Bjerring and colleagues. European Journal of Preventive Cardiology. https://doi.org/10.1177/2047487320929245

Bjerring, A. W., Landgraff, H. E., Leirstein, S., Aaeng, A., Ansari, H. Z., Saberniak, J., Murbræch, K., Bruun, H., Stokke, T. M., Haugaa, K. H., Hallén, J., Edvardsen, T., & Sarvari, S. I. (2018). Morphological changes and myocardial function assessed by traditional and novel echocardiographic methods in preadolescent athlete's heart. European Journal of Preventive Cardiology, 25(9), 1000-1007. https://doi.org/10.1177/2047487318776079

Bjerring, A. W., Landgraff, H. E., Leirstein, S., Haugaa, K. H., Edvardsen, T., Sarvari, S. I., & Hallén, J. (2020). From talented child to elite athlete: The development of cardiac morphology and function in a cohort of endurance athletes from age 12 to 18. European Journal of Preventive Cardiology. https://doi.org/10.1177/2047487320921317

Brownlie, L. (2020). Aerodynamic drag reduction in winter sports: The quest for «free speed». Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology. https://doi.org/10.1177/1754337120921091

Golovachev, A.I., Kolykhmatov, V.I., & Shirokova, S.V. (2020). Model indicators of physical preparedness of elite female ski-racers in preparation for the 2022 winter Olympic Games in Beijing (CHINA). Human Sport Medicine, 19(2), 81-87. https://doi.org/10.14529/hsm19s211

Grachev, N.P. (2002). Construction of training loads in the annual cycle of skiers-racers 15-16 years old, taking into account factors that limit performance (dissertation). Moscow: All-Russian Research Institute of Physical Culture and Sports [in Russia].

Grimsmo, J., Grundvold, I., Maehlum, S., & Arnesen, H. (2010). High prevalence of atrial fibrillation in long-term endurance cross-country skiers: echocardiographic findings and possible predictors - a

28-30 years follow-up study. European Journal of Cardiovascular Prevention & Rehabilitation, 17(1), 100-105. https://doi.org/10.1097/HJR.0b013e32833226be

Ilkin, A.N. (2013). The structure and content of sports training of skiers-universalists of mass categories (dissertation). Naberezhnye Chelny: Volga region state academy of physical culture, sports and tourism [in Russia].

Isaev, A.P., Erlikh, V.V., Romanov, Y.N., & Bakhareva, A.S. (2016). Adaptation of athletes to middle-altitude conditions via the intensive development of local-regional muscular endurance and strength motor capability, stretching, and relaxation. Journal of Physical Education and Sport, 16(4), 194, 1219-1229. https://doi.org/10.7752/jpes.2016.04194

Khaliullin, R. S. (2012). Features of the pumping function of the heart of gymnasts in the competition period and when performing functional loads (dissertation). Kazan: Kazan (Volga region) Federal University [in Russia].

Kupriyanov, A.V. (2015). Effect of exercises for the development of local-regional muscle endurance on the functional state of the cardiorespiratory system in 13-15-year-old skiers (dissertation). Chelyabinsk: Chelyabinsk state pedagogical University [in Russia].

Litvishko, O.V., Vysotskaya, T.P., Bodrov, I.M., Nosov, S.M., & Buyanova, T.V. (2019). Ways to improve efficiency of professional sports financing mechanisms. Teoriya i Praktika Fizicheskoy Kultury, 9, 102-104.

Lunkov, S. M. (2000). Dynamics of special performance as a factor in managing the training of young ski racers (dissertation). Moscow: All-Russian Research Institute of Physical Culture and Sports [in Russia].

Nagovitsyn, R., Volkov, P., & Miroshnichenko, A. (2017). Planning of physical load of annual cycle of students', practicing cyclic kinds of sports, training. Physical Education of Students, 21(3), 126-133. https://doi.org/10.15561/20755279.2017.0305

Ohtonen, O., Lindinger, S., & Linnamo, V. (2013). Effects of Gliding Properties of Cross-Country Skis on the Force Production during Skating Technique in Elite Cross-Country Skiers. International Journal of Sports Science & Coaching, 8(2), 407-416. https://doi.org/10.1260/1747-9541.8.2.407

Pellegrini, B., Zoppirolli, C., Bortolan, L., Holmberg, H.-C., Zamparo, P., & Schena, F. (2013). Biomechanical and energetic determinants of technique selection in classical cross-country skiing. Human Movement Science, 32 (6), 1415-1429. https://doi.org/10.1016/j.humov.2013.07.010

Petrov, R. E. (2014). Physical training of cross-country skiers taking into account bioenergetic types (dissertation). Naberezhnye Chelny: Volga Region State Academy of Physical Culture, Sports and Tourism [in Russia].

Rybakova, E., Shutova, T., & Vysotskaya, T. (2020). Sports training of ski jumpers from a springboard based on body composition control and physical fitness. Journal of Physical Education and Sport, 20(2), 752-758.

Sadova, N. I. (2006). Pumping function of the heart of highly qualified athletes in various periods of sports training (dissertation). Kazan: Tatar state humanitarian and pedagogical University [in Russia].

Sandbakk, O., & Holmberg, H.-C. (2017). Physiological capacity and training routines of elite cross-country skiers: Approaching the upper limits of human endurance. International Journal of Sports Physiology and Performance, 12 (8), 1003-1011. https://doi.org/10.1123/ijspp.2016-0749

Sanz de la Garza, M., Grazioli, G., Bijnens, B. H., Pajuelo, C., Brotons, D., Subirats, E., Brugada, R., Roca, E., & Sitges, M. (2016). Inter-individual variability in right ventricle adaptation after an endurance race. European Journal of Preventive Cardiology, 23(10), 1114-1124. https://doi.org/10.1177/2047487315622298

Shutova T.N. & Vysotskaya T.P. (2019). Training structure of powerlifters with regard to biological rhythms and operational functional condition. Physical education of students, 23(1), 45-50. https://doi.org/10.15561/20755279.2019.0107

Solli, G.S., Kocbach, J., Seeberg, T.M., Tjønnås, J., Rindal, O.M.H., Haugnes, P., Torvik, P.Ø., (...), & Sandbakk, Ø. (2018). Sex-based differences in speed, sub-technique selection, and kinematic patterns during low- and high-intensity training for classical cross-country skiing. PLoS ONE, 13 (11). https://doi.org/10.1371/journal.pone.0207195

Vysotskaya, T., Shutova, T., & Golubnichy, S. (2020). The effective means of aquafitness in correction of mature women's functional state. Journal of Human Sport and Exercise, 15(Proc2), 189-199. https://doi.org/10.14198/jhse.2020.15.Proc2.09

Vakhitov I. Kh. (2005). Pumping function of the heart depending on the age of initiation to muscle training (dissertation). Kazan: Kazan state pedagogical University [in Russia].