

Improving motor and functional qualities through individualized training programs for student skiers

ELENA ROMANOVA¹, VIKTOR KRAYNIK², ANTON VOROZHEIKIN³, ALEKSANDR LIMARENKO⁴, ELENA FALEEVA⁵, MAXIM GURYANOV⁶, ARTYOM NEPANOV⁷, ANDREY LEPIKHOV⁸, ELENA STOLONOGOVA⁹, MIKHAIL ZAREMBOVSKIY¹⁰, PAVEL TYUPA¹¹, REGINA KOVYLINA¹²

¹Altai State University, Barnaul, RUSSIA

²Altai State Pedagogical University, Barnaul, RUSSIA

^{3,7,8,9}Peter the Great St. Petersburg Polytechnic University, St. Petersburg, RUSSIA

⁴Siberian Federal University, Krasnoyarsk, RUSSIA

⁵Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, RUSSIA

⁶Privolzhsky Research Medical University, Nizhny Novgorod, RUSSIA

¹⁰Linguistics University of Nizhny Novgorod, Nizhny Novgorod, RUSSIA

¹¹Immanuel Kant Baltic Federal University, Kaliningrad, RUSSIA

¹²Semey Medical University, NCJSC, Semey, KAZAKHSTAN

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Abstract:

Enhancing the means and methods of physical education for student youth is essential for maintaining and improving their physical health. Purpose: This study aims to perform a comparative analysis of motor skill development and the condition of the cardiovascular and muscular systems among students engaged in academic physical training in the gym versus those in a group of student skiers who transition to ski training during the winter months. **Materials and Methods:** The study involved 96 male students aged 17–19 years from the University of the Siberian Federal District. They were randomly assigned to two groups: a control group (CG) and an experimental group (EG). Physical education classes for students in CG were aimed at developing the main motor skills of a person using the means and methods of academic physical training in the gym. In EG, ski training was used in the snowy period of the year in the amount of 56 hours. Testing of the main motor skills and functional indicators of the body was conducted. **Results.** It was found that inclusion of skiing in the physical training program contributes to the improvement of endurance, which was more than 25% higher than in the control group. Higher values of motor coordination and agility indicators, as well as muscle strength, were established compared to the results of young men, where physical education classes were held in the gym. At the end of the experiment, students in the EG had a significantly lower resting heart rate, recovery time after a test load of 20 squats in 30 secs, Robinson index and optimal blood pressure. In this group of young men, higher values of strength indicators were recorded in motor tests and dynamometry of muscle strength of both hands compared to the results of students in the CG. Young men who were engaged in physical education only in the gym had better speed qualities, flexibility and speed-strength abilities compared to the experimental group. **Conclusions.** The results of the research project demonstrate the importance of individualization of educational programs depending on the goals and needs of each student, as well as the possibility of using various types of physical activity for the harmonious development of physical and functional qualities. Ski training can be more effective for the formation of physical, mental, somatic health and a healthy lifestyle in students compared to physical education classes in a gym.

Key Words: motor qualities, functional qualities, physical training, ski training

Introduction

Running and skiing are popular among the population in regions with snowy landscapes and these types of physical activity act as recreational or competitive sports (Kropta et al., 2020). Skiing is widely used as a recreational and strengthening means for independent active recreation of the population and for physical education of young students. In the modern world, student life is filled with many different areas of activity. This includes academic workload, social and community events, sports and creative interests (Eksterowicz, & Napierała, 2020). During their studies, young people often experience physical inactivity, psychoemotional stress associated with knowledge control, which reduces the body's reserve capacity (Grajek, & Sobczyk, 2021; Bocharin et al., 2021). In such a hectic pace, concern for maintaining and improving physical and psychological health often remains in the background (Kolokoltsev et al., 2020). This causes a deterioration in the health of students (Baker et al., 2022; Bocharin et al., 2023) and a delay in the development of their motor skills is recorded (Faílde-Garrido et al., 2022). Nevertheless, it is becoming increasingly clear that taking care of your

physical and mental health is extremely important, especially when the academic and psycho-emotional stress increases (Semeniv et al., 2021). There is convincing evidence in the scientific literature about the greater reserve capacity of the body of student-athletes to withstand exam stress compared to students who ignore sports activities (Romanova et al., 2023). Ski training and skiing are one of the most effective and accessible ways to maintain physical activity and improve human health. This physical education and sports activity is considered to be relatively safe, despite isolated cases of frostbite of the fingers of the upper extremities (Jellestad, & Holm, 2023) or severe consequences for life during avalanches in mountainous terrain (Kučerová et al., 2024) available in the scientific literature.

For students who face high levels of stress, lack of time and insufficient physical activity on a daily basis (Syamsudin et al., 2021; Mazin et al., 2021), ski training can significantly improve their physical, mental and somatic health. This is especially important for those who spend a lot of time studying and lead a sedentary lifestyle. Regular skiing training helps improve blood circulation and oxygen saturation of the body. Cross-country skiing prevents obesity and overweight, which has a positive effect on the heart and blood vessels (Grzebisz-Zatońska et al., 2023; Bushmanova, & Lyudinina, 2024; Snezhitsky et al., 2022). Scientific research indicates that positive changes in cardiac activity are associated with the cyclic nature of physical activity. At the same time, an increase in the tolerance of the cardiovascular system to physical activity begins to be recorded in adolescent athletes, as early as at the age of 12 (Bjerring et al., 2018). Cross-country skiing develops special endurance in an athlete, which is the most important motor quality in this sport (Losnegard, 2019; Nakai, 2020). This motor quality is also important in the constant life of people.

Physical activity in the fresh air helps to reduce the level of psychoemotional stress and improve mood, reducing the risk of developing mental disorders (Svensson et al., 2022). This is especially important for students who often experience psychoemotional stress due to studies, exams and other obligations. During skiing, almost all muscles of the legs, trunk and shoulder girdle are involved, which work in aerobic (Losnegard, 2019; Andersson et al., 2020) and less often in anaerobic modes (Karlsson et al., 2018). Skiing requires good coordination and balance, which contributes to the development of psychomotor skills and better stability of your body. This improves overall physical fitness and self-confidence. In general, the integration of ski training into student life can bring significant benefits, forming a high motivation for physical activity for many years to come (Davydov et al., 2021) and a healthy lifestyle.

The scientific literature contains numerous studies that are devoted mainly to the observation of highly qualified skiers (Stöggli et al., 2023), and the results of testing physical qualities are presented mainly on roller skis. At the same time, it is necessary to conduct a comparative analysis of the level of motor skills, cardiovascular and other system indicators in students who, when mastering the subject "Elective physical education courses", have different focuses of the means and methods of the physical education process.

These physical education courses at universities provide for various forms, means and methods of mastering the subject (Lukina et al., 2019). General physical training classes in a gym or outdoors are widely used in physical education of students. They include the use of running and gymnastic exercises, strength training with your own weight and sports equipment, work on simulators, sports games, high-intensity interval training and other means and methods. In general physical training, acyclic or mixed exercises are mainly used, which are often performed in anaerobic mode (Semeniv et al., 2021).

Thus, the use of ski training and general physical training classes in a gym in physical education of students have different focus of exercises and a different mechanism for obtaining energy for the working muscles. To analyze the effectiveness of the development of a certain motor quality and the state of the body's tolerance to stress in physical education of students, it is relevant to conduct a comparative study that concerns the assessment of the impact of different areas of physical training on the body. The scientific literature does not fully reflect the issues of comparative analysis of the state of physical fitness and the cardiorespiratory system of students who are engaged in general physical training throughout the academic year in the gym and a group of students who are engaged only in ski training during the snowy period of the year. We believe that the obtained differences in the development of motor skills provide students with an opportunity to choose the type of physical education classes. This allows using the selected type of elective physical education course to correct the physical health of students.

Research aim. To conduct a comparative analysis of the level of development of motor skills and the state of the cardiovascular and muscular systems of students who are engaged in academic physical training in a gym and a group of students who switch to ski training during the snowy season.

Material & methods

The research project involved 96 male students aged 17-19 years (17.9 ± 1.6 years), who were studying at Altai State University (Siberian Federal District, Russia) in the 2023-2024 academic year. The students were randomly divided into 2 groups: the control group (CG, $n=48$ males) and the experimental group (EG, $n=48$ males). According to the results of the medical examination at the beginning of the academic year, all students in the experimental groups were practically healthy and had no contraindications for performing physical activity in the elective physical education course. All project participants voluntarily gave written consent to participate in

the study. The experiment does not violate the moral and ethical principles of the 2008 Helsinki Declaration, which provides for the participation of people in experiments. CG students were engaged in general physical training during the academic year in the gym twice a week for 2 hours, according to the work program of the elective course of physical education, compiled taking into account the Federal State Educational Standard of Higher Education for the Bachelor's Degree Program. Physical education classes for students at CG were aimed at developing the basic motor skills of a person. For this purpose, the program of classes included various physical activities using physical exercises of a predominantly acyclic nature, which were performed in anaerobic and aerobic modes. They used drill, running and gymnastic exercises in place and in motion, elements from sports games, outdoor games for recreation, strength exercises with their own weight and using sports equipment, circuit training of various focuses, high-intensity interval training, stretching and breathing exercises.

At the beginning of the academic year, EG students began their physical education training with general physical training classes in the gym. As in CG, physical exercises were aimed at developing the students' basic motor skills. About 15-20% of the total time of each lesson was devoted to studying and learning the elements of ski training in a gym. The basic motor actions of a skier were formed and developed through imitation of skiing techniques. Attention was paid to strength training of students. They performed 3 types of strength exercises: general, versatile and special. General exercises involved developing the strength of all muscles without taking into account the specifics of skiing. Versatile exercises developed the strength of the muscles that are involved in pushing off in cross-country skiing. Special exercises developed the muscles of the body that coincide with the movements of a skier.

Starting in November, when the snow cover settled, students completely switched to cross-country skiing training 2 times a week for 2 hours. Ski training continued until the 3rd ten-day period of March and lasted 14 weeks (56 academic hours). After completing ski training, the students returned to the gym, where they did general physical training. A final assessment of the level of development of motor skills was conducted in the students of the control and experimental groups. For this, generally accepted motor tests were used (PCFSN, 2011). The following motor quality indicators were used to assess the development of the test: "speed" (100 m run test, s), "agility and coordination of movements" (5x10 m shuttle run, s), "general endurance" (3000 m run, m/s), "dynamic strength of the upper limb muscles" (pull-ups from a hang on a high bar, number of times), "speed-strength endurance of the trunk muscles" (lifting the trunk in 30 s, number of times), "speed-strength endurance of the lower limb muscles" (long jump from a standing position, cm) and "flexibility" (forward bend from a standing position, cm).

In the course of the research project, a dynamic assessment of the reserve capacities of the cardiovascular system was carried out in students from both experimental groups. For this purpose, the heart rate (HRV) was studied at rest and after performing 20 deep squats in 30 seconds (beats/10 s). Systolic blood pressure (SBP), mm Hg and diastolic blood pressure (DBP), mm Hg were measured. Systolic work of the heart was assessed by the Robinson index (IR), $IR = HRV \times SBP$: 100, conventional units, (Robinson, 1967). The strength capabilities of the hand muscles were determined using a hand dynamometer, kg. After measuring body weight (kg), the strength index was calculated ($SI = \text{hand muscle strength} / BM \times 100\%$). To determine the main trends and characteristics of the attitude of the university student audience towards ski training, a survey was conducted in both experimental groups at the beginning and end of the project.

The obtained digital data were processed using parametric statistics methods with finding the arithmetic mean and its error. The reliability of differences in the values of the indicators was determined by the value of the Student's t-criterion. The difference was considered reliable at $p < 0.05$. Statistica 10.1 and MS Excel 2016 software were used in processing the material.

Results

The results of testing the students' motor skills at the beginning and end of the research project are presented in Table 1.

Table 1. Values of the indicators of the boundary testing of motor skills in students of both experimental groups ($M \pm m$)

No Test	Tests	CG (n=48)		EG (n=48)	
		At the beginning of the project	At the end of the project	At the beginning of the project	At the end of the project
Speed qualities					
1.	100 m run, s	14.85±0.14	14.42±0.16*	14.92±0.16	14.74±0.15
Agility and coordination of movements					
2.	Shuttle run 5x10 m, s	8.28±0.23	8.13±0.26	8.34±0.22	6.03±0.20*
Agility and coordination of movements					
3.	Standing long jump, cm	213.47±5.24	215.65±5.63	210.27±4.28	223.93±5.72*
4.	Body lift in 30 sec. times	45.15±1.32	51.41±1.61*	46.45±1.16	53.41±2.17*

<i>General endurance</i>					
5.	<i>3000 m run, m/s</i>	17.2±1.22	16.4±1.14	17.8±1.76	12.3±1.02*
<i>Strength qualities</i>					
6.	<i>Pull-ups from a hanging position on a high bar, number of times</i>	8.73±0.19	9.25±0.25*	8.15±0.25	11.63±0.24*
<i>Hip joint flexibility and spine</i>					
7.	<i>Forward bend from a standing position, cm</i>	9.19±1.26	13.33±1.46*	10.24±1.66	11.37±1.73

Note. * reliable difference in the values of motor test indicators after the experiment, $p < 0.05$

It was found that at the beginning of the research project the level of development of motor skills in students in CG and EG was approximately the same, $p > 0.05$, which indicates the correctness of the selection of subjects for experimental observation. At the end of the research project, after the completion of the pedagogical experiment, an increase in the values of all indicators of motor skills was found in both observation groups compared to the initial testing. A reliable increase in the value of speed skills was found in the CG students who were engaged in the general physical training program, $p < 0.05$.

Students in this group had significantly better values of speed-strength endurance, strength skills and flexibility, $p < 0.05$. Agility and coordination of movements were better expressed in EG students, whose program included ski training, $p < 0.05$. In this group of students, the results of testing speed-strength endurance, general endurance and strength qualities were also higher compared to the beginning of the experiment, $p < 0.05$.

The increase in the values of the motor test indicators at the end of the experiment compared to its beginning is shown in Figure 1.

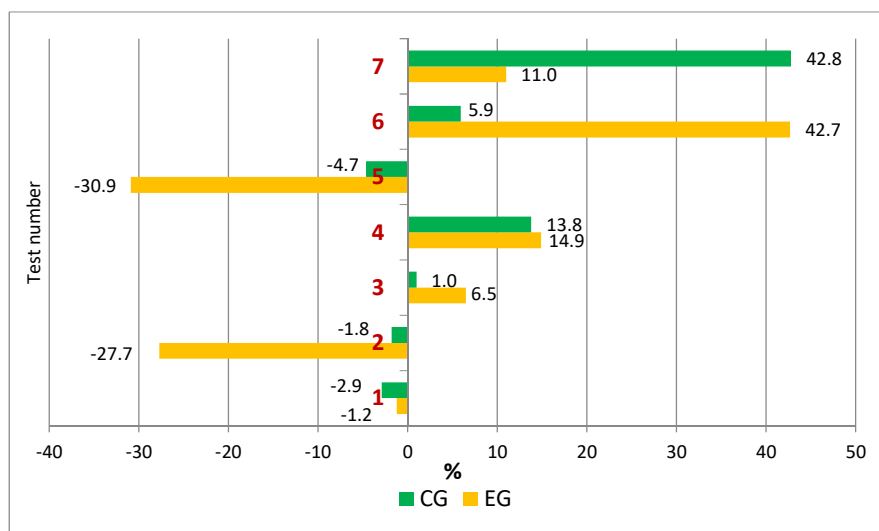


Fig. 1. Increase in the values of the motor test indicators at the end of the research project

At the end of the research project, compared to its beginning, the students in CG showed the greatest increase in the values of the motor quality indicators in test #1 (speed) and in test No 7 (flexibility). In the experimental group of students, the greatest increase was found in test No 2 (dexterity and coordination of movements), in test No 5 (general endurance) and in test No 6 (strength qualities). Approximately the same increase was found in both experimental groups in test No 4 (speed-strength qualities in the test "lifting the body in 30 seconds").

The data obtained as a result of the research project indicate that the direction of the educational and training process in physical education classes for students can have a significant impact on the development of certain motor qualities. To assess the impact of different directions of training loads on functional indicators, a milestone test of the cardiovascular and muscular systems was conducted in students in both experimental groups, Table 2.

Table 2. Milestone dynamics of the values of the cardiovascular and muscular systems in students CG and EG (M±m)

No	Functional indicators	CG (n=48)		EG (n=48)	
		At the beginning of the project	At the end of the project	At the beginning of the project	At the end of the project
Cardiovascular system					
1.	Heart rate at rest, beats/min	75.6±3.42	73.5±3.0	76.4±3.64	67.4±2.72*
2.	Heart rate after physical activity 20 squats in 30 sec	116.6±5.49	115.5±4.53	118.4±5.62	93.5±3.45*
3.	t of pulse recovery after the load of 20 squats, sec	78.4±2.15	63.2±2.79*	80.0±3.83	57.6±3.58*
4.	SBP, mm Hg	125.5±1.72	126.7±2.01	123.4±1.33	119.3±2.81
5.	DBP, mm Hg	70.5±1.45	69.0±0.83	62.4±0.73	73.5±1.86*
6.	IR, conventional units	94.8±2.26	93.1±2.42	94.3±3.34	80.4±2.35*
Muscular system					
7.	Dynamometry of the left hand, kg	38.5±0.84	43.5±1.22*	36.4±0.65	47.5±1.48*
8.	Dynamometry of the right hand, kg	44.5±1.68	51.5±1.43*	43.3±1.23	55.4±1.87*
9.	SI of the left hand, %	52.5 ±1.53	56.0±1.87*	51.5±1.66	58.5±2.18*
10.	SI of the right hand, %	62.5±1.65	68.5±2.27*	59.7±2.45	67.6±3.16*

Note. * reliable difference in the values of test indicators at the end of the pedagogical experiment ($p < 0.05$)

At the end of the research project, it was established that physical activity during physical education classes caused significant changes in the parameters of the functional indicators of the main body systems in male students. Analysis of the results of the study of the cardiovascular system indicates an increase in the reserve capacity of the students' bodies in both observation groups. This is evidenced by the improvement in the values of the indicators in all functional tests of the examined students.

At the end of the research project, the most pronounced changes occurred in the young men in EG. They had significantly better all the studied parameters of the cardiovascular system (with the exception of the value of the systolic pressure), $p < 0.05$. These data indicate the formation of higher reserve capacities of the cardiovascular system and significant physical performance in comparison with the results of the young men in the control group. The results in the motor endurance test in young men EG (test "running 3000 m") confirm the relationship of this motor quality with positive functional changes in their cardiovascular system. The analysis of the results of the study of the strength of the hands of both hands showed that at the end of the research project, a reliable increase in strength indicators was noted in young men in both experimental groups, $p < 0.05$. However, the increase in strength ability indicators was greater in young men in EG. These data may indicate an effective result of the development of strength abilities when using general development training in CG and the inclusion of ski training in EG physical education for 14 weeks. The results of changes in the values of functional indicators in young men in both experimental groups at the end of the research project are presented in Figure 2.

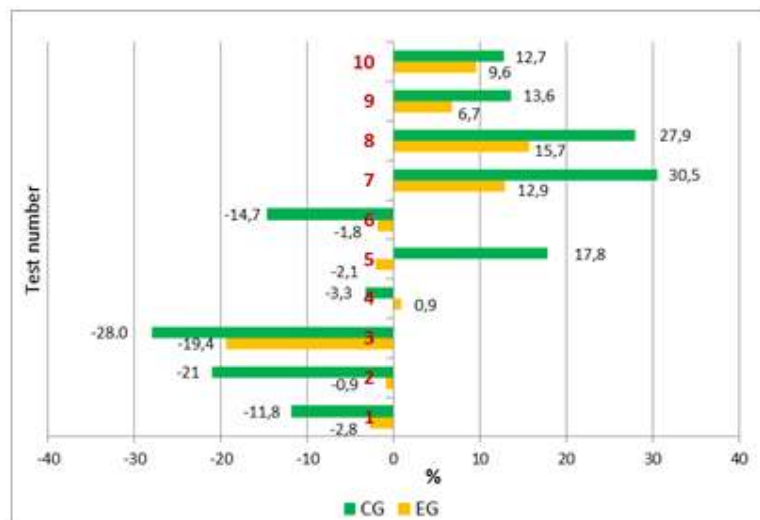


Fig. 2. The value of the increase in the functional test indicators in young men at the end of the project

At the end of the research project, positive dynamics of the cardiovascular and muscular system indicators were established for all young men, Figure 2. Higher growth rates of the heart activity parameters, the strength of the muscles of the hands and the strength index were recorded for students in the EG, where ski training was used in physical education. This is indicated by a significant decrease in the heart rate at rest, a shorter pulse recovery time after a load of 20 squats in 30 seconds, a low Robinson index and optimal blood pressure dynamics compared to the values of the cardiovascular system indicators in CG students. Young men in the experimental group had higher values of strength ability indicators, as evidenced by the results of hand strength dynamometry and the strength index compared to the results of testing young men in the control group. The analysis of the results of the research project showed that outdoor ski training helps the body adapt to long-term physical activity, which develops endurance, which turned out to be greater than that of young men in CG. These data emphasize the importance of including cardio training in the form of ski training in the general program of physical activity of students to achieve an optimal level of physical performance and maintain physical health.

Dicussion

The search for ways to improve the health of the younger generation using the means and methods of physical education and sports activities is a pressing issue in the field of sports pedagogy. Based on this, the topic of this research project seems important and timely. The relevance of the research topic is due to the still high level of morbidity among modern youth, including severe pathology (Baker et al., 2022; Bocharin et al., 2023; Romanova et al., 2023) and the delay in the development of their motor and functional qualities (Faílde-Garrido et al., 2022). One of the reasons for this may be due to poor knowledge of the health-improving potential of some means and methods of physical education. One of the powerful health-improving types of physical education is skiing (Grzebisz-Zatońska et al., 2023; Bushmanova, & Lyudinina, 2024). The health-improving effect of this type of physical activity is associated with the cyclic nature of the load, which is performed mainly in the aerobic mode (Losnegard, 2019; Andersson et al., 2020) and much less often in the aerobic mode (Karlsson et al., 2018), when the athlete overcomes the ski distance while climbing a mountain.

The present study allowed us to establish the effect of ski training on the physical qualities of students. The results obtained demonstrate that cross-country skiing contributes to the effective development of endurance and aerobic abilities, which is consistent with the opinion of other researchers in this field (Losnegard, 2019; Nakai, 2020; Vorozheikin et al., 2022). According to our data, comparative testing of this motor quality showed significant advantages of cross-country skiing training in the development of endurance compared to physical education classes in the gym. The increase in the test values in the 3000 m run was 6.5 times greater in young men who used cross-country skiing compared to the results of young men who did general physical training in a gym. This is due to intensive training outdoors, which stimulates the development of the reserve capabilities of the cardiovascular system and improves the functioning of the respiratory system. This is confirmed by our results of comparative testing of the cardiovascular system in young men who were engaged in different areas of physical training. At the end of the research project, a reliable improvement was found in almost all functional indicators of the reserve capabilities of cardiac activity in young men who used cross-country skiing. A reliable decrease in resting pulse rate, pulse recovery time after a control motor test in the form of 20 squats, a decrease in the Robinson index value, and more effective blood pressure dynamics were found. These data are consistent with the findings of other researchers (Bjerring et al., 2018; Grzebisz-Zatońska et al., 2023; Bushmanova, & Lyudinina, 2024), who in their studies showed the role of cyclic loads in increasing the tolerance of athletes to physical activity.

Efficient use of ski training is closely related to the need to develop human strength abilities (Losnegard, 2019; Andersson et al., 2020). When skiing in aerobic mode, almost all muscles of the human body work. Therefore, in such training, much attention is paid to improving strength abilities. In the present study, we began developing special strength abilities in young men during their training in the gym and continued during ski training. This led to a more significant development of strength compared to the results of the study of this motor quality in young men in the control group. In the experimental group, the values of dynamometry indicators and strength indices of the hands of both arms were significantly higher. Despite the local nature of hand strength measurement, the results of this study can be extrapolated to the general characteristics of the state of human strength abilities. This is evidenced by the results obtained in the motor test "pull-ups from a hang on a high bar". The results of this testing showed that the strength abilities of the young men of the experimental group were 25.5% higher compared to the results of the young men of the control group.

One of the features of cross-country skiing is the development of high coordination ability and dexterity, which are necessary to maintain dynamic and static balance. These qualities cause the development of psychomotor skills, which improves physical fitness and self-confidence. According to our observations, the results of the indicators in the test for coordination and dexterity (the "shuttle run 5x10" test) were 26.0% better for the young men of the experimental group than for the young men of the control group.

Students who used general physical training tools and methods in their classes had well-developed motor qualities of "speed", "flexibility" and "speed-strength endurance". This is due to the more frequent use of

loads in classes to develop speed qualities and acyclic exercises that are performed in anaerobic mode. This is reported in the study materials of Semeniv et al. (2021), with whose opinion we fully agree.

Our survey of students showed that about 68% of them prefer training in the gym, considering it a more convenient and accessible form of training. Such classes are less dependent on weather conditions and require less time to prepare for them. Students have an opinion about the improvement in physical fitness, appearance and well-being, which are associated with training in the gym and strength exercises.

However, the results of this study indicate that ski training has a number of benefits, including improved physical endurance, strength and coordination of movements, rapid recovery after training and a positive effect on the physical condition of students. Therefore, it is advisable to actively recommend the use of ski training among students and create conditions for its regular practice in regions with snowy landscapes. We agree with the opinion of Davydov et al. (2021) that the integration of ski training into the student environment can form a high motivation for physical activity and adherence to the basics of a healthy lifestyle for many years to come.

Conclusions

The conducted research project revealed the positive effect of ski training, which is included in the program of physical education classes for students, on the development of their physical and functional qualities. Regular skiing helps to increase endurance, coordination of movements and agility, as well as muscle strength compared to academic physical training classes in the gym. One of the main characteristics of ski training is the cyclic nature of performing physical activity in the aerobic mode of muscle work, which ensures an increase in the reserve capacity of the body and tolerance to physical activity. This is reliably evidenced by a decrease in the heart rate at rest, a reduction in the recovery time after a test load in the form of 20 squats in 30 seconds, a low Robinson index and effective dynamics of systolic and diastolic blood pressure. These students also have higher values of strength indicators in motor tests and strength dynamometry and strength indices of the muscles of the hands of both hands. The use of academic physical training in the gym in the physical education work program allows you to achieve high results in the development of speed, flexibility and speed-strength endurance, which can be important for achieving success in some sports and everyday life.

The results of the study emphasize the importance of individualizing curricula depending on the goals and needs of each student, as well as the possibility of including a variety of physical exercises for the harmonious development of physical and functional qualities. Despite the preference of male students for training in the gym, cross-country skiing may be more effective in developing physical health and in helping them adhere to the principles of a healthy lifestyle.

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

References:

- Andersson, E. P., Noordhof, D. A., & Løgdal, N. (2020). The anaerobic capacity of cross-country skiers: the effect of computational method and skiing sub-technique. *Frontiers in sports and active living*, 37(2). DOI:10.3389/fspor.2020.00037
- Baker, C., Kirby, J.B., O'Connor, J., Lindsay, K.G., Hutchins, A., & Harris, M. (2022). The perceived impact of ashwaagandha on stress, sleep quality, energy, and mental clarity for college students: qualitative analysis of a double-blind randomized control trial. *J Med Food*, 25(12), 1095-1101. DOI: 10.1089/jmf.2022.0042
- 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. DOI:10.1177/2047487318776079
- Bocharin, I. Guryanov, M., Kolokoltsev, M. et al. (2021). Cardiac diagnostics of student-athletes by the HRV method, *Journal of Physical Education and Sport*, 21(6), 3496-3503. DOI: 10.7752/jpes.2021.06473
- Bocharin, I., Guryanov, M., Romanova, E., Pozdeeva, A., Kolokoltsev, M., Vorozheikin, A., Malkin, A., Poboronchuk, T., Lobastova, R., & Kovalev, A. (2023). Instrumental control of functional indicators in students with health deviation. *Journal of Physical Education and Sport*, 23(5), 1096-1102. DOI:10.7752/jpes.2023.05137
- Bushmanova, E. A., & Lyudinina, A. Y. (2024). Bioimpedance analysis of body composition and resting energy expenditure in elite cross-country skiers. *Voprosy pitaniia*, 93(3), 23-30. DOI:[10.33029/0042-8833-2024-93-3-23-30](https://doi.org/10.33029/0042-8833-2024-93-3-23-30)
- Davydov, M.V., Alekseeva, N.D., Ivachev, A.A., & Alekseev, M.V. (2021). The impact of skiing training on the motivational and value-based attitude of students and university staff to physical education and sports. *Scientific Notes of P.F. Lesgaft University*, 201(11), 115-118. Available from 115.pdf (lesgaft-notes.spb.ru)
- Eksterowicz, Jerzy, & Napierała, Marek (2020). Sexual dimorphism of the selected somatic features of students attending physical education course in Kazimierz Wielki University during the years 2006-2017. *Journal of Physical Education and Sport*, 20(1), Art 32, pp. 242 – 248. DOI:10.7752/jpes.2020.01032

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- Faílde-Garrido, J.M., Ruiz Soriano, L., & Simón, M.A. (2022). Levels of physical activity and their relationship with motivational determinants, self-regulation, and other health-related parameters in university students. *Psychol Rep*, 125(4), 1874-1895. DOI: 10.1177/00332941211005116
- Grajek, M., & Sobczyk, K. (2021). Well-being levels among students during the COVID-19 pandemic. *Journal of Physical Education and Sport*, Vol. 21 (4), Art 213, pp. 1682 – 1687. DOI:10.7752/jpes.2021.04213
- Grzebisz-Zatońska, N., Grzywacz, T., & Waśkiewicz, Z. (2021). The Influence of endurance training on the lipid profile, body mass composition and cardiovascular efficiency in middle-aged cross-country skiers. *International journal of environmental research and public health*, 18(20), 10928. DOI:[10.3390/ijerph182010928](https://doi.org/10.3390/ijerph182010928)
- Jellestad, P. L., & Holm, M. O. (2023). Frostbite treated with hyperbaric oxygen. *Ugeskrift for laeger*, 185(15), V09220522. Frostbite treated with hyperbaric oxygen - PubMed (nih.gov)
- Karlsson O., Gilgien M., Gloersen O.N., Rud B., & Losnegard T. (2018). Exercise intensity during cross-country skiing described by oxygen demands in flat and uphill terrain. *Front Physiol*. 846(9). DOI: 10.3389/fphys.2018.00846
- Kolokoltsev, M. M., Ermakov, S. S., Tretyakova, N. V., Krainik, V. L., & Romanova, E. V. (2020). Physical activity as a factor in improving the quality of life of students. *Education and Science*, 22(5). DOI:10.17853/1994-5639-2020-5-150-168
- Kropta, R., Khmelnytska, Y., Hruzevych, I., Kormiltsev, V., Yefanova, V., Smirnova, Z., Tron, R., & Stankevich, L. (2020). Realization of the functional preparedness of the ski athletes under the model conditions of competitive distance. *Journal of Physical Education and Sport*, 20(1), Art 22, pp. 164 – 169. DOI:10.7752/jpes.2020.01022
- Kučerová, Š. P., Hamerlik, L., Kovařík, D., Valdová, M., Gavronová, A., Rudinská, L. I., Vlčková, A., & Hejna, P. (2024). Avalanche fatalities in Czech Republic: a 23-years retrospective study. *Soudní lékařství*, 69(2), 14-19. Energy system contribution during competitive cross-country skiing. PubMed (nih.gov)
- Losnegard, T. (2019). Energy system contribution during competitive cross-country skiing. *European journal of applied physiology*, 119(8), 1675–1690. DOI:[10.1007/s00421-019-04158-x](https://doi.org/10.1007/s00421-019-04158-x)
- Lukina S.M., Lobanov Yu.Ya., Sharonova A.V., Yarchikovskaya L.V., & Mironova O.V. (2019). Mastering the discipline "physical education and sport" in the university using innovative technologies. *Theory and practice of physical education*, 4, 44-46. Available from <https://www.teoriya.ru/ru/node/9709>
- Mazin, V., Kovalov, Y., & Bytsiuk, V. (2021). Effect of fitness classes on the physical and mental health of 35-55-year-old women living in Australia, Ukraine, and the UAE. *Journal of Physical Education and Sport*, 21 (3), Art 179, pp. 1406 - 1412, DOI:10.7752/jpes.2021.03179
- Nakai, A. (2020). Effects of the net efficiency of roller skiing on cross-country ski racing performance using the diagonal stride. *Journal of Physical Education and Sport*, Vol 20 (Supplement issue 3), Art 283, pp 2104 – 2109. DOI:10.7752/jpes.2020.s3283
- PCFSN. The president's challenge: Physical fitness test (2011). Available from: The President's Physical Fitness test - Grade Valley
- Robinson, B.F. (1967). Relation of heart rate and systolic blood pressure to the onset of pain in angina pectoris. *Circulation*, 35, 1073-1083. DOI:10.1161/01.CIR.35.6.1073
- Romanova, E., Kolokoltsev, M., Vorozheikin, A., Kononov, D., Vrachinskaya, T., Fedorov, V., Kondrashova, Y., Aganov, S., & Garov, S. (2023). The dependence of the academic performance of university students on the level of their physical activity. *Journal of Physical Education and Sport*, 23 (2), Art 45, pp. 379 – 384. DOI:10.7752/jpes.2023.02045
- Semeniv, D.A., Osten, V.A. & Mamulevich, A.V. (2021). Use of general physical fitness tools for students of higher education institutions in the practical module of the discipline "Physical Education". *International Journal of Humanities and Natural Sciences*, 5-1 (56). DOI:10.24412/2500-1000-2021-5-1-219-222.
- Snezhitsky, P., Romanova, E., Kolokoltsev, M. et al. (2022). Complex pedagogical diagnostics of personal motor activity. *Journal of Physical Education and Sport*, 22(11), 2681-2687. DOI 10.7752/jpes.2022.11341
- Stöggli, R., Müller, E., & Stöggli, T. (2023). Technique and maximal skiing speed for youth cross-country skiing performance. *Front. Sports Act. Living* 5:1133777. DOI: 10.3389/fspor.2023.1133777
- Svensson, M., Erhardt, S., Hållmarker, U., James, S., & Deierborg, T. (2022). A physically active lifestyle is associated with lower long-term incidence of bipolar disorder in a population-based, large-scale study. *International journal of bipolar disorders*, 10(1), 26. DOI:10.1186/s40345-022-00272-6
- Syamsudin, F., Wungu, Citra Wati Dyah Kencono, Qurnianingsih, E., & Herawati, L. (2021). High-intensity interval training for improving maximum aerobic capacity in women with sedentary lifestyle: a systematic review and meta-analysis. *Journal of Physical Education and Sport*, 21(4), Art 226, pp. 1788 - 1797. DOI:10.7752/jpes.2021.04226
- Vorozheikin, A., Romanova, E., Kolokoltsev M. et al. (2022). Combined program for young skiers' special endurance development during the preparatory period of the annual macrocycle. *Journal of Physical Education and Sport*, 22(4), 941-947. DOI 10.7752/jpes.2022.04119
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