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Original article

Assessment of the functional state of the cardiovascular system of students during a mountain hiking trip

Alexander Skaliy[1ABCE], Kateryna Mulyk[2ABCE], Zhijing Ban[2,3CEFG], Andrzej Ostrowski[4CEFG], Olena Anosova[2ABCE]

[1]University of Economy in Bydgoszcz, Poland
[2]Kharkiv State Academy of Physical Culture, Ukraine
[2]Longbai Group, China
[4]Akademia Wychowania Fizycznego im. Bronisława Czecha w Krakowie, Poland

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim. In the conditions of hiking trip, a particularly important role is played by the high adaptive abilities of the body, based on the reactivity and lability of functional systems. Of particular importance is the assessment of the functional state of the cardiovascular system of students when participating in a mountain hike. The purpose of the study is to evaluate the effect of physical activity on the state of the cardiovascular system of students in the process of overcoming a mountain hiking trip.

Material and Methods. The study involved 30 students aged 18-22 years old who were involved in various sports at the amateur level. The hiking trip lasted six days and covered 114 km. Canyon SportMaster hand-held heart rate monitors were used to determine the power of the students' cardiovascular system. When overcoming climbs during a mountain hike, the rate of heart rate recovery after physical activity was determined (heart rate indicators were recorded before the climb, at the end of the climb, and two minutes after the climb).

Results. Analysis of the data obtained showed that the power of the cardiovascular system changed during the hiking trip. The third day turned out to be the most difficult day; the level of power of the cardiovascular system on this day was 76% of the maximum. In all subsequent days, the tourists' cardiovascular system coped with the stress much better. The indicators obtained on the last day of the hike indicate the adaptive changes that occurred in the athletes' bodies.

Conclusions. It was found that on the first day of the hike the cardiovascular system worked at a sufficient level. In the next two days, there was a decrease in recovery rates and a deterioration in the performance of the cardiovascular system. This is explained by fatigue after the first day, and the fact that the body has not yet had time to work and adapt to unusual loads. Analysis of the last three days of the hike clearly indicates that the body systems have adapted to the stress and environment. Heart rate recovery indicators went up sharply, and the heart rate system worked at only 65% of maximum power. Also, important factors that also need to be taken into account: the weight of the backpacks, the length of the distance, weather conditions, temperature conditions, the psychological atmosphere in the group, equipment, etc.

Keywords: sports tourism, students, cardiovascular system, adaptation.

Анотація

Оцінка функціонального стану серцево-судинної системи студентів в процесі подолання гірського туристського походу

Олександр Скалій, Катерина Мулик, Чжіцзін Бань, Анджей Островський, Альона Аносова.

Передумови та мета дослідження. В умовах туристських походів особливо важливу роль відіграють високі адаптивні здатності організму, що ґрунтуються на реактивності та лабільності функціональних систем. Особливе значення має оцінка функціонального стану серцево-судинної системи студенів під час участі у гірському поході. Мета дослідження – оцінити вплив фізичних навантажень на стан серцево-судинної системи студентів в процесі подолання гірського туристського походу.

Матеріал і методи. У дослідженні взяли участь 30 студентів віком 18-22 років, які займалися різними видами спорту на аматорському рівні. Похід тривав шість днів протяжністю 114 кілометрів. Для визначення потужності роботи серцево-судинної системи студентів використовувались ручні пульсометри Canyon SportMaster. При подоланні підйомів під час гірського походу визначалася швидкість відновлення ЧСС після навантаження (реєструвалися показники пульсу перед підйомом, в кінці підйому, і через дві хвилини після підйому).

Результати. Аналіз отриманих даних показав, що потужність роботи серцево судинної системи протягом походу змінювалась. Найважчим днем виявився третій, рівень потужності роботи серцево-судинної системи склав 76% від максимального. У всі наступні дні серцево-судинна система туристів з навантаженнями справлялася значно краще. Показники отримані в останній день походу свідчить про адаптаційні зміни, які відбулися в організмі спортсменів.

Висновки. Встановлено, що у перший день походу серцево-судинна система працювала на достатньому рівні. У наступні два дні відбулося зниження показників відновлення, та погіршення працездатності серцево-судинної системи. Це пояснюється втомою після першого дня, і тим, що організм ще не встиг впрацюватися і адаптуватися до незвичних навантажень. Аналіз останніх трьох днів походу чітко вказує на те, що відбулась адаптація систем організму до навантажень і навколишнього середовища. Показники відновлення ЧСС різко пішли в гору, а ССС працювала лише на 65% від максимальної потужності. Також важливими факторами, які теж необхідно враховувати є: вага рюкзаків, довжина дистанції, погодні умови, температурні режими, психологічна атмосфера в групі, екіпіровка тощо.

Ключові слова: спортивний туризм, студенти, серцево-судинна система, адаптація.

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Introduction

The issue of physical education of student youth today receives a lot of attention. A number of dissertation studies have been carried out [2; 10], which determines preferences for certain types of physical education activities.

At the same time, there is a general opinion that the existing 2-time physical education classes are not enough for the health and recreation of student youth. This is due to conditions of insufficient motor mode. Students spend a long time in classrooms, sitting at a table, working with a computer. As a result of this, their blood circulation and posture are disrupted, which leads to a decrease in performance and the occurrence of prenosological health problems [24]. Therefore, it is necessary to prevent and overcome these risk factors. The main tool of this activity is physical exercise in the form of various types of sports and recreational activities, especially those that take place outdoors. These types include all types of tourism.

It is known that tourist activities have a strong reflex and diverse physiological effect on the body of adolescents and young people. As a result, a number of local and general reactions occur, in which all organs and systems participate. Walking, weekend hikes and multi-day hikes help relieve tension and activate the mental processes of schoolchildren and students after educational activities, which means rapid recovery and increased mental performance [14].

The main feature of sports and health tourism is that, unlike most other sports, it does not require relatively large material costs. This type of recreation develops in the existing environment and does not require significant capital investments for the preparation and holding of tourist and sports mass events and the construction of special structures for their holding. Material, technical and organizational support for these events is largely carried out by the forces and resources of the tourists themselves.

Sports tourism is one of the important means of harmonious development, physical improvement, health change, and attracting people to physical activity. Today, sports tourism is developing in two directions: organizing and conducting competitions in types of tourism, which involves identifying and unified comparison of athletes' abilities to overcome natural obstacles and organizing and conducting sports multi-day hikes. Sports tourism is available for different age categories; athletes, from children aged 10 to old age inclusive, can participate in tourism activities available to them. Participation in multi-day hikes requires significant thorough preparation, which is carried out in the following areas: organizational, topographical, technical, tactical, psychological and physical.

In the conditions of hiking trips, a particularly important role is played by the high adaptive abilities of the body, based on the reactivity and lability of functional systems. An increase in such lability under the influence of muscle activity underlies the process of physical training and ensures the functional restructuring of the body in conditions of hiking trips [14; 20].

Research on the impact of sports tourism on the human body is extremely insufficient. Several areas of research can be identified, which were reflected in works on: content and teaching methods [1]; the influence of category hiking trips on the body of tourists [3]; psychological and pedagogical aspects in tourism [18]; pre-trip preparation [12; 25; 15]; the use of tourism elements for the treatment and prevention of certain types of diseases, in particular, diseases of the respiratory and cardiovascular systems [9]; [17]; training for sports and health tourism [13].

Physical activity as a form of human life activity is carried out under certain environmental conditions and under certain neuromuscular loads. The external environment supports the vital functions of the body, supplying it with oxygen and food necessary to replenish energy. At the same time, the human body is a system that is both closely connected with the external environment and sharply separated from it. This means that the body has its own internal environment, which is significantly different from the external one. A characteristic feature of the internal environment of the body is its relative constancy. Regardless of any changes in external conditions, the internal environment remains constant, which is a necessary condition for the life of the organism.

Human health presupposes a fairly high level of physical fitness, physical development and performance. This raises the problem of finding physical activity that is adequate to the physical condition of the individual. This problem, first of all, faces coaches, whose goal, on the one hand, is to contribute to the achievement of high sports results of their students, and on the other, to maintain and improve the physical condition of the athletes' bodies without mobilizing their reserve capabilities.

The level of preparedness of athletes in modern sports determines the functional state of organs and systems. Assessing the state of the cardiovascular system is of particular importance. Similar results have been reported in other studies.

Thus, the authors of Fesyun et al., 2019 assessed the functional state of the cardiovascular system of people involved in physical education and sports. The results of the study showed that athletes involved in cyclic sports have a high degree of adaptation of the cardiovascular system to physical activity compared to athletes involved in team sports.

The study by Vorobieva et al., 2019 showed that the nature of work and rest is important when studying the indicators of the cardiovascular system of badminton athletes, which is reflected in the characteristics of adaptation to physical activity. The authors proved that the level of adaptation is much better due to the high level of fitness of the athletes' bodies.

Based on the above, the **purpose of this study** was to evaluate the effect of physical activity on the state of the cardiovascular system of students in the process of overcoming a mountain hiking trip.

Materials and Methods

Participants.

The study involved 30 students of the Faculty of Physical Education of the Ternopil National Pedagogical University named after Vladimir Hnatyuk aged 18-22 years. Students engaged in various sports at the amateur level.

Ethics Statements and Participants.

This study was approved by the Bioethics Committee for Clinical Research and conducted according to the Declaration of Helsinki. All participants gave their written consent to research and were informed about the purpose and test procedures and about the possibility of withdrawal of consent at any time for any reason.

Study design.

The study involved assessing the level of functional state of the cardiovascular system of students during mountain sports hiking. The hiking trip lasted six days and covered 114 km.

Determining the power of the cardiovascular system and the rate of recovery of heart rate after exercise made it possible to see the dynamics of the functional state of the participants in

accordance with the loads received when overcoming climbs.

The power of the cardiovascular system was determined using data obtained from a manual heart rate monitor Canyon SportMaster CNS-SW1 (manufacturer: China).

Determination of the reaction of heart rate to the load and the rate of its recovery was carried out during the passage of climbs (sections with a sharp change in height from less to greater, steeper than 30° and length of at least 100 m). The height and dynamics of its change were determined using a tourist hand-held computer SkiMaster CNS-SW3.

Heart rate monitor readings were recorded before the start of the climb and at its top. On the first day of the hike, six ascents were recorded, on the second day – seven, on the third day only three ascents were recorded, this is due to the topography of this route; in the last three days of the hike, five ascents were recorded (Figure 1).

To analyze the dynamics of the cardiovascular system during physical activity, its power was determined during each day of the hike, which was estimated in % relative to the maximum. The maximum power is determined using a special program in the CANYON heart rate monitor. The heart rate monitor automatically determined and displayed on the display the power of the cardiovascular system relative to the maximum as a percentage.

All obtained indicators were recorded before and after the physical activity (climbing a slope with a steepness of more than 30° and a length of at least 100 m).

When overcoming climbs during a mountain hike, we also determined the rate of heart rate recovery after the physical activity. Heart rate readings were recorded before the ascent, at the end of the ascent, and two minutes after the ascent.

A statistical analysis of the obtained data was carried out using the licensed program MS Excel. Descriptive statistics indicators were determined: arithmetic mean (X), standard deviation (SD) and coefficient of variation (V). The Ruffier Index was used to determine the response of the cardiovascular system to physical activity. The significance of the differences was assessed using the t-test (Student's test), the differences were considered significant at ($p<0,05$) given the small size of the groups. Data processing was carried out using Microsoft Excell's Data Analysis research programs.

Results

The results of changes in heart rate indicators of students in the process of overcoming climbs while participating in a mountain hike are presented in Table 1. Thus, it was found that heart rate indicators before the physical activity (before the climb) and after the physical activity (at the end of the climb) have significant differences ($p<0,001$). Similar results were obtained when comparing heart rate results after a physical activity (at the end of the climb) and after rest (after 2 minutes) ($p<0,001$).

When comparing heart rate indicators before physical activity and after rest, no significant differences were found, which indicates a sufficient level of preparedness for physical activity during the route. However, on the first day after the first ascent, significant differences were established for the same indicators ($t=7.3$; $p<0.001$), this indicates that the cardiovascular system of students has not yet adapted to the non-standard load.

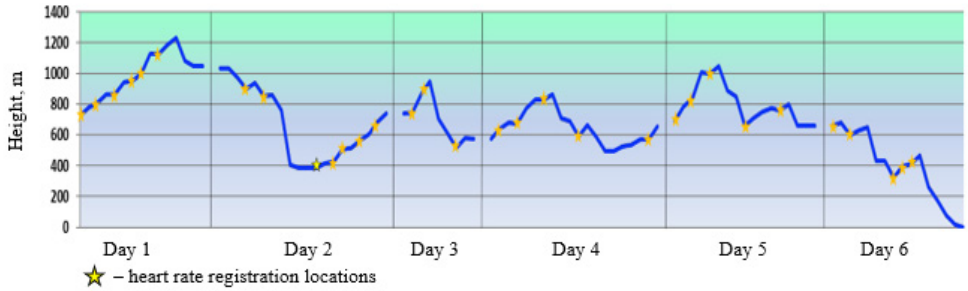

Figure 1. Graph of altitude difference and recording of heart rate characteristics by a group of tourists.

Table 1. Heart rate results of students in the process of overcoming climbs during a mountain hike ($n_1= n_2= n_3=30$)

	Before physical activity		After physical activity		Recovery (after 2 minutes)		Assessment of reliability	
	$X_1±SD_1$	V_1	$X_2±SD_2$	V_2	$X_3±SD_3$	V_3	t	p
Day 1								
Climb 1	80,0±7,49	1,07	133,1±19,31	6,9	101,4±14,22	7,1	$t_{1,2}=14,0$ $t_{2,3}=7,2$ $t_{1,3}=7,3$	$p_{1,2}<0,001$ $p_{2,3}<0,001$ $p_{1,3}<0,001$
Climb 2	103,8±15,87	6,5	150,2±14,89	10,1	112,5±17,78	6,3	$t_{1,2}=11,7$ $t_{2,3}=8,9$ $t_{1,3}=2,0$	$p_{1,2}<0,001$ $p_{2,3}<0,001$ $p_{1,3}>0,05$
Climb 3	117,7±17,16	6,9	152,0±16,23	9,4	115,1±19,40	5,9	$t_{1,2}=8,0$ $t_{2,3}=8,0$ $t_{1,3}=0,5$	$p_{1,2}<0,001$ $p_{2,3}<0,001$ $p_{1,3}>0,05$
Climb 4	119,5±17,89	6,7	154,4±16,86	9,2	117,0±17,62	6,6	$t_{1,2}=7,8$ $t_{2,3}=8,4$ $t_{1,3}=0,5$	$p_{1,2}<0,001$ $p_{2,3}<0,001$ $p_{1,3}>0,05$
Climb 5	117,8±15,85	7,4	147,4±16,33	9,0	120,4±14,72	8,2	$t_{1,2}=7,1$ $t_{2,3}=6,7$ $t_{1,3}=0,6$	$p_{1,2}<0,001$ $p_{2,3}<0,001$ $p_{1,3}>0,05$

Climb 6	98,5±16,42	6,0	139,0±23,00	6	109,1±15,55	7,0	$t_{1,2}$=7,9 $t_{2,3}$=5,9 $t_{1,3}$=2,6	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,05
Day 2								
Climb 1	102,0±16,23	6,3	133,8±17,08	7,8	110,9±19,70	5,6	$t_{1,2}$=7,4 $t_{2,3}$=4,8 $t_{1,3}$=1,9	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 2	110,0±21,47	5,1	154,2±22,26	6,9	107,3±17,68	6,1	$t_{1,2}$=7,8 $t_{2,3}$=9,0 $t_{1,3}$=0,5	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 3	107,3±18,92	5,7	151,2±13,10	11,5	107,4±15,21	7,1	$t_{1,2}$=10,4 $t_{2,3}$=12,0 $t_{1,3}$=0	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 4	95,4±16,15	5,9	154,8±24,04	6,4	113,3±19,52	5,8	$t_{1,2}$=11,2 $t_{2,3}$=7,3 $t_{1,3}$=3,9	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,001
Climb 5	120,9±18,43	6,6	164,1±16,49	9,9	116,0±15,16	7,7	$t_{1,2}$=9,6 $t_{2,3}$=11,8 $t_{1,3}$=1,1	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 6	96,6±12,37	7,8	159,1±19,57	8,1	114,5±17,81	6,4	$t_{1,2}$=14,8 $t_{2,3}$=9,2 $t_{1,3}$=4,5	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,001
Climb 7	105,9±11,17	9,5	148,9±13,64	10,9	110,7±11,38	9,7	$t_{1,2}$=13,4 $t_{2,3}$=11,8 $t_{1,3}$=1,6	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Day 3								
Climb 1	99,2±16,44	6,0	154,9±19,67	7,9	108,3±14,75	7,3	$t_{1,2}$=11,9 $t_{2,3}$=10,4 $t_{1,3}$=2,2	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,05
Climb 2	103,1±11,07	9,3	153,5±17,33	8,9	108,2±13,87	7,8	$t_{1,2}$=13,4 $t_{2,3}$=11,2 $t_{1,3}$=1,6	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 3	90,0±12,27	7,3	156,2±12,12	12,9	105,4±12,47	8,5	$t_{1,2}$=21,0 $t_{2,3}$=16,0 $t_{1,3}$=4,8	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,001
Day 4								
Climb 1	94,5±13,42	7,0	139,5±20,33	6,9	103,1±17,83	5,8	$t_{1,2}$=10,1 $t_{2,3}$=7,4 $t_{1,3}$=2,1	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,05
Climb 2	102,5±13,37	7,7	146,6±26,62	5,5	98,4±18,87	5,2	$t_{1,2}$=8,1 $t_{2,3}$=8,1 $t_{1,3}$=1,0	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 3	99,8±14,57	6,8	148,5±22,60	6,6	104,3±18,12	5,8	$t_{1,2}$=9,9 $t_{2,3}$=8,4 $t_{1,3}$=1,0	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 4	93,1±15,62	6,0	142,1±21,61	6,6	101,3±14,66	6,9	$t_{1,2}$=10,1 $t_{2,3}$=8,6 $t_{1,3}$=2,1	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,05
Climb 5	110,4±20,70	5,3	148,7±14,54	10,2	106,3±11,11	9,6	$t_{1,2}$=8,3 $t_{2,3}$=12,7 $t_{1,3}$=0,9	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Day 5								
Climb 1	90,8±14,66	6,2	138,8±18,21	7,6	97,7±16,00	6,1	$t_{1,2}$=11,2 $t_{2,3}$=9,3 $t_{1,3}$=1,8	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 2	96,7±16,07	6,0	132,2±24,50	5,4	93,7±19,16	4,9	$t_{1,2}$=6,6 $t_{2,3}$=6,8 $t_{1,3}$=0,6	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 3	87,8±8,56	10,2	135,5±19,97	6,8	94,4±13,20	7,1	$t_{1,2}$=12,0 $t_{2,3}$=9,4 $t_{1,3}$=2,3	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,05
Climb 4	95,4±18,37	5,2	139,8±14,79	9,4	94,7±16,61	5,7	$t_{1,2}$=10,3 $t_{2,3}$=11,1 $t_{1,3}$=0,2	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 5	99,3±16,11	6,2	137,6±13,50	10,2	97,1±12,58	7,7	$t_{1,2}$=10,0 $t_{2,3}$=12,0 $t_{1,3}$=0,6	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Day 6								

Climb 1	84,7±8,59	9,9	112,4±20,18	5,6	87,0±15,32	5,7	$t_{1,2}$=6,9 $t_{2,3}$=5,5 $t_{1,3}$=0,7	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 2	99,6±11,93	8,4	128,4±14,82	8,7	101,6±10,71	9,5	$t_{1,2}$=8,3 $t_{2,3}$=8,0 $t_{1,3}$=0,7	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 3	90,4±15,71	5,8	148,6±19,56	7,6	105,4±14,12	7,5	$t_{1,2}$=12,7 $t_{2,3}$=9,8 $t_{1,3}$=3,9	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$<0,001
Climb 4	100,7±13,06	7,7	139,5±21,63	6,4	97,3±15,03	63,5	$t_{1,2}$=8,4 $t_{2,3}$=8,8 $t_{1,3}$=0,9	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05
Climb 5	98,2±11,72	8,4	134,8±15,20	8,9	99,6±11,36	8,8	$t_{1,2}$=10,5 $t_{2,3}$=10,2 $t_{1,3}$=0,5	$p_{1,2}$<0,001 $p_{2,3}$<0,001 $p_{1,3}$>0,05

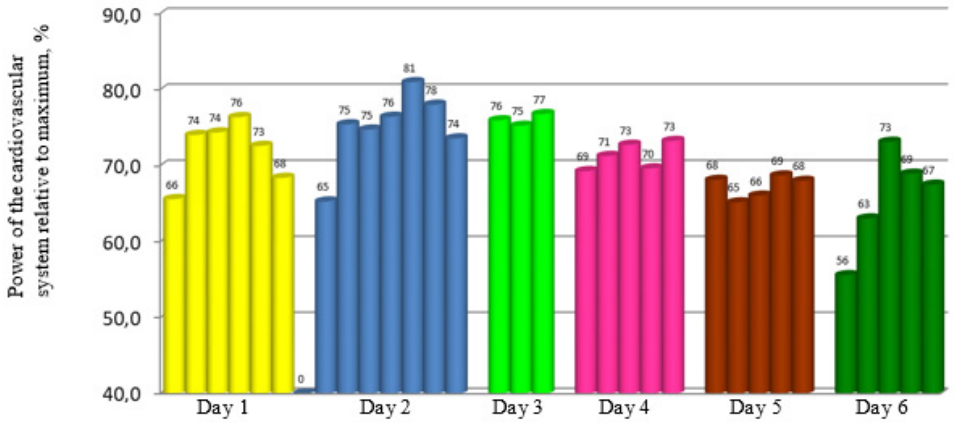

Figure 2. Dynamics of cardiovascular power relative to the maximum for the entire group when overcoming each climb.

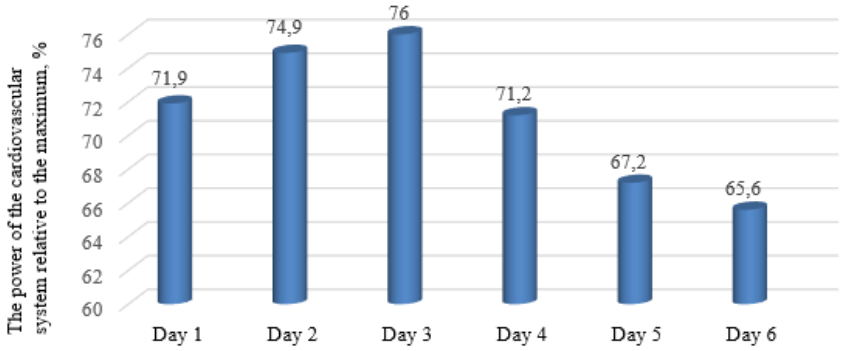

Figure 3. Dynamics of the power of the cardiovascular system relative to the maximum for the entire group (average values per day)

Also, as a result of calculations, the daily dynamics of the cardiovascular system of the entire group was obtained (Figure 2).

Having analyzed these graphs, you can see how the power of the cardiovascular system changed during the hike. The third day turned out to be the most difficult day; the level of power of the cardiovascular system was 76% of the maximum. On all subsequent days, the cardiovascular system of tourists coped with physical activity much better, and on the last day the average power indicator was only 65.6%. This means that the group worked at only 65% of maximum power, and also indicates the adaptive changes that occurred in the athletes' bodies (Figure 3).

Having analyzed the heart rate recovery graphs of each of the tourists, it was found that no significant differences were identified, therefore a graph of heart rate recovery for the entire group as a whole according to the Rufier Index is shown (Figure 4).

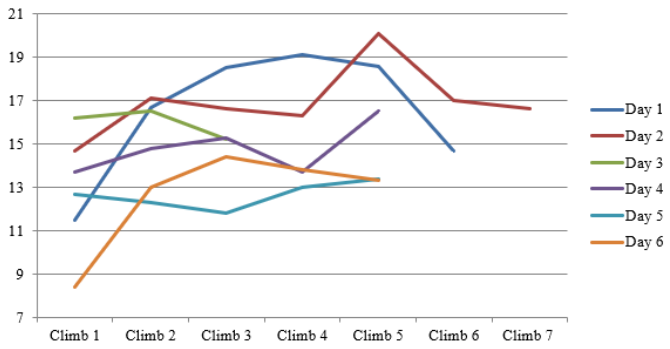

Figure 4. Graph of recovery of the pulse of a group of tourists according to the Ruffier Index, conventional units.

The graph clearly shows how heart rate recovery changes with the duration of the hike. Having analyzed each

day, we can say that the recovery of heart rate on almost every climb was within the normal range. Over the next two days, heart rate recovery decreased sharply. This can be explained by fatigue after the first day and the fact that the body has not yet had time to adapt to such loads, however, reliable conclusions require more in-depth research and analysis of these indicators. Important factors, in our opinion, also need to be taken into account: the weight of backpacks, distance length, weather conditions, temperature conditions, psychological atmosphere in the group, equipment.

However, analysis of the results of the last three days of the hike clearly indicates that adaptation of the body systems to the physical activity and the environment occurred.

Discussion

Today, sports and health tourism is very popular among students, this is due to: the need for social interaction with peers, the need for aesthetic satisfaction from the environment, acquiring new skills and physical development during hikes. What is confirmed by the study of motives for engaging in sports tourism [16; 23].

In addition to obtaining aesthetic satisfaction and the need for physical development, sports tourism has great health value for different groups of the population. A study is devoted to the issue of student health [10]. It is staying in natural conditions and the positive influence of climate, forest resources, and landscape features that greatly contribute to the relief of stress, positive mood and general health of the tourist. Low mountain areas are especially suitable for this. The attractiveness of foothill and low-mountain areas is determined by a favorable climate and, most often, good transport accessibility [5].

Sports tourism, like any type of physical activity, has positive and negative features. It places high demands on the level of physical fitness of athletes. Numerous scientific studies [4; 8; 9], show that the physical and psychophysiological parameters of the body, especially children, adolescents and students, are significantly influenced by the volume of physical activity, which should not be limited only by classes in an educational institution.

In the conditions of hiking trips, a particularly important role is played by the high adaptive abilities of the body, based on the reactivity and lability of functional systems. An increase in such lability under the influence of muscle activity underlies the process of physical training and ensures the functional restructuring of the body in extreme conditions.

The effect on the functional state of athletes of various qualifications and sports has been studied by a large number of scientists. Podrihalo O. et al., 2023, made a comparative analysis of the results of the tapping test for taekwondo athletes of all ages and found that positive changes in the functional state of athletes occur under the influence of regular physical activity. The results reflect an increase in the strength of the nervous processes of taekwondo athletes of all ages.

The choice of the cardiovascular system as a tool for monitoring the condition of participants is due to its physiological significance and the informativeness of control and monitoring indicators. Many works have been devoted to the study of the cardio system of students involved in various sports. The level of vegetative balance and adaptive reserves of the body of student-athletes was determined by the method of monitoring heart rate variability (HRV) [2]. This technique is most convenient for population studies and identification of prenosological health disorders. The assessment of the functional reserves of the cardiorespiratory system in students of cadet corps was studied in a study by Eisfeld et al., 2021. It has been proven that sufficient physical activity of cadets improves indicators of physical development and muscle strength, which is accompanied by an increase in the functional reserves of the respiratory and cardiovascular systems.

It is known that the most reliable information about the state of the cardiovascular system is obtained by determining heart rate and blood pressure. But in the field, determining blood pressure is not very convenient, takes extra time and to a certain extent affects the results. Therefore, the study used only heart rate determination.

The rapid development of multimedia technologies, their penetration into everyday life, including learning, leisure and recreation, has led to the emergence of a new concept of “gamification”. This is a technology for adapting gaming methods to non-game processes and events. Its main principle is to ensure the receipt of constant, quantitative feedback from the user, providing the ability to dynamically adjust his behavior. Gamification helps create interest among users in achieving any set goals. In addition, gamification uses a gradual change and complication of goals and objectives as users acquire new skills and abilities. In fact, gamification consists of using special programs and mobile applications to monitor a person’s condition while performing any activity. In this study, the principles of gamification were implemented using the Canyon SportMaster CNS-SW1 handheld heart rate monitor. This approach is quite widespread in sports science.

Currently, sports bracelets are widely used in scientific research to monitor the heart rate of athletes. The use of such devices is discussed in the study [19]. The general structure of heart rate monitoring is presented and the heart rate monitoring algorithm is described in detail. The bracelet records your heart rate by measuring the reflected light from the skin of your hand. It has been experimentally proven that indicators for sports basketball are informative. The use of this device is simple, so you can use it during the training process without unnecessary intervention.

Sports bracelets have also been used in a study of adult patients performing intense physical activity (cycling or athletics) [11]. It was found that heart rate indicators from the bracelet correspond to ECG measurements during physical activity of moderate and high intensity. Therefore, the authors suggest using sports bands instead of ECGs or heart rate monitors with a chest strap during moderate- to vigorous-intensity physical activity.

The following study compares metrics (heart rate, energy expenditure, and maximal oxygen consumption) from a wrist-based optical heart rate monitor to reference research methods [21]. The results indicate that the sports bracelet can accurately estimate heart rate during high-intensity running.

Therefore, to determine the power of the cardiovascular system in our study, a group of tourists used hand-held heart rate monitors Canyon SportMaster CNS-SW1. This made it possible to obtain informative data assessing the state of the cardiovascular system of students in the process of overcoming climbs while participating in a mountain hike.

The results obtained confirm existing data from other scientists. The level of adaptation is much better due to the highly trained body of athletes [26]. The nature of work (physical activity) and rest is important for the cardiovascular system. This mode of operation has a positive effect on adaptation to physical activity. It was concluded that during the hikes, overcoming physical activity and rest are also used, which had a positive effect on the adaptive capabilities of student-athletes.

Athletes involved in cyclic sports have a high level of adaptation of the cardiovascular system to physical activity

[7]. Movements in sports tourism are also cyclical. Such as: walking, running, skiing, cycling, rowing, etc.

Conclusions

An analysis of the work of the cardiovascular system of students in the process of overcoming a mountain hiking trip showed that there was an adaptation of the body systems to physical activity during a hiking trip. It was found that on the first day of the hike the cardiovascular system worked at a sufficient level. In the next two days, there was a decrease in recovery rates and a deterioration in the performance of the cardiovascular system. This is explained by fatigue after the first day, and the fact that the body has not yet had time to work and adapt to unusual loads. Analysis of the last three days of the hike clearly indicates that the body systems have adapted to the stress and environment. Heart rate recovery rates went up sharply, and the cardiovascular system worked at only 65% of maximum power. Also, important factors that also need to be taken into account: the weight of the backpacks, the length of the distance, weather conditions, temperature conditions, the psychological atmosphere in the group, equipment, etc.

The study confirmed that the implementation of gamification principles, namely the use of the Canyon SportMaster CNS-SW1 hand-held heart rate monitor during a hike, is a mobile, informative and effective means of monitoring the cardiovascular system. This approach is quite widespread in sports science.

Conflicts of Interest
The authors declare no conflict of interest.

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Authors:

Alexander Skaliy: https://orcid.org/0000-0001-7480-451X, skaliy@wp.pl,. Institute of Sports and Physical Culture of University of Economy in Bydgoszcz, Garbary 2, Bydgoszcz, 85-229, Poland

Kateryna Mulyk (Correspondent author): https://orcid.org/0000-0002-6819-971X, kateryna.mulyk@gmail.com, Kharkiv State Academy of Physical Culture, str. Klochkivska, 99, Kharkiv 61058, Ukraine

Zhijing Ban: https://orcid.org/0000-0003-3022-039X, banzhijing@126.com, Kharkiv State Academy of Physical Culture, str. Klochkivska, 99, Kharkiv 61058, Ukraine; Longbai Group, Shangyu Economic Dev. Zone Shangyu, Zhejiang, 312300 China

Andrzej Ostrowski: http://orcid.org/0000-0003-3075-093X, andrzejostrowski@poczta.fm, Akademia Wychowania Fizycznego im. Bronisława Czecha w Krakowie, Al. Jana Pawła II 78, Kraków, 31-571, Poland

Olena Anosova: https://orcid.org/0000-0003-1185-0740, alena.anosova84@gmail.com, Kharkiv State Academy of Physical Culture, str. Klochkivska, 99, Kharkiv 61058, Ukraine