Comparative analysis of morphometric indicators in skiers

Isaev Aleksandr Petrovich
Doctor of Biological Sciences, Professor, Department of Theory and Methods of Physical Education and Sports
South Ural State University
Chelyabinsk, Russia
isaevap@susu.ru
0000-0003-2640-0240

Zaliapin Vladimir Ilyich
Candidate of Physical and Mathematical Sciences, Professor of the Mathematical Analysis and Mathematics Teaching Methods Department,
South Ural State University
Chelyabinsk, Russia
zaliapinvi@susu.ru
0000- 0001-6981-6305

Maleev Dmitriy Olegovich
Candidate of Pedagogical Sciences, Associate Professor, Head of the Ski Sports Department
Tyumen State University
Tyumen, Russia
massport@mail.ru
0000-0003-4254-1705

Nenasheva Anna Valerievna
Doctor of Biological Sciences, Associate Professor, Head of the Department of Theory and Methods of Physical Education and Sports,
South Ural State University
Chelyabinsk, Russia
nenashevaav@susu.ru
0000-0001-7579-0463

Erlikh Vadim Viktorovich
Doctor of Biological Sciences, Associate Professor, Department of Theory and Methods of Physical Education and Sports,
South Ural State University
Chelyabinsk, Russia
erlikhvv@susu.ru
0000-0003-4416-1925

Korableva Yulia Borisovna
Junior Researcher, Research Center for Sports Science, Institute of Sport, Tourism and Service
South Ural State University
Chelyabinsk, Russia
julya-74@yandex.ru
0000-0003-2337-3531

Abstract. The purpose of the study was to find indicators that significantly respond to the use of techniques that develop LRME and form hypoxia by changing their dynamics. Materials and methods. Ski-racers (I category and candidates for the Master of Sport) were examined with a sports experience of 5-7 years. The level of physical performance in ski-racers was determined using the treadmill system model T 2100 GE. The hypoxic test (the Hypoxia Index) was carried out with a mask system on a hypoxicator of the HYPOXICO Everest Summit II model (USA), a pulse oximeter sensor manufactured by Angio Scan-01 P (Russia) was put on the finger. Results. It was found that such variables as the time to reach the aerobic threshold, (TAeP, min), the time to failure, (Tr, min) and the time to reach the threshold of anaerobic metabolism, (TPANO, min) for the experimental group in the base period were significantly less than in the pre-competition period. In the control group, the values of these indicators are indistinguishable. Conclusion. Our study shows that the aerobic threshold (AeP, bpm) does not change in the experimental group, while in the control group its values in the base period significantly exceed the values in the pre-competition period, which can also serve as a marker for the use of techniques that develop LRME and hypoxia.

Keywords – ski-racers, morphometry, local-regional muscular endurance.

I. Introduction

Highly skilled (17-19 years old) ski-racers (I category and candidates for the Master of Sport) with a sports experience of 5-7 years were examined. The experimental group and the control group consisted of 12 athletes, respectively. The experimental and control groups at the beginning of the study were identical in age, qualifications, and physical fitness. The experimental group was engaged in the concentrated development of local-regional muscular endurance (LRME) and steady adaptation to hypoxic effects at the base period. The control group worked according to generally accepted methods.

II. Materials and methods

In the experimental group, LRME developed intensively in 50% of the total volume of loads, which included gravitational and ballistic movements and jumping exercises.

The control group was prepared by traditional means, including specialized physical fitness classes, special activities, strength endurance exercisesб etc. Both groups in the basic and pre-competition period practiced swimming (breaststroke - twice a week and crawl - once a week). These types of swimming included worked with the muscles invlolved in the skating stride and classical ski techniques.

According to our data, the body mass index was 22.00 ± 0.26 kg / m2, the fat component of ski-racers (Candidates for the Master of Sport) aged from 15 to 16 years old was 10.12 ± 1.27%. Moreover, among the members of the youth team, it was 9.00 ± 0.58% [1]. The fat component is determined by the total water content and at the final stages it becomes an invariant sum.

The main task was to establish the presence or absence of the effect of the development of LMRE and adaptation to hypoxic effects on the main indicators of physical performance, the polymetric and metabolic status of athletes, which included the following indicators: I-Hyp – the hypoxia index, cu; AeP - aerobic threshold, bpm; PANO - anaerobic metabolism threshold, bpm; TAeP - time to reach the aerobic threshold, bpm; T PANO - time to reach the threshold of anaerobic metabolism, bpm; lactate max - the concentration of lactate in the blood during the failure to work, mmol / l; HR max - heart rate during the failure work, bpm; HR recovery - recovery time in 5 minutes; Tr. - the time to failure in the test, min.

We studied indicators of manual dynamometry and the polymetric status: HRav - average heart rate at rest, bpm; RRmax – respiratory rate at load, breaths/min; MEmax – maximum metabolic equivalent; OD - oxygen debt, ml/kg; MP - maximum power, ml/min/kg; spirometry - ml; hand dynamometry - dynamometry of the right and left hands; SV - stroke volume of the heart, ml.

Experiment. The level of physical performance of skiers was determined using the treadmill system model T 2100 GE. Athletes performed the threshold work (running) of a stepwise-increasing nature "to failure."

The initial speed of movement on a horizontal track during the first 2 minutes (warm-up) was 5 km/h. The load increased every 2 minutes due to an increase in speed by 1 km/h and an increase in the elevation angle of the treadmill by 1.0%. The criterion for the termination of work was the refusal of the subjects from its further performance. Regardless of the stage at which the athletes completed the test, for the next 5 minutes (recovery phase) they continued to run at a speed of 4 km / h and a track tilt angle of 0%.

The subjects performed the specified load using the CardioSoft diagnostic complex (USA). The amount of work performed in metabolic units (metabolic equivalent) was automatically calculated and recorded. This indicator indirectly reflects the activity of metabolic processes in the body by calculating metabolism (oxygen consumption) at a given load.

The metabolic equivalent value for each step of the stress test helps determine exercise tolerance based on such factors as body weight, fitness and age. In general, the assessment of general physical performance in the laboratory was carried out based on the analysis of the following indicators: the number of steps; running speed achieved during the "refusal" of work (km / h); total time for the steps completed.

The hypoxic test (I-Hyp) was carried out with a mask system on a hypoxicator of the HYPOXICO Everest Summit II model (USA), designed to produce hypoxic gas mixtures from ambient air by the membrane separation method of oxygen and nitrogen molecules in the air.

During the test, the value of SpO2 was determined. The athlete was comfortably seated in the chair. A pulse oximeter sensor of the Angio Scan-01 P company (Russia) was put on the finger of the hand. The hypoxicator displayed a height corresponding to an oxygen concentration of 10% (6400 meters above sea level). The athlete breathed the indicated hypoxic mixture through a mask that fit tightly to his face. The time (s) for the decrease in SpO2 from the initial level (96-98%) was recorded when the gas mixture was inhaled 10% O2 to 80% SpO2. The time was measured by a stopwatch. These data indicate the degree of body resistance to hypoxia and are designated as Td (time to decrease).

With a decrease in SpO2 to 80%, the subject took off his mask and breathed atmospheric air. Using a stopwatch, the recovery time of SpO2 to 95% was measured. This indicator is designated as Tr (recovery time) in seconds. According to the data obtained, the hypoxia index is calculated - I-Hyp = Td / Tr.

In the 2-minute test on a treadmill at 10 load levels with a 5-minute recovery, an increase in running speed and lift angles from 2 to 11 ° was noted. The intensity of the load correlates with indicators of metabolic rate and the consumption of O2 [2], blood lactate, and increased ventilation [3, 4, 5].

A gradual increase in physical performance at the beginning causes the restructuring of the neurohumoral mechanisms of movement regulation and autonomic functions to a more intense mode of activity and, thus, improves statokinetic stability. The locomotor system adapts than the vegetative system, depending on the power of work and adaptability. A stable state is characterized by a gradual increase in heart rate, SV, minute volume of blood, maximum oxygen consumption. The increase in movements and the angles on the track enhances anaerobic processes, the accumulation of oxygen and the shift of the pH of the blood to the acidic side. Fatigue causes a decrease in physical performance, deterioration in information processing and decision making. Changes occur in the autonomic and nervous systems. Under the development of LRME (30 s), the reserves of ATP and creatine phosphate in the muscle decrease, while the glycogen content decreases only by 3%. The depletion of intramuscular phosphagenic reserves causes fatigue.

Dynamics of the average values in the basic period. The following indicators were considered: ChDDm (Rr max - respiratory rate at load, breaths/min), MET (ME max - maximum metabolic equivalent), KDm (OD - oxygen debt, ml/kg), MM (MP - maximum power , ml/min/kg), UOS (SV - stroke volume of the heart, ml), ChSSav (HRav - average heart rate at rest, bpm), Spiro (Spirometry - ml), KDmR, KDmL (Hand dynamometry - dynamometry of the right and left hands).

The subject of the study was the presence or absence of the dynamics of the selected indicators in the basic period from the beginning of the cycle to its end. The significance of differences in the medians was estimated using the parametric student t-test (for normal data) and nonparametric sign test - the sign test, the Mann-Whitney rank test.

Student's test determines whether the mean values can be considered the same. Sign tests check the equality of medians. They are less sensitive to distribution and outliers. If the normality of the indicator was doubtful, Student's test was not conducted.

III. Results and discussion

Below are the results for each pair of indicators in the experimental and control groups.

1. The variables NUR, AeP, TAeP, PANO, TPANO, Tr demonstrate a significant (at 0.05) increase in indicators from the beginning to the end of the preparatory period, both in the experimental and control groups.
2. The variables Laktat, ChSSm, which show significant growth in the experimental group, do not show such differences in the control group, although the trend towards an increase in the values of these indicators remains. These indicators are statistically stable (from the beginning to the end of the preparatory period) in the subjects of the control group.
3. The variable ChSSv is significantly greater at the beginning of the period than at the end for the subjects of the experimental group. In the control group, there are no significant differences of this indicator at the beginning and end of the study.
4. The variables MM, UOS, Spiro, KDmL, MEm significantly (at 0.05) increase from the beginning of the preparatory period to the end, both in the experimental and in the control group.
5. The variables KDmR, ChSSav significantly increase in the experimental group from the beginning of the examination to the end, and are statistically stable in the control group.
6. The variable ChDDm significantly decreases from the beginning of the examination to the end in the experimental group and is statistically stable in the control group.
7. The variable KDm is statistically stable both in the experimental and in the control group, although in the control group there is a statistically insignificant increase in this indicator.

Dynamics of the average values in the pre-competition period. The variables studied were: NUR, AeP, TAeP, PANO, TPANO, Tr, Laktat, ChSSm, ChSSv.

1. The variables AeP, TAeP, PANO, TPANO, Tr demonstrate a significant (at 0.05) increase from the beginning to the end of the study, both in the experimental and in the control group.

2. The variables NUR, Laktat, ChSSm, showing significant growth in the experimental group, are statistically stable in the control group, although there is a tendency to increase the values of these indicators from the beginning to end of the experiment.

3. The variable ChSSv significantly decreases for the subjects of the experimental group. In the control group, there are no significant differences in this indicator at the beginning and end of the study.

The dynamics of the indicators from the basic to the pre-competition period is of considerable interest. The following variables were investigated; NUR, AEP, TAEP, PANO. TPANO, Tr, Laktat, ChSSm, ChSSv.

Table 1 shows the absolute values of the studied indicators. Table 2 demonstrates the results of comparative assessment.

Table I. Brief data

Cod		NURI	NURII	AePI	AePII	TAePI	TAePII
control	Mean	3.10	4.83	151.08	158.42	4.67	6.08
	St. deviation	.91	1.55	3.87	4.814	1.37	1.44
exp	Mean	2.86	7.22	153.91	161.83	4.67	7.58
	St. deviation	.97	2.27	5.08	5.89	1.87	2.10
Cod		PANOI	PANOII	TPANOI	TPANOII	TrI	TrII
control	Mean	167.75	172.67	7.58	8.75	15.30	15.84
	St. deviation	4.24	4.97	1.44	1.65	1.21	1.15
exp	Mean	169.42	176.67	7.83	10.83	16.41	17.32
	St. deviation	3.91	4.86	1.40	2.29	.53	.58
Cod		LaktatI	LaktatII	ChSSmI	ChSSmII	ChSSvI	ChSSvII
control	Mean	9.19	9.58	197.75	198.08	123.00	123.00
	St. deviation	.77	.64	1.86	2.02	4.090	6.95
exp	Mean	9.24	10.60	196.58	200.42	123.83	113.42
	St. deviation	1.01	1.19	6.28	6.51	6.52	8.07

Table II. Dynamics of mean values

Variable	Experimental group	Control group
NURI	П<С	П=С
NURII	П>С	П>С
AePI	П<С	П=С
AePII	П=С	П>С
TAePI	П<С	П=С
TAePII	П<С	П=С
PANOI	П=С	П=С
PANOII	П=С	П=С
TPANOI	П<С	П<С
TPANOII	П<С	П=С
TrI	П<С	П=С
TrII	П<С	П=С
LaktatI	П=С	П=С
LaktatII	П=С	П=С
ChSSmI	П=С	П>=С
ChSSmII	П=С	П>=С
ChSSvI	П=С	П<=С
ChSSvII	П=С	П=С

IV. Conclusion

In the basic period, such indicators as the concentration of lactate in the blood during the “refusal” of work, (Laktat, mol/l), heart rate during the “refusal” of work (ChSSm, bpm), the average heart rate at rest (ChSSav, bpm), dynamometry of the right hand, (KDmR, daN) significantly increase in the experimental group from the beginning of the examination to the end, while in the control group these indicators remain statistically stable.

The respiratory rate during exercise (ChDDm, breaths/min) and recovery time (ChSSv) decrease in the experimental group from the beginning of the examination to the end, while in the control group these indicators are statistically stable. The dynamics of the other indicators studied turned out to be identical in both the experimental and control groups.

In the pre-competition period, as markers of LRME and hypoxia development in skiers, it is possible to consider the indicators of the concentration of lactate in the blood during the “refusal” of work (Laktat, mmol/l) and heart rate during the “refusal” of work (ChSSm, bpm) that significantly increase from the beginning of the study to the end. In this period, they should be supplemented with a hypoxic index, which also shows significant growth and recovery time (ChSSv), which decreases in the experimental group from the beginning of the study to the end.

As in the basic period, the mentioned indicators are statistically stable in the control group and do not show significant dynamics. All other indicators evolve identically both in the control and in the experimental group.

Our calculations show that in this case, the markers of the methods used can be the hypoxic index, (NUR, cu), aerobic threshold, (AeP, bpm), time to reach the aerobic threshold, (TAeP, min) and the time to failure in the test (Tr, min). At the beginning of the survey, the values of these indicators for the experimental group are significantly less than at the beginning of the pre-competition period, while in the control group the difference in the values of these indicators is not statistically significant.

Acknowledgment

This article was supported by the Government of the Russian Federation (Act No. 211 dd. March 16, 2013; agreement No. 02.A03.21.0011) within the framework of the state contract of the Ministry of Education and Science of the Russian Federation (grant No. 19.9733.2017 / БЧ).

References

[1] A.P. Isaev, V.V. Erlikh, Y.N. Romanov, A.S. Bakhareva, «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, vol. 16 (4), p. 1219, 2016.

[2] A.S. Bakhareva, A.P. Isaev, V.V. Erlikh, A.S. Aminov, “Effective long term adaptation and metabolic state regulation of ski-racers», Pedagogics psychology medical-biological problems of physical training and sports, vol. 20(3), p. 4, 2016.

[3] G.A.V. Borg, «The increase of perceived exerted ashes and pain of the legs, heart rate and blood lactate during exercise on bicycle ergometer», Cur. J. Appl. Physiol, vol .54(2), p. 343, 1995.

[4] A.S. Bakhareva, V.I. Zalyapin, E.V. Kharitonova, G.V. Budanov, «Significance of biochemical and hematological indicators of racing skiers during adaptation to training loads», Human Sport Medicine, vol. 18 (3), p. 30, 2018.

[5] K.J. Killian, Berth lessens the sense of respiratory muscle effort. The perception of exertion the physical work, Stockholm, 1986.