ATLANTIS PRESS

Advances in Health Sciences Research, volume 17

4th International Conference on Innovations in Sports, Tourism and Instructional Science (ICISTIS 2019)

Postural analysis of body reserves in ski racers

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

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

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

Shevtsov Anatoliy Vladimirovich
Doctor of Biological Sciences, Professor, Head of the Physical Rehabilitation Department
Lesgaft National State University of Physical Education, Sport, and Health
Saint Petersburg, Russia
sportmedi@mail.ru
0000-0002-9878-3378

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

Kharitonova Elena Vladimirovna
Candidate of Mathematical Sciences, Associate Professor, Mathematical Analysis and Methods of Teaching Mathematics Department
South Ural State University
Chelyabinsk, Russia
kharitonovaev@susu.ru
0000-0002-4485-1806

Abstract. As a result of the long-term adaptation of the body, the indicators of system-forming parameters (statokinetic stability, spectrum power, stability, stability index, dynamic component of balance) are revealed. The configuration of stabilogram, statokinesiogram, spectrum analysis, ballistic cardiogram was studied.

It was established that the postural control of muscles was disturbed as a result of distal muscles fatigue compared to proximal muscles fatigue. The fatigue of the distal muscles of the ankle provokes proximal muscles recruitment of the knee and hip. The ratio of the decrease in the maximum group of extensors and the speed of decrease in the center of foot pressure increases significantly with a 30% loss of the ability of arbitrary contraction [1]. The study of motor activity (MA) applies to the system of sports reserve training with respect to age and sports qualification characteristics [2].

Keywords: long-term adaptation, local-regional muscle endurance, statokinetic and hypoxic stability.

I. INTRODUCTION

Progress in the sports of high achievements is determined by the application of advanced technologies in the system of sports reserve training. This allows for creating conditions for efficient adaptation and better results. According to current trends, the study of local-regional muscle endurance and statokinetic and hypoxic stability providing high sports performance and the optimal ratio of aerobic and anaerobic processes is considered as one of the leading in sports science. At the current stage of ski racing development, there are no possibilities for a close to threshold highly intensive load. The search for a new, scientifically justified technique based on ergogenic training is becoming the main direction of the training process.

Physical performance and successful long-term adaptation are determined by the features of functional and metabolic activity, depending on the dominant type of muscle fibers, which are largely genetically determined.

The prospects for modeling biological statuses, identifying their markers, and developing technological projects in the system of sports reserve training require a systematic approach to control factors in the conditions of successful performance. More than thirty years of economic and social stagnation in Russia resulted in a decrease in the quality of sports reserve training at all stages – in educational establishments, human resourcing, and sports science. The concept of development and modernization in education, science, and sports reserve training, as well as its implementation, is slowly being introduced into society. Various training programs based on artificial hypoxia combined with traditional training tools can be considered as one of the most effective means for creating a new state of the body. However, reserve mechanisms and indicators of effective adaptation limiting sports performance are still not well understood.

The effect of the development of local-regional muscle endurance and statokinetic stability in the conditions of hypoxia training demonstrated the effectiveness of these training methods. The application of hypoxic tents and the Carbonic sports equipment provided a significant effect.

It can be supposed that the application of such technologies creates a possibility for constructing the models of competitive success and assessing body reserves in extreme conditions.

Therefore, this study aims at establishing the speed of changes in sensory vestibular, spatial, strength, and temporal characteristics of athletes and assessing multifunctional and metabolic processes in teenagers as a result of the proposed technologies.

II. MATERIALS AND METHODS

The study was conducted in the premises of the Center for Sports Science at Tyumen State University and South Ural State University. Twelve ski racers of the II and III ranks aged 13-14 years participated in the study from June to October. The concentrated development of local-regional muscle endurance was 30 % in June – August and 40% in September

– October. The rest time was dedicated to running, roller skis, skiing at 6-10-degree ascension, and swimming.

In this group, stabilometry and postural balance measurements are used as methods for studying biomechanical balance and statokinetic stability. Stabilometry is considered as a projection of the center of mass of the body on the support plane and its oscillations in the stance of a ski racer depending on the changes in dynamic positions and skiing stances in the conditions of ascending, descending, and turning movements.

III. RESULTS AND DISCUSSION

The sensory vestibular test allowed recording certain anthropometric data in ski racers aged 13-14 years. Sports experience in young ski racers was 3-4 years (the III and II qualification ranks).

Table I shows the anthropometric data of athletes demonstrating the features of their development.

Table I. ANTHROPOMETRIC DATA AND ITS VARIABILITY IN YOUNG ATHLETES

Parameters	Indicators M±m	Variation coefficient (%)
Body length, cm	163.00±1.85	3.00 %
Foot length, cm	27.00±0.18	2.10 %
Ankle to toe distance, mm	200.00±0.18	5.80 %
Foot width, mm	80.00±0.09	2.90 %

A study of functional and structural characteristics of the foot and Achill tendon allowed establishing muscle activation, viscoelastic fiber properties, and the biomechanical structure of foot deformity for providing motor activity [3, 4].

Progress in cross-country skiing is determined by retrospective changes in the biomechanics of ski movements, the anatomical and physiological contribution, the seasonal and ecological factors of the increase in hypoxia stability, concentrated development of local-regional muscle endurance, and the increase in statokinetic stability. A high maximum oxygen consumption, a decrease in stress in the elements of functional body systems are accompanied by an increase in the viscoelastic properties activation and shortening of individual fascia during the repulsion cycle [3, 4, 5]

According to the classical concept of the stretching – shortening cycle, neuromuscular synergization determines an increase in the strength of ski movements by preserving and releasing the energy of elastic deformation.

The Y-axis passes exactly in the middle between the feet. It is important to consider the distance between the heels. The X-axis is frontal, and runs at a strictly defined distance, O - A is calculated in accordance with the athlete's foot size according to the formula: O - A = 0.59 r -1.8, where the foot length is in cm, 1.80 is the subtracted length in cm [6]. The contact of the parts of the foot with the support is determined. In the frontal plane, foot roll-over is called the lateral-medial roll-over, which biomechanically determines neuromuscular viscoelastic interactions.

Activation reactions are comprehensive and include a spectrum of components at the systemic-synergetic and local levels. The power level of motor activity determines greater variability, progress, and efficiency.

The width of the foot is determined by the calculation of the area of the support. The ankle to toe distance is measured in the sagittal plane. Foot width is measured for calculating the foot area. The foot is a segment of the body that determines the vertical and horizontal components that transform the transmission of the support.

Further, the indicators of the sensory-vestibular test of the skiers who participated in the examination at the basic training stage were studied.

After the test, it was established that the deprivation of vision caused significant changes in the speed of the general center of pressure, power levels in the planes, stability index, stability indicator, the dynamic component of balance, the average position of the center of pressure in the sagittal plane ($p < 0.05$). Our data on postural balance are consistent with studies [7]. The athlete’s model in the main stance consists of many elements, determines the spectrum of oscillations, and is characterized by a uniform distribution of energy over the degrees of freedom. The complex biomechanical model includes the components of the musculoskeletal system affecting the organs of the thoracic and abdominal cavities. The ratio of the amplitude and frequency of oscillations is fundamental due to the spectrum of free oscillatory processes according to the law 1 / f [8]. The change in balance during head turns and distractive effects (eyes closed) of postural oscillations is determined by the action of gravitationally dependent sensory systems of the statokinetic spectrum (analytic, spatial, temporal, organ and systemic).

Insufficient spatial contact is manifested in sports motor activity. The general provisions of the regulation of the status and control of motor activity determine a change in freedom of movement [9]. N. Douskaia [10] proposed a new interpretation of the control of human motor activity, including the generation of movement, the effect of interaction, control of the leading joint, the mechanical effect of rotation and the subordination of regulation of joint movement. For ski racers, it is important to take into account the stiffness of snow and the terrain, as well as the stiffness of the joints, the viscoelastic properties of the muscles. It is advisable to take into account the stability and instability of the body, upper and lower extremities and the effects of training in conditions of variability of statokinetic stability.

Gravitational and ballistic motor activity is connected with jump-related activities, jump simulation, and power shock absorbers and tools in the conditions of the development of local-regional muscle endurance. The creation of a training environment allows translating motor activities in a sports technique and increasing sports performance as a result of effective adaptation. In this regard, the neurophysiological criteria for correcting sports performance and controlling motor activity, proprioceptors, and sensorimotor integration are of great importance. It is extremely important to learn fixation mechanisms responsible for sports performance with statokinetic stability in the conditions of different terrain, snow conditions at different times of the season and type of activity.

French scientists made a review of the effect of general and local fatigue on postural control [1]. Postural control is a complex function that involves keeping the vertical projection of the center of gravity. According to the authors, physical exercises degrade postural stability as the increase of energy needs amplifies liquid movements and cardiac and respiratory muscular contractions. Moreover, then muscular activity generates fatigue, it affects the regulating system of postural control by its effects on the quality and treatment of sensory information, as well as motor command. Anaerobic and aerobic exercises degrade postural stability. There is a correlation between oxygen consumption and sway path. After an exhaustive physiological exercise such as a maximal oxygen uptake test (V˙O2max) generating a large post-exercise oxygen deficit, postural control is degraded. After a 2-mile run at 90% of the maximal heart rate postural control increases. Postural control increases after a treadmill exercise when the exercise intensity is superior to the lactate accumulation threshold.

At the basic period of training, local-regional muscle endurance developed intensively (50% of load volume) in ski racers aged 13-14 years. During general and special physical preparation there was a decrease in load concentration to 40-30% respectively, before competitions load concentration was 20%. At the same time, motor activity as a part of local-regional muscle endurance was integrated into the system of statokinetic stability. Stabilograms changed configuration when turning the head and with eyes closed.

Stabilogram, statokinesiogram, and ballistic cardiogram were analyzed in the main stance, during head turns with eyes open and closed. The comparison of the data of the intensive development of local-regional muscle endurance and statokinetic stability during head turns allowed establishing the changes in the conditions of limited visual information. Desynchronization between the criteria of statokinetic stability was revealed due to the markers of spectral analysis in the main stance and during turns with eyes open and closed [10].

Statokinesiogram is a graphical trajectory of the center of pressure on the horizontal plane. The distractive factors of head turn and deprivation of vision change the pattern of the statokinesiogram. The symmetry in the main stance is the projection of the center of mass in the sagittal plane. Sometimes a sensory conflict occurs as a result of contradictions between the data of statokinesiogram stability, motor, visual, tactile, and vestibular analyzers and the autonomic disorder of motor activity. The motor strategy is determined by maintaining the stance and coordinating motor activity in the ankle, knee, and hip joints under conditions of correction of the center of mass in the sagittal plane.

Ballistic cardiogram reflects impulsion (oscillation frequency and amplitude) under the presence of distractive factors. Motion control is connected with the position of limbs, center of pressure, the center of mass motion, and circular velocity [11, 12].

IV. Conclusion

The results of the study demonstrated the effectiveness of applying these technologies in the system of sports training and revealed the markers of functional and metabolic systems and postural effects. Based on oscillatory processes (amplitude and frequency-related) determining the indicators with physiological variability, models are proposed.

The application of these technologies allowed enhancing adaptation, identifying markers, increasing sports efficiency and biological reliability under the conditions of local regional muscle endurance, statokinetic and hypoxia stability.

Acknowledgment

The article was supported by the Government of the Russian Federation (Act 211 dd. 16.03.2013; contract No 02.A03.21.0011) as a part of the state contract of the Ministry of Education and Science of the Russian Federation (grant No 19.9733.2017/БЧ).

References

[1] T. Paillard, «Effects of general and local fatigue on postural control: a review», Neurosci. Biobehav. Rev., vol. 36, p. 309, 2012.

[2] A.S. Bakhareva, A.P. Isaev, D.O. Maleev, A.S. Aminov, «Physiological markers of the speed of muscle contraction and relaxation of type I muscle fibers in racing skiers», Human Sport Medicine, vol. 17, p. 25, 2017.

[3] R. Donatelli, Sports – specific rehabilitation, U.S.A., 2007.

[4] P. Larson, “Foot strike patterns of recreational and sub-elite runners in a long-distance road race», Journal of Sports Sciences, vol. 29, p. 1665, 2011.

[5] J.B. Coquart, M. Tabben, A. Farooq, “Submaximal, Perceptually Regulated Exercise Testing Predicts Maximal Oxygen Uptake: A Meta-Analysis Study», Sports Med, vol. 46, no. 6, p. 885, 2016.

[6] A. Gollhofer, “Importance of core muscle strength for lower limb stabilization», 6 International Congress on Science and Skiing, p. 11, 2013.

[7] A.S. Bakhareva, V.I. Zalyapin, A.P. Isaev, A.S. Ushakov, «Correlation between lipid metabolism and competitive success rates in elite cross-country skiing», Teoriya i Praktika Fizicheskoy Kultury, vol. 1, p. 23, 2019.

[8] A.V. Gribanov, A.K. Sherstennikova, Physiological mechanisms of human postural balance regulation, Journal of Medical and Biological Research, p. 20, 2013.

[9] K. Davids, P. Glarier, «Deconstructing neurobiological on the role of the biomechanics motor control nexus», Exercise and Sport Sciences Reviews, vol. 38, no. 2, p. 86, 2010.

[10] N. Dounskaia, «Control of human limb movements: the leading joint hypothesis and its practical applications», Exerc Sport Sci Rev., no. 38(4), p. 1, 2010.

[11] A.P. Isaev, V.V. Erlikh, V.B. Ezhov, Local-regional muscle endurance in the system of training and adaptation in runners and ski-racers under the conditions of plain and middle-altitude: monograph, Chelyabinsk: SUSU, 2014.

[12] M. Eriksson, K.A. Halvorsen, L. Gullstrand, “Immediate effect of visual and auditory feedback to control the running mechanics of well-trained athletes», Journal of Sports Sciences, vol. 29(3), p. 253, 2011,

[13] J. Lennartsson, Probabilistic modeling in sports, finance and weather, 2014.