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CONTENT

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ASSESSMENT OF THE RISK OF INJURY AMONG ATHLETES DUE TO PSYCHOPHYSIOLOGICAL INDICATORS (SKI SPORTS)

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Author contribution: A – study concept and design; B – data collection; C – data analysis and interpretation; D – paper writing; E – paper editing; F – paper final adoption

Abstract

Introduction. In today's sport high level of physical performance of an athlete is caused by functional features and state of all the body's system. The assessment of the central nervous system's functional state is of a particular importance. At the same time, potential risk of getting injuries increases every year so the main objective for sporting physicians, psychologists, and physiologists, notably in high performance sport is to reduce injuries.

The *aim* of the research is to compare the state of psychophysiological functions among highly qualified athletes specializing in sports with different degrees of extremeness and risks of injury (snowboarding, Alpine skiing, cross-country skiing).

Material and methods. To determine the state of psychophysiological functions among athletes the diagnostic system «Diagnost-1» (M.V. Makarenko, V.S. Lyzohub) was used. These sports make particular demands principally on the athletes' central nervous system. The hidden periods of basic hand-eye reactions, basic and complex choice reactions, efficiency of sensory-motor activities and dynamics of nervous processes in terms of feedback, accuracy of reaction to a moving object and correlation between advanced and delayed reactions, dynamic muscle endurance of the right and left wrists (by the test of tapping), as well as the main features of nervous system, namely functional mobility and strength of nervous processes were studied.

Results. Higher psychophysiological status by the indicators of nervous processes' strength and the ones of reaction to a moving object, higher level of dynamic muscle endurance by the indicators of tapping-test were demonstrated by the athletes with higher degree of extreme of the sporting activities and risks of injury (snowboarders and Alpine skiers).

Conclusions. The found discrepancies in the states of psychophysiological functions among athletes with different degree of extreme of the sporting activities and level of risk of injury can have a prognostic value and be used for optimization of sports improvement in these sports.

Key words: highly qualified athletes, state of psychophysiological functions, snowboarding, Alpine skiing, cross-country skiing.

Introduction. The growing of strain amount in sports trainings underlines finding physiological, psychophysiological factors ensuring the efficiency of activity and being the basis for stable functional state and health of the athlete. In today's sport high level of physical performance of an athlete is caused by functional features and state of all the body's system [8, 13, 15, 21, 24].

The assessment of the functional state of central nervous system interrelated to the athletes' individual typological characteristics as well as defining individual psychological determinants of stress resistance is gaining a particular importance [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**]. At the same time, every year together with the increasing requirements for athletes, potential risk of injury also increases, so today one of the main objectives for sporting physicians, psychologists, and physiologists, notably in high performance sport is to reduce injuries [0, **Error! Reference source not found.**].

The analysis of research and methodological literature makes it possible to state that today the problem of individualization of the athletes' training is one of the relevant ones and requires constant research.

Most scientists emphasize the importance of control for the athletes' body states to assess their readiness for executing severe physical workloads in high performance sport, to assess the efficiency of functioning of different physiological systems for optimizing the structure of the athletes' performance, and to monitor the athletes' mental state, etc. [**Error! Reference source not found.**, 0, **Error! Reference source not found.**, **Error! Reference source not found.**].

Many researchers' data in the sphere of high performance sport show the importance of assessing functional state of neuromuscular systems and anticipating the risk of the athletes' injury to assess their readiness for executing severe workloads, degree of mobilization, and using reserve abilities of the body [0, **Error! Reference source not found.**].

Increasing special physical functionality among athletes is based on increasing the amount and intensity of training and competitive workloads, at the same time the growth of sports injury is mentioned. Quite a few researchers accentuate on negative consequences of stress caused by professional and sporting activities [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**]. The level of stress can influence on injury rate among athletes [27].

The role of psychological indicators increases with the growth of sporting qualification, some of them can be used as model characteristics for anticipating an athlete's reliability: features of nervous system, some anatomic and morphological and psychological indicators (characterological features, memory,

thinking, rate of processing information, indicators of sensory motility, etc.) [**Error! Reference source not found.**]. The main condition for reliability of intended sporting performances of an athlete or a team is considered the [illegible] extreme conditions [**Error! Reference source not found.**].

Sporting activity in today's sport is accomplished upon extreme conditions. Nervous and mental strain particularly grows directly in the course of competitions where quite a few extreme and overextreme situations occur [12].

Most authors consider mountaineering, skateboarding, snowboarding, parachuting, rock climbing, speleology, rope-jumping, etc. solely extreme sports [0, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**]. Undoubtedly, extreme sports are often related to balancing on the edge of living abilities which greatly increases the risk of injury compared to other sports so it cannot but cause emergence of stress. Therefore, among athletes with high degree of sporting activity's extremeness there is a need in developing stress resistance [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**] making particular requirements both to psychophysiological selection of athletes and to psychological training in these sports.

Individual psychological determinants related to the athletes' stress resistance among those doing extreme sports were found [**Error! Reference source not found.**, **Error! Reference source not found.**].

The results of the research show that the structure of stress resistance among athletes in extreme sports is balanced and includes system volitional [illegible] es [illegible] behavior self-regulation (self-esteem and peculiarities of nervous system characterizing receptivity to external events (emotional stability or neuroticism) [28].

The determinants of stress resistance for the athletes in non-extreme sports are a bit different. Notably, self-control plays an important role which did not define the expected considerable impact on the level of stress resistance among athletes in extreme sports unlike self-esteem equally not determining stress resistance development among the athletes in non-extreme sports [14].

To M.H. Samoilov's opinion [12], psychological training of an athlete has to be correlated both with the specificity of sporting activity and development of psychological stability towards the actions in extreme situations. According to M.H. Samoilov's classification, all the sports are divided into three groups by the intensity of extreme factors' impact on an athlete.

The first group includes badminton, different types of shooting, table tennis, arm sport, billiard sport, gorodki sport, golf, skittles, radio sport, checkers and chess. The second group includes game sports, cycling (track, highway), combat sport, winter and water sports, gymnastics, acrobatics, diving and trampolining, athletics and weightlifting. The third group includes the following sports: automobile, motorcycle, hang gliding, underwater,

Alpine skiing and parachuting, as well as rock climbing and mountaineering [12].

The athletes of the third group by M.H. Samoilov doing those sports involving committing actions under impact of factors as abruptness of emergence and uncontrollability over extreme situation, increased degree of risk, threat for health and life, stand ns tions than the ones of two first groups by the degree of extremeness [12].

So, today there is a need in searching for fundamentally new ways for solving both the problem of achieving the highest levels of special physical functionality and the problem of preserving the athletes' health at the same time. Constant control on the state of psychophysiological functions for anticipating the risk of injury among athletes, psychological training in order to preserve an athlete's health and providing him an opportunity to lead active sporting life as long as possible are important steps on this way.

The **aim of the research** is to compare the state of psychophysiological functions among highly qualified athletes specializing in sports with different degrees of extremeness.

Methods and organization of the research. 18 highly qualified athletes took part in the research as the examined: candidates for Master of Sports, Masters of Sports, International Masters of Sports, and Honored Masters of Sports aged 15–42 years old, sports – snowboarding, Alpine skiing, and cross-country skiing.

To determine the state of psychophysiological functions among athletes and maximal rate of moving of the wrist (by the tapping-test methodology) the diagnostic system «Diagnost-1» (M.V. Makarenko, V.S. Lyzohub) was used [7].

Statistical processing of data was conducted using methods of non-parametric statistics.

Connection of the work with important research programs or practical tasks. In the course of researches involving the athletes in accordance with the principles of bioethics we followed the «Program of complex biological research of the functional capabilities' peculiarities among athletes» developed in the laboratory of theory and methodology for sports training and reserve capabilities among the athletes of Science and Research Institute of National University of Ukraine on Physical Education and Sport as well as legal system of Ukraine on healthcare, 2000Helsinki Declaration, and Directive 2010/63/EU on the people's participation in medical and biological researches [**Error! Reference source not found.**]. The paper was completed in Science and Research Institute of National University of Ukraine on Physical Education and Sport according to state budget scientific and research topic «Technology of assessment of the risk of injury among athletes by electroneuromyographic and psychophysiological indicators» (state registration number 0119U000307) approved by the Ministry of Education and Science of Ukraine.

Results of the research and their discussion. Qualified athletes doing ski sports characterizing by privilege of dynamic speed work and high degree of possible injury took part in the research.

These sports make particular requirements principally to central nervous system (CNS) among athletes. The degree of extremeness of sporting activities in snowboarding and Alpine skiing is, undoubtedly, a lot higher than in cross-country skiing [22]. That is why the examined athletes were divided into two groups: I group – snowboarders and Alpine skiers (n=8) and II group – athletes specializing in cross-country skiing (n=10). The groups of athletes were not divided by age or sporting experience (*table 1*).

Table 1

Indicators of dynamic muscular endurance (by tapping-test) among athletes (n=18), Me [25%, 75%]

Indicators	I group, n=8	II group, n=10
Indicators of dynamic muscular endurance of the wrist movement of a dominant hand (tapping-test), number of taps	421.50 [384.50; 436.00]*	382.00 [363.00; 400.00]
Indicators of dynamic muscular endurance of the wrist movement of a subdominant hand (tapping-test), number of taps	357.00 [329.00; 400.00]	329.50 [310.00; 358.00]
Indicator of asymmetry (tapping-test)	1.15 [1.10; 1.19]	1.17 [1.11; 1.17]
Age, years	20.00 [17.00; 24.00]	20.50 [19.00; 28.00]
Special sporting experience, years	10.50 [8.50; 15.00]	11.00 [10.00; 18.00]
Overall sporting experience, years	12.50 [11.00; 20.00]	12.00 [10.00; 18.00]

Note: * $p<0.05$ – significant differences between I and II groups by Mann Whitney U test.

According to the aim of the work, latent periods of basic hand-eye reaction, basic and complex choice reactions, notably, the efficiency of sensory-motor activity (determined by the period of minimal signal exposition in terms of feedback), dynamicity of nervous processes (determined by the period of entering minimal exposition in terms of feedback), accuracy of reaction to a moving object (PPO), and correlation between the advanced and delayed reactions, dynamic muscular endurance of the right and left wrists (by indicators of tapping-test) as well as the main features of nervous system (namely, functional mobility of nervous processes – ФРНП and strength of nervous processes – СНП) were examined among athletes.

By the results of the conducted researches, the groups of athletes found by Mann Whitney U test did not differ significantly both by indicators of ФРНП, sensory-motor activity efficiency, dynamicity of nervous processes, and by latent periods of basic hand-eye reactions, as well as basic and complex choice reactions (*table 2*).

The discrepancies between the formed groups of athletes by the СНП indicator in terms of compulsive rhythm were established (*table 2*) with high speed of presentation and processing of stimuli – 140 sign·min^{-1} ($p<0.05$). By the other СНП examined measures, the discrepancies between the formed groups of athletes did not reach the level of significance. As it is possible to observe in the data given in the table 2, the tendency towards higher results by СНП indicators is inherent for snowboarders and Alpine skiers.

Overall among the athletes of the I group the privilege among responders with higher indicators of strength of nervous processes in terms of feedback (it corresponds to average level) was found showing higher sensory-motor endurance, and higher cerebrum functionality in the course of continuous sensory-motor workloads.

Table 2

Indicators of the state of psychophysiological functions among the examined athletes (n=18), Me [25%, 75%]

Indicators	I group, n=8	II group, n=10
Latent period of basic hand-eye reaction, ms	236.60 [231.10; 268.67]	252.84 [241.73; 299.77]
Motor component of hand-eye reaction, ms	84.67 [67.57; 105.39]	102.02 [84.57; 121.67]
Latent period of choice reaction PB 1-3 (one signal out of three), ms	353.67 [344.56; 359.61]	392.00 [312.33; 442.56]
Motor component PB 1-3, ms	101.60 [89.78; 121.37]	125.52 [102.56; 141.00]
Time for central processing of information PB 1-3, ms	115.41 [94.33; 131.44]	110.84 [82.86; 133.91]
Latent period of choice reaction PB 2-3 (two signals out of three), ms	411.67 [393.87; 428.61]	419.00 [400.00; 447.61]
Motor component PB 2-3, ms	97.81 [89.43; 128.06]	138.36 [97.50; 164.18]
Time for central processing of information PB 2-3, ms	163.76 [125.53; 206.22]	170.68 [163.38; 183.08]
Indicator of strength of nervous processes (5 min test), overall number of processed signals	638.50 [609.50; 658.50]	618.50 [543.00; 671.00]
Indicator of functional mobility of nervous processes (5 min test), T 120, s	67.56 [65.84; 68.27]	67.24 [63.60; 69.11]
Indicator of functional mobility of nervous processes (in terms of compulsive rhythm), sign·min^{-1}	100.00 [95.00; 110.00]	90.00 [80.00; 110.00]
Indicator of strength of nervous processes (in terms of compulsive rhythm), % mistakes	15.34 [12.53; 19.34]	20.87 [15.67; 26.24]
Number of mistakes (in terms of compulsive rhythm), speed of presentation and processing of stimuli	20.00 [16.50; 28.00]*	29.00 [23.00; 35.00]
Indicator of accuracy of reactions to a moving object, number of accurate shots	14.00 [13.00; 18.50]	13.50 [12.00; 17.00]
Total deviation in reactions to a moving object, ms	1981.00 [1554.00; 2108.00]	2074.00 [1766.00; 2904.00]
Total advance in reactions to a moving object, ms	879.00 [640.00; 1170.00]*	1291.00 [892.00; 1604.00]
Total delay in reactions to a moving object, ms	1003.00 [817.00; 1087.00]	778.00 [542.00; 1300.00]
Correlation between total advance and total delay in reactions to a moving object	0.87 [0.62; 1.28]*	1.59 [1.18; 2.26]
Average deviation in reactions to a moving object, ms	22.00 [17.25; 23.40]	23.05 [19.60; 32.30]
Average advance in reactions to a moving object, ms	25.80 [21.40; 27.85]	29.55 [22.90; 37.90]
Average delay in reactions to a moving object, ms	24.85 [22.75; 26.70]	26.90 [17.00; 31.80]
Correlation between average advance and average delay in reactions to a moving object, ms	1.00 [0.92; 1.11]*	1.22 [1.04; 1.53]

Notes: * $p<0.05$ – significant differences between I and II groups by Mann Whitney U test.

Among the athletes of II group the advance of responders with low and medium strength of nervous processes in terms of feedback were found.

It is worth noting that latent periods of complex choice reaction can be considered as additional indicators of strength and functional mobility of nervous processes [7]. Though the discrepancies between the groups of athletes in this case did not reach the level of significance, it is worth emphasizing the tendency towards decreasing of latent period of complex choice reaction among the athletes of the I group. It can also show higher development of sensory-motor endurance among the athletes of the I group compared to the II group (*table 2*).

One of the main genetically caused qualities of nervous processes is functional mobility (Holzinger coefficient for ФРНП – 0.61-0.86) [8]. It is known that the efficiency in speed, speed-strength and some other sports depends on speed processes in the athletes' nervous system [**Error! Reference source not found.**, **Error! Reference source not found.**]. The formed groups did not differ by the ФРНП indicators: for most athletes of both groups an average functional mobility of nervous processes is inherent (*table 2*).

An analogous situation appeared with PPO accuracy indicators: the examined athletes did not differ by the number of accurate shots. However, by the other measures of PPO indicators the level of the central nervous system functional state was higher among the athletes of the I group with higher degree of extremeness of sporting activity and risk of injury (*table 2*).

One of the indicators of the body's functional state characterizing the ability of all motor analyzer elements for speed and endurance as well as dynamic muscular endurance, as M.V. Makarenko noted, is maximal rate of moving of the wrist by the tapping-test methodology [7]. The methodology of tapping-test is quite well-known and is widely used in today's psychophysiology [3, 7].

The relations between the efficiency of maximal rate of moving of the wrist and the level of sporting qualification among representatives of speed-endurance sports were found [**Error! Reference source not found.**]. The asymmetry between the right and the left hands among the athletes of the I and II groups by the tapping-test indicators did not differ. For the dominant (right) hand, the dynamic muscular endurance of moving of the wrist was significantly higher among the athletes of the I group ($p<0.05$).

The tendency towards increasing dynamic muscular endurance of moving of the wrist of the subdominant (left) hand among the athletes of the I group was found, but these discrepancies by the Mann Whitney U test did not reach the significance level.

So, the gained results show higher level of dynamic muscular endurance among the athletes of the I group (*table 1*). As it was mentioned, the athletes with higher degree of extremeness of sporting activities – snowboarders and Alpine skiers were included in the I group.

By psychophysiological indicators, the athletes with higher degree of extremeness of sporting activity and risk of injury (I group) demonstrated higher results, some discrepancies

reached the significance level which can indicate principally higher development of sensory-motor endurance, strengths of nervous processes and dynamic muscular endurance among snowboarders and Alpine skiers. The level of CNS functional state by PPO indicators was also higher among snowboarders and Alpine skiers.

It is known that the main features of the nervous system are genetically caused but they develop and improve with aging [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**] and in the course of sporting activity [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**].

By the results of the conducted research, extreme sports with high risk of injury are not an exception also promoting development and improvement of psychophysiological functions. This shows positive impact of physical workloads and doing different sports. So, the gained results confirm and complement the known literary data [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**].

The found discrepancies in the state of psychophysiological functions among athletes with different degree of extremeness of sporting activity and level of risk of injury can have a prognostic value and be used to optimize sporting improvement in these sports.

Conclusions:

1. The athletes with higher degree of extremeness of sporting activity and risk of injury (snowboarders and Alpine skiers) demonstrated higher psychophysiological status by the indicators of strength of nervous processes (in terms of feedback, in the course of long-term sensory-motor workloads, and in terms of compulsive rhythm) and by indicators of reaction to a moving object.
2. Higher level of dynamic muscular endurance by the indicators of tapping-test was found among snowboarders and Alpine skiers.

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