

Instrumental control of functional indicators in students with health deviation

IVAN BOCHARIN¹, MAXIM GURYANOV², ELENA ROMANOVA³, ANNA POZDEEVA⁴, MIKHAIL KOLOKOLTSEV⁵, ANTON VOROZHEIKIN⁶, ANDREI MALKIN⁷, TATIAYNA POBORONCHUK⁸, RAISA LOBASTOVA⁹, ALEXANDER KOVALEV¹⁰

^{1,2,4}Privolzhsky Research Medical University, Nizhny Novgorod, RUSSIA

¹Nizhny Novgorod State Agrotechnological University, Nizhny Novgorod, RUSSIA

³Altai State University, Barnaul, RUSSIA

⁵Irkutsk National Research Technical University, Irkutsk, RUSSIA

⁶Kaliningrad Institute of Management, RUSSIA

⁷Siberian Federal University, Krasnoyarsk, RUSSIA

⁸Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, RUSSIA

⁹Altai State Pedagogical University, Barnaul, RUSSIA

¹⁰Immanuel Kant Baltic Federal University, Kaliningrad, RUSSIA

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Abstract:

In modern conditions of conducting physical education classes, the role of tools and methods of monitoring the body's functional characteristics as markers of student's health state is increasing. *Purpose:* to study the longitudinal dynamics of the students, studying at a special medical group body functional state features during three years of study at the university. *Materials and methods.* 314 students of 1-3 years of study at six universities of Russia, having a disease and studying at a special group for physical education took part in the experiment. To determine the indicators of bio-impedance analysis and heart rate variability, the software and hardware complex «MedicalSoft Sports Testing System» (MS FIT – 01) was used. The heart rate indicators were determined; temporal (SDNN, RMSSD), spectral (TP, LF/HF, SI) parameters of heart rate variability, hemodynamic parameters (stroke volume, cardiac output), bio-impedance analysis (BMI, phase angle, basal metabolic rate). Based on certain indicators, the program calculated an integral indicator of health – wellness score (WS). *Results.* It was found that the 3rd year students of the special group have a higher level of body functional reserves and physical fitness relative to the groups of students in the 1st and 2nd studying years. This fact is confirmed by the body mass index dynamics, basal metabolism, phase angle, heart rate variability, as well as when calculating the integral score. They have a better BMI ratio, more optimal parameters of pumping heart activity and heart rate variability, a physiological level of stress index, higher physical performance in terms of phase angle during university studies. *Conclusions.* Physical education teachers should pay increased attention to junior students due to their low functional indicators. Timely monitoring of functional indicators should be carried out in order to take measures for prevention, preservation and promotion of health.

Key Words: physical education (PE), students, bioimpedance measurement, heart rate variability, adaptive reserves

Introduction

Students' professional training requires good health and high mental and physical performance of young people. According to experts in the field of physical culture, an important role in maintaining and strengthening the health and improving the cognitive abilities of students is assigned to regular physical activity, including using the means and methods of the discipline «Elective courses of physical culture and sports» (Savko, & Hojempo, 2018; Zurita-Ortega et al., 2019; Zhang et al., 2019). To implement educational programs in physical culture, students undergo an annual periodic medical examination, according to the results of which, in accordance with physical development, health status and various physiological parameters, they are divided into medical groups for PE classes. Students having deviations in the state of health for physical education are transferred to a special group.

According to research materials, students' health status begins to decline significantly even while studying at school (Krasnozhan et al., 2017) and by the time of admission to university, the number of students with various diseases can reach 50% or more of the number of students (Gerber et al., 2017; Hollis et al., 2017). Every fifth student is exempt from physical activity during PE classes for health reasons (Glazkova et al., 2020).

Physical education coach should pay special attention to students who have a disease (Momot et al., 2020; Mozolev, 2020). It is due to the fact that such students have serious disorders of the body with damage to various systems and low indicators of physical fitness (Badau et al., 2021). Diseases of the cardiovascular and

respiratory systems, musculoskeletal system, gastrointestinal tract, endocrine and other systems are often registered in young people (Doménech-Asensi et al., 2018). There is a prolonged release of students from physical loadings by doctors, which is not entirely correct, since the absence of dosed physical exercises contributes to a further decrease in physical performance and functional reserves (Enns et al., 2018) and further worsens the state of health. Under these conditions, the role of tools and methods of monitoring the functional characteristics of the body as markers of students' health status is increasing (Adams et al., 2018; Aparecida Maria Catai et al., 2020). Among students, the analysis of the body functional indicators state allows assessing the potential of young people in performing physical work, their resistance to the effects of the external and internal environment negative factors and difficulties in adapting to the study conditions at the university. A study of a person's, engaged in physical exercises functional characteristics may indicate fatigue, overstrain or overtraining of the body (Sergio Jiménez Morgan, & José Arturo Molina Mora, 2017) caused by physical exertion, and show the dynamics of recovery processes course after physical training (Dupuy, & Dugué, 2018).

Physical education classes for students with health disabilities have a specific organization and technology (Mozolev, 2020) due to the presence of serious somatic diseases. When organizing the educational process of students' physical education, a key role should be given to compliance with the principle of individualization of physical activity (Gumenyuk et al., 2021). This principle includes dynamic instrumental monitoring of the body's functional indicators state (Belousko, 2019). The use of modern instrumental technologies of control, which has a sufficiently high information content, reliability and validity of the conducted research, allows the teacher of physical culture to make an informed decision on the individualization of the educational process (Zaitsev, & Sheinin, 2021). It provides for an individual dosage of the volume, intensity and direction of students' physical exercises. Instrumental pedagogical control provides for the study of the leading functional indicators of the cardiovascular, musculoskeletal, nervous and other systems in the process of teaching students at the university

The scientific literature presents the data of the authors' research, which indicate that, despite the numerous training programs for physical education of students with health disabilities, the correction of training sessions is relevant, taking into account the identified features of the students' functional indicators (Koryahin, 2018). The issues of students' in the special medical group of health longitudinal dynamics of instrumental control of functional indicators in the process of their education at the university continue to be insufficiently studied.

Research aim is to study the longitudinal dynamics of the students, studying at a special medical group body functional state features during three years of study at the university.

Material & methods

The project involved 314 students of both sexes of the first, second and third years of study at six universities of humanities and technical fields of study in the Russia. According to the results of a medical examination at the beginning of each academic year, all students participating in the project were diagnosed with certain somatic diseases. This fact led to their inclusion in a special medical or III functional health group for physical education with a limitation of the volume and intensity of physical activity. Before the start of the research project, all students were familiarized with the conditions of the experiment, they signed an informed voluntary participation and consent to the processing of their personal data, according to the protocol of the Helsinki Declaration of 2008.

To determine the indicators of bio-impedance analysis and heart rate variability, the software and hardware complex «MedicalSoft Sports Testing System» (MS FIT - 01, Russia) was used. Testing was carried out in the middle of the academic day, during the inter-session period and in a state of physiological rest. Heart rate variability (HRV) was recorded in a sitting position, in a quiet and calm room, at an air temperature of 20-22° and a relative humidity of 45-55%. The method of counting the number of zero crossings was used to determine the QRS complexes of the cardiointervalogram. The resting heart rate (SBR) was determined; temporal (SDNN, RMSSD), spectral (TP, LF/HF, SI) HRV parameters (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability. Measurement standards. Physiological interpretation and clinical application, 1996).

Such hemodynamic parameters were calculated: cardiac stroke volume (SV), ml; cardiac output (MVB), l/min. According to bio-impedance analysis, the following indicators were calculated: body mass index (BMI, kg/m²), phase angle (FU, c.u.) and the main exchange (BM, kcal). Based on passing the test, the program calculated an integral indicator of health – wellness score (WS).

To determine systolic blood pressure (SBP), mm Hg; diastolic blood pressure, (DBP), mm Hg, an automatic tonometer «Omron M2 Basic» was used.

The data were processed by methods of variational parametric statistics using the Statistica 10.1 software package for Windows and Microsoft Excel 2016. The arithmetic mean (M) and the mean-square deviation (σ) were calculated. The Kolmogorov-Smirnov criterion with the Lilliefors correction was used to check the group data of samples for the distribution normality. One-factor analysis of variance ANOVA was used to compare students of different studying years with each other. The differences were considered significant at $p < 0.05$.

Results

The research results analysis shows that there are no statistically significant differences in the value of the body mass index (BMI) between the young men of the first and second years of study. At the same time, there is a statistically significant decrease in BMI in third-year students by 3.3% relative to 1st-year students, and by 3.7% relative to 2nd-year students, $p < 0.05$. This fact indicates a more optimal ratio of height and weight and a possible increase in the physical performance of young men by the third year of study. The opposite situation was recorded in girls: the BMI of freshmen was statistically significantly lower than the value of the indicator of sophomores by 2.7%, and by 4.5% relative to the peers of the 3rd year, $p < 0.05$. In general, the values of the parameters are within the boundaries of the normal distribution of length and body weight, however, in boys of the 1st and 2nd studying courses, as well as girls of the 2nd and 3rd ones, BMI is at the upper limit of the normative range, Fig. 1.

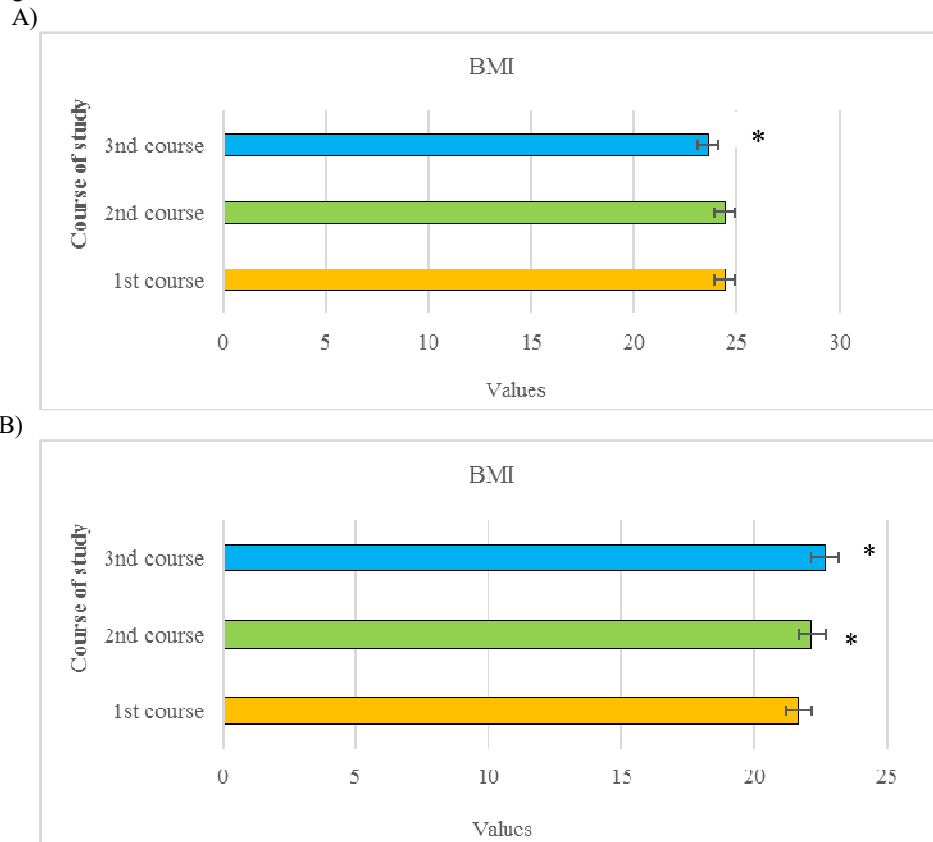


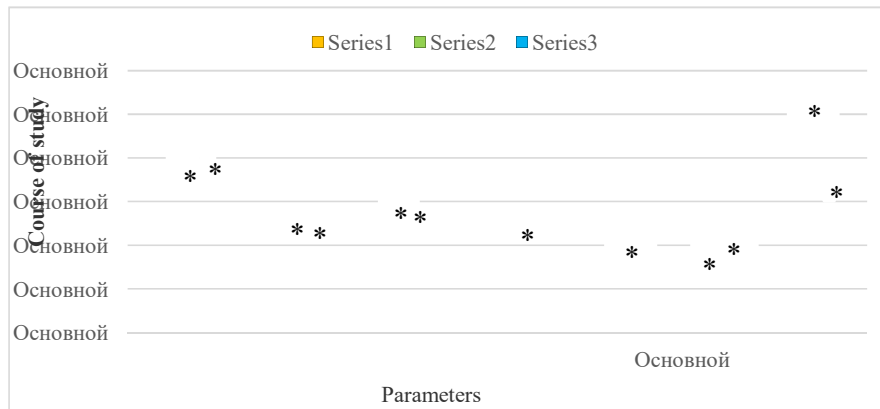
Fig. 1. Body mass index of students of different courses (A – boys, B – girls), «*» - differences between students of different courses are statistically significant, $p < 0.05$

The values of indicators characterizing blood pressure are within the normal range in all observed groups, Fig. 2. In boys and girls of the first year, SBP has a more optimal value relative to the other groups, $p < 0.05$. A decrease in DBP was registered in 1st year students, which may characterize a decrease in the elastic tone of the vascular wall or the existing features of the autonomic regulation of blood vessels. In girls, DBP was established within the normative range, no statistically significant differences were found between representatives of different courses, $p > 0.05$. It should be noted that sophomore students whose heart rate approached the upper limit of the standard (a value close to 90 bpm) and was higher by 5.2% relative to first-year students and by 9.1% relative to third-year students, $p < 0.05$. The girls also retain the tension of regulatory systems and increased sympathetic stimulation of the heart muscle, as evidenced by a fairly high heart rate among all groups of subjects. When studying the shock volume, it turned out to be higher for 3rd-year students relative to junior students by 5.6% and 7.6%, respectively, $p < 0.05$. A similar pattern is observed among girls, which may indicate both a higher level of fitness and functional reserves of the body, and the peculiarities of the morphological development of their body. According to the time index of heart rate variability value in 3rd-year boys, SDNN is fixed at a higher value, and in 1st and 2nd-year students it approaches the lower limit of the norm, $p < 0.05$. This fact indicates a decrease in the heart rate variation with the presence of its centralization. The same dynamics of SDNN is observed in girls of all courses of study, while in first-year students it manifests itself with pronounced sympathicotonia.

It was found that the 3rd year boys have the best recovery capabilities of the body, based on the value of RMSSD as an indicator characterizing parasympathetic activity. Its value in boys turned out to be 20.1% and 18.8% higher relative to 1st and 2nd year students, $p < 0.05$. There is a relative decrease in the parasympathetic activity of first-year girls (a decrease of 9.4% compared to sophomores and third-year students), $p < 0.05$. At the same time, the 1st year girls have a pronounced tension of regulatory systems, due to the high value of the stress index (SI), Fig.2, which can lead to disruption of adaptation mechanisms. In 2nd-year boys, the stress index is recorded at a value close to 200 c.u.

In terms of the total power of the spectrum, there is an increase in functional reserves among male 3rd-year students (31.0% and 30.2% higher compared to 2nd and 1st-year ones). Among the girls, students of the 2nd and 3rd courses can be noted – their total spectral analysis power was $1451.3 \pm 131.7 \text{ ms}^2$ and $1438.4 \pm 171.4 \text{ ms}^2$, and freshmen – $1357.2 \pm 114.2 \text{ ms}^2$, $p < 0.05$.

A)



B)

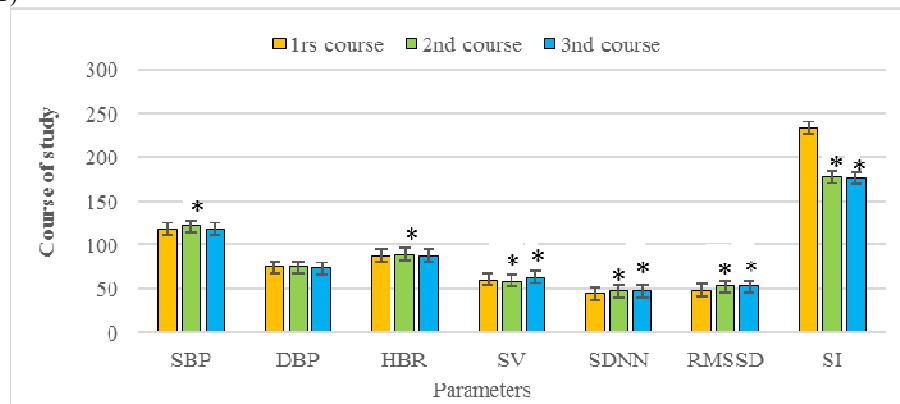


Fig. 2. Hemodynamic indices, NRV in students of different courses of study (A – boys, B – girls), «*» - differences between students of different courses are statistically significant, $p < 0.05$

All students have a normotonic reaction of the autonomic nervous system according to the value of the power ratio of the HRV spectral analysis in the low and high frequencies (chart). The phase angle is calculated – an indicator characterizing the level of fitness and physical performance, metabolic rate and general condition of the body. Young men of all courses have a relatively high content of musculoskeletal tissue and cell mass, and probably a good condition of cell membranes.

This fact indicates a high level of physical performance, especially among 3rd year students. Girls of the 1st year have a slight decrease in this indicator, $p < 0.05$. In addition, this is confirmed by a relatively high value of the basal metabolism index, which is 0.7% higher for 3rd year students relative to sophomores, and 2.2% higher relative to freshmen, $p < 0.05$. There were no statistically significant differences in the level of basal metabolism among girls, $p > 0.05$.

Table. Index of vegetative equilibrium, phase angle, basic metabolism, wellness score for students of different courses of study

Parameter	Boys			Girls		
	Course of study					
	I	II	III	I	II	III
LF/HF, c.u.	1.2±0.01	1.7±0.02*	1.2±0.01	1.7±0.02*	1.2±0.01	1.7±0.02*
FU, c.u.	7.8±0.07	8.1±0.08*	7.8±0.07	8.1±0.08*	7.8±0.07	8.1±0.08*
BM, kcal	1715.6±90.8	1744.7±152.6*	1715.6±90.8	1744.7±152.6*	1715.6±90.8	1744.7±152.6*
WS, c.u.	383.0±7.3	403.0±8.3	429.7±6.8*	369.7±6.6	399.7±6.8	408.0±9.3*

Note. - * the difference is significant, $p < 0.05$.

The integral score value (WS) for students of 1-2 courses is registered on the assessment «satisfactory». In the third year, boys and girls have a «good» grade. This fact indicates higher functional reserves of students studying in the third year of universities.

Discussion

The problem of protecting students' health is one of the important tasks facing specialists in this field, especially for students in a special group of PE classes (Li, 2022). One of the methods of monitoring students' health state is the use of instrumental technologies for monitoring the functional indicators of students' body (Adams et al., 2018; Aparecida Maria Catai et al., 2020). The value of such control increases significantly with longitudinal observations of the dynamics of the body's reserve capabilities state.

In recent years, in the practice of physical culture and sports, the MedicalSoft software and hardware complex, MS FIT - 01, Russia, has been used, which allows characterizing the state of the leading functional indicators of the human body (Bocharin et al., 2022). The available materials of scientific research in the field of instrumental methods of monitoring the functional characteristics of those engaged in physical culture or sports do not fully contain data on long-term observations of their physiological indicators. It can reduce the effectiveness of physical culture and wellness technologies or miss the negative effects of excessive physical exertion on the student's body (Sergio Jiménez Morgan, & José Arturo Molina Mora, 2017).

It is known that the acceleration of the learning process at universities is associated with the tense psycho-physiological state of students, and excessive loads are accompanied by the mobilization of the functioning of the body's physiological systems (Kolokoltsev et al., 2022; Machado, & Soares, 2022). At the same time, upon reaching the subsequent stages of adaptation, one can observe both its satisfactory level and the failure of adaptation (Vollmer-Conna et al., 2020). Based on this, it can be assumed that the process of studying at a university may be considered as a factor directly affecting the state of regulatory systems, and their timely monitoring makes it possible to take effective measures to prevent, preserve and strengthen students' health (Rodrigues et al., 2021).

The analysis of our results shows that students of the 3rd year of the special group have a higher level of functional reserves of the body and physical fitness, relative to students in the 1st and 2nd courses. This fact is confirmed by the positive dynamics of third-year students' body mass index values, basal metabolism, phase angle, heart rate variability parameters, as well as the level of the integral score in the wellness test. In our opinion, the use of targeted aerobic physical activity and instrumental methods of monitoring functional indicators in PE classes has led to an increase in the reserve capabilities of students by the third year of study. Our data are consistent with the materials of scientific studies by other authors indicating the positive impact of regular physical activity on human health (Savko, & Hojempo, 2018; Zurita-Ortega et al., 2019; Zhang et al., 2019). According to our data, the most pronounced positive changes in functional indicators were found in 3rd-year students in the cardiovascular system. These data do not contradict numerous research materials by other authors (Sergio Jiménez Morgan, & José Arturo Molina Mora, 2017; Dupuy, & Dugué, 2018; Gumenyuk et al., 2021), which point to the leading role of the cardiovascular system in the physical activity performance.

Our results of the study indicate that physical education coaches do not pay enough attention to the adaptation of students assigned to a special medical group. It is especially important to control the adaptation of students in the junior years of education of an educational institution.

Conclusions

Our research project shows that the 3rd year students of the special medical group have a better ratio of body mass index, more optimal parameters of pumping activity of the heart and heart rate variability, physiological level of stress index, the highest physical performance in terms of phase angle and integral health score. These data indicate a favorable adaptation to the educational and motor load during the students' studies at the university. PE teachers should give increased attention to those studying at junior courses due to the low reserve capabilities of their body. It is advisable to carry out longitudinal instrumental monitoring of the functional indicators of the body for the correction of sports and wellness technologies that are aimed at preventing, preserving and strengthening students' health.

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

References:

- Adams, J.A., Patel, S., Lopez, J.R., & Sackner, M.A. (2018). The effects of passive simulated jogging on shortterm heart rate variability in a heterogeneous group of human subjects. *J Sports Med*, 4340925. DOI:10.1155/2018/4340925
- Aparecida Maria Catai, Carlos Marcelo Pastre, Moacir Fernandes de Godoy, Ester da Silva, Anielle Christine de Medeiros Takahashi, Luiz Carlos Marques Vanderlei (2020). Heart rate variability: are you using it properly? Standardisation checklist of procedures. *Braz J Phys Ther*, 24(2), 91-102. DOI:10.1016/j.bjpt.2019.02.006
- Badau, D., Badau, A., Trambitas, C., Trambitas-Miron, D., Moraru, R., Stan, A.A., Oancea, B.M., Turcu, I., Grosu, E.F., Grosu, V.T., Daina, L.G., Daina, C.M., Suteu, C.L., & Moraru, L. (2021). Differences between Active and Semi-Active Students Regarding the Parameters of Body Composition Using Bioimpedance and Magnetic Bioresonance Technologies. *Int J Environ Res Public Health*, 18(15), 7906. DOI: 10.3390/ijerph18157906.
- Belousko, D. V. (2019). Background of the development of the model of mirror individualization of physical culture education. *Health, Physical Culture and Sports*, 4(15), 3-10. Retrieved from <http://hpcas.ru/article/view/7064>
- Bocharin, I., Guryanov, M., Martusevich, A., Apoyan, S., Kolokoltsev, M., Melnichuk, A., Vorozheikin, A., & Romanova, E. (2022). Young men's body hemodynamics variability in different states of motor activity. *Journal of Physical Education and Sport*, 22(3), 562-569. DOI: 10.7752/jpes.2022.03070.
- Doménech-Asensi, G., Gómez-Gallego, C., Ros-Berruezo, G., García-Alonso, F.J., & Canteras-Jordana, M. (2018). Critical overview of current anthropometric methods in comparison with a new index to make early detection of overweight in Spanish university students: the normalized weight-adjusted index. *Nutr Hosp*, 35(2), 359-367. DOI: 10.20960/nh.1189.
- Dupuy, O., Douzi, W., Theurot, D., Bosquet, L., & Dugué, B. (2018). An evidence-based approach for choosing post-exercise recovery techniques to reduce markers of muscle damage, soreness, fatigue, and inflammation: a systematic review with meta-analysis. *Front Physiol*, 9(403), 403. DOI: 10.3389/fphys.2018.00403
- Enns, A., Eldridge, G.D., Montgomery, C., & Gonzalez, V.M. (2018). Perceived stress, coping strategies, and emotional intelligence: A cross-sectional study of university students in helping disciplines. *Nurse Educ Today*, 68, 226-231. DOI: 10.1016/j.nedt.2018.06.012.
- Gerber, M., Ludyga, S., Mucke, M., Colledge, F., Brand, S., & Puhse, U. (2017). Low vigorous physical loads is associated with increased adrenocortical reloads to psychosocial stress in students with high stress perceptions. *Psychoneuroendocrinology*, 80, 104-113. DOI:10.1016/j.psyneuen.2017.03.004
- Glazkova, G., Mamonova, O., Gracheva, D., & Pukhovskaya, M. (2020). Social aspects of physical education of students with deviations in health status. *Journal of Physical Education and Sport*, Vol.20(5), Art 347, pp. 2545 – 2553. DOI:10.7752/jpes.2020.05347
- Gumenyuk, S., Sereda, I., Hulka, O., Lavrin, H., Ladyka, P., & Kuz, Y. (2021). Effect of yoga on biological age indicators of 14-15-year-old girls. *Journal of Physical Education and Sport*, Vol 21 (Suppl. issue 5), Art 392, pp 2956 – 2962. DOI:10.7752/jpes.2021.s5392
- Hollis, J.L., Sutherland, R., Williams, A.J., Campbell, E., Nathan, N., Wolfenden, L., Morgan, P.J., Lubans, D.R., Gillham, K., & Wiggers, J. (2017). A systematic review and meta-analysis of moderate-to-vigorous physical loads levels in secondary school physical education lessons. *International Journal of Behavioral Nutrition and Physical Loads*, 14, DOI:10.1186/s12966-017-0504-0
- Kolokoltsev, M., Romanova, E., Limarenko, O., Vorozheikin, A., Bocharin, I., Mungalov, A., Tarasov, A., Aganov, S., & Balashkevich, N. (2022). Motor qualities of girls from different populations and evolutionary constitution types. *Journal of physical education and sport*, 22(6), 1372-1377, DOI: 10.7752/jpes.2022.06172
- Koryahin, V., Blavt, O., Bakhmat, N., Guska, M., Ludovyk, T., Prozar, M., Bodnar, A., Kravets, S., & Bezgrebelnaya, E. (2018). Differentiated correction of attention abilities of students with chronic diseases during physical education. *Journal of Physical Education and Sport*, 18(4), Art 343, pp. 2278 – 2283, DOI:10.7752/jpes.2018.04343
- Krasnozhan, S.V. (2017). Motor activity as a criterion of the level of health. *Physical education. Sport. Tourism. Motor recreation*, 2(1), 46-52
- Li, Y. (2022). Analysis of Psychological Disorders and Adaptive Influence of Blended Learning of College Students. *Comput Intell Neurosci*, 5418738. DOI: 10.1155/2022/5418738.
- Machado, F.P., & Soares, M.H. (2022). Cross-cultural adaptation of the University Student Depression Inventory for Brazil. *Rev Bras Enferm*, Suppl 3, e20220004. DOI: 10.1590/0034-7167-2022-0004.
- Momot, O., Diachenko-Bohun, M., Hrytsai, N., Grygus, I., Stankiewicz, B., Skaliy, A., Hagner-Derengowska, M., Napierała, M., Muszkieta, R., Ostrowska, M., & Zukow, W. (2020). Creation of a healthcare

- environment at a higher educational institution. *Journal of Physical Education and Sport*, Vol 20 (Supplement issue 2), Art 138, pp 975 – 981. DOI:10.7752/jpes.2020.s2138
- Mozolev, O., Kravchuk, L., Ostrovska, N., Nahorna, O., Polishchuk, O., & Khmara, M. (2020). Checking the effectiveness of the method of conducting physical education classes with 17-19 -year-old female students of special medical group. *Journal of Physical Education and Sport*, Vol.20(2), Art 124, pp. 870 – 876. DOI:10.7752/jpes.2020.02124
- Rodrigues, J.M., Matos, L.C., Francisco, N., Dias, A., Azevedo, J., & Machado, J. (2021). Assessment of qigong effects on anxiety of high-school students: a randomized controlled trial. *Adv Mind Body Med*, 35(3), 10-19. PMID:34237025.
- Savko, E.I., & Hojempo, S.V. (2018). Student youth and their attitudes to physical culture, and healthy lifestyles. *Health, Physical Culture and Sports*, 4(11), 62-76. <http://journal.asu.ru/index.php/zosh>
- Sergio Jiménez Morgan, & José Arturo Molina Mora (2017). Effect of heart rate variability biofeedback on sport performance, a systematic review. *Appl. Psychophysiol. Biofeedback*, 42(3), 235-245. DOI:10.1007/S10484-017-9364-2
- Task force of the European Society of cardiology and the North American Society of pacing and electrophysiology (1996). Heart rate variability. Standards of measurement. Physiological interpretation and clinical use. *Circulation*, 93, 1043–1065, PMID:8598068
- Vollmer-Conna, U., Beilharz, J.E., Cvejic, E., Macnamara, C.L., Doherty, M., Steel, Z., Hadzi-Pavlovic, D., Harvey, S.B., & Parker, G. (2020). The well-being of medical students: A biopsychosocial approach. *Aust N Z J Psychiatry*, (10), 997-1006. DOI: 10.1177/0004867420924086.
- Zaitsev, A.A., & Sheinin, A.A. (2021). Features of human motor activity control using rank analysis of heart rate. East - Russia - West. Physical culture, sports and a healthy lifestyle in the XXI century. *Proceedings of the XXII International Symposium*. Kaliningrad, pp. 33-38.
- Zhang, Z., Chen, B., & Chen, W. (2019). The mediating effect of perceived health on the relationship between physical activity and subjective well-being in Chinese college students. *Journal of American College Health*, 1–8. DOI:10.1080/07448481.2019.1645676
- Zurita-Ortega, F., Badicu, G., Chacon-Cuberos, R., & Castro-Sanchez, M. (2019). Motivational Climate and Physical Activity: A Multigroup Analysis in Romanian and Spanish University Students. *International Journal of Environmental Research and Public Health*, 16(11). DOI:10.3390/ijerph16112013