

Relation between typological characteristics of nervous system and high sport achieving of wrestlers

NATALIA CHERNENKO¹, VLADIMIR LYZHUB², GEORGIY KOROBENNIKOV³, VLADIMIR POTOP⁴,
IRINA SYVASH⁵, LESIA KOROBENNIKOVA⁶, IVANNA KOROBENNIKOVA⁷, VICTORIA
MISHCHENKO⁸, VASIL KOSTUCHENKO⁹

^{1,2,3} The Bohdan Khelnytsky National University of Cherkasy, Cherkasy, UKRAINE

^{5,6,7,8,9} National University of Physical Education and Sport, Kiev, UKRAINE

⁴ Ecological University of Bucharest, ROMANIA

Published online: May 30, 2020

(Accepted for publication: May 18, 2020)

DOI:10.7752/jpes.2020.03221

Abstract.

Purpose: was to clarify the role of individual-typological characteristics of the central nervous system for achieving of high results in the Greco-Roman wrestling. *Material:* The 2 groups of Greco-Roman wrestling were examined. The first group - 27 elite wrestlers (age 18-27), members of the National Team of Ukraine who having sports experience from 5 years and more. The second group 37 young wrestlers age 13-15. The third group (control) contains 13 couples of monozygotic (MH) and 18 - dizygotic (DZ) twins. They were not athletes. *Methods of genetics, research of typological characteristics of the central nervous system: functional mobility (FMNS), strength (SNP), poise (PNP) of nervous processes and time of central processing of information, video recording and analysis of technical methods of wrestlers and mathematical statistics was used. Results.* The links between genetically determined typological characteristics of the central nervous system and success of the Greco-Roman wrestling was found. Hereditary dependence of functional mobility and the relative advantage of the genotype - strength, poise of nervous processes and time of central processing of information is proved. Sensomotor characteristics did not reveal any dependence on genetic factors. The expressed dependence of the indexes of technological skills and the effectiveness of the competitive performance of wrestlers on their individual features that resulting from genetically was established. This index was functional mobility. The wrestlers, who had better indexes of the typological characteristics of the central nervous system, were characterized by higher level assessments of technological skills and conduct of the fight. *Conclusions.* Typological characteristics of the central nervous system - functional mobility, along with technical preparedness, - are recommended as highly genetically determined criteria for assessing the prospects of wrestlers.

Key words: Greco-Roman wrestling, psychophysiological functions, sensomotrics, technical preparedness

Introduction.

The Greco-Roman wrestling is in demand and it is a part of the Olympic program. Leading trainers and scholars of United World of Wrestling (UWW) emphasize the volume and intensity of physical activity have become critical, and their further growth is limited by the biological capabilities of the human organism at the present stage of development of sport of higher achievements (Mirzaei et al., 2009; Curby et al., 2016; Iermakov et al., 2016; Korobeynikov et al., 2019; Lysohub et al., 2019). Therefore, only a talented person who possesses a complex of genetic properties for this kind of sport, can achieve high results in the wrestling. It is assumed that the prognosis of sporting giftedness can be realized only on the basis of genetic markers (Drozdovska et al., 2013; Kozina et al., 2018; Podrigalo et al., 2018; Lysohub et al., 2019). That is why, researchers are showing considerable interest to the search of genetically determined markers, which are the most informative about of forecasting the individual result of sports training (Sybil et al., 2018; Chernozub et al., 2018; 2019; Lysohub et al., 2019). As known, the criterias for selection in the wrestling are: state of health, functional capabilities of the organism systems, the level of development of motor qualities, the ability to master the technique and tactics, transfer significant training and competitive load, motivation, performance, mobilization readiness, assessment of the level of reserve capabilities (Barbas et al., 2011; Podrigalo et al., 2017; Korobeynikov et al., 2018). We can assume that adaptive reactions of psychophysiological and cognitive functions for wrestlers will be due to the individual-typological characteristics of the nervous system (Korobeynikov et al., 2019). We offered to these criteria to add individual - typological characteristics of the central nervous system: functional mobility, strength, poise of nervous processes (Makarenko et al., 2006; 2007). The part of individual-typological characteristics of the central nervous system (Makarenko et al., 2006; 2007; Chernenko-Kuragina, 2016; Dudnyk et al., 2017;

Lysohub et al., 2018; Lysohub et al., 2019). The role of individual-typological characteristics of the central nervous system as a genetic markers of giftedness to high sports achievements in certain sports and, especially, in the Greco-Roman wrestling, has not been clarified yet. It is not possible to generalize the role of highly genetically determined individual-typological characteristics of the central nervous system in enhancing the functional capabilities of elite wrestlers on the basis of scientific literature. It is even more difficult to substantiate of relation between typological characteristics of nervous system and high sport achieving in wrestlers.

The **purpose** was to clarify the role of individual-typological characteristics of the central nervous system for achieving of high results in the Greco-Roman wrestling.

Material and methods.

The 2 groups of Greco-Roman wrestling were examined. The first group - 27 elite wrestlers (age 18-27), members of the National Team of Ukraine who having sports experience from 5 years and more. The second group 37 young wrestlers age 13-15. The third group (control) include 13 pairs of monozygotic (MZ) and 18 - dizygotic (DZ) twins – youths, who were not involved in sports.

Using the computer device "Diagnostic-1M" determined the typological characteristics: functional mobility (FMNS), strength (SNP), poise (PNP) of nervous processes, latent periods of simple, complex reaction of choice 1 from 3 indicators (RC1-3), the reaction of choice 2 from 3 indicators (RC 2-3), time of central processing of information (CPI) and simple sensory - motor reaction (SSMR) (Makarenko et al., 2007). The level of the FMNS was determined by the results of the processing of complex visual information in the mode of "imposed rhythm" that stood at the disparities of positive and inhibitory stimuli (geometric figures). The indicator of the FMNS was the maximum speed of signal processing when surveyed did not make more than 5.0-5.5% of the mistakes. The higher the speed of processing information, the higher the pace of processing information, the higher the FMNS. Indicator of the efficiency of the cerebral cortex pointed to the SNP. This indicator was estimated by the number of mistakes (%), that the researcher made when performing the entire task. The definition of the PNP involved the registration of the accuracy of the reactions to the moving object. The total amount of reactions, that were ahead or delayed, indicated the level of PNP. The smaller the amount of deviation of motor reactions (in ms), the higher the PNP. The part of hereditary and environmental factors in the formation of neurodynamic signs was determined by calculating the Holzinger's heredity factor (H), which expresses the force of heredity. The coefficients of intraclass correlation (r) for monozygotic (MZ) (r_{mz}) and dizygotic (DZ) (r_{dz}) were calculated for each indicator of the studied functions. The value of H was calculated by the formula: $H = (r_{mz} - r_{dz}) / (1 - r_{dz})$. It is believed when H is equal to 0, the development of the sign is determined solely by the factor of the environment, and when $H=1$ - completely depends on the hereditary factors. The Holzinger (H) coefficient, which is greater than 0.5, indicates a relative advantage, and more than 0.7 is a criterion for the absolute superiority of genetic factors.

Video recording and analysis of competitive activities of wrestlers-participants in the Cup and the Ukrainian Championship was carried out. The main competitive indicators of the Greco-Roman style wrestlers were calculated such as: the total number of technique used by wrestlers, separately recorded the number of technical and tactical actions and their individual components for a fight, conducted an expert evaluation of competitive activities. The results are processed by methods of mathematical statistics on the program Microsoft Excell. Methods of parametric and nonparametric statistics, correlation analysis, the significance of statistical differences of mean values was used.

Results.

The determination of the share of hereditary and environmental factors in the formation of neurodynamic characteristics was carried out on monozygotic (MZ) and dizygotic (DZ) twins - youths, who were not involved in sports (Table 1).

Table 1 Coefficients of pair correlation (R) and heredity (H) of sensory-motor and major characteristics of the basic nervous processes and central processing of information for MZ and DZ twins

Research indicators	Coefficients of pair correlation (R)		
	MZ	DZ	Coefficients of heredity (H)
Simple sensory - motor reaction, ms	0.38	0.15	0.26
Complex reaction of choice 1 from 3 indicators, ms	0.54	0.43	0.20
Complex reaction of choice 2 from 3 indicators, ms	0.57	0.23	0.29
Time of central processing of information, ms	0.79	0.57	0.52
Functional mobility of nerve processes, secret unit	0.88	0.65	0.65
Strength of nerve processes, secret unit	0.73	0.51	0.53
Poise of nervous processes, secret unit	0.81	0.56	0.56

Correlation coefficients for SSMR values did not reach the statistical probability ($p > 0.05$). Only for the complex reactions of choice (RC_{1-3} and RC_{2-3}) coefficient r for MZ, respectively, was 0.54 and 0.57 ($p < 0.05$), while for the CPI value, the coefficient r for MZ was 0.79 ($p < 0.05$). The coefficient of heredity (H) showed significant values only for CPI. It was 0.52 ($p < 0.05$).

Analysis of the results for the MZ group of twins showed that the correlations of the indices of individual-typological characteristics of the main nervous processes were within the range of 0.88 - 0.73, for DZ - from 0.65 to 0.51 ($p < 0.05$). In studying intra-pair similarity in twin groups, it was found that all of the investigated indexes of typological characteristics are characterized by a higher level of correlation in MZ than in DZ pairs, which indicates a pronounced genetic effect on these parameters ($p < 0.05$).

The differentiated effect of genotypic and environmental factors on the indices of different individual characteristics of the nervous system is shown by the Holzinger's (H) heredity. It indicates a relative advantage if it is greater than 0.5, and it is a criterion for the absolute superiority of genetic factors if H more than 0.7 (Bray et al., 2009; Drozdovska et al., 2013).

In our experiments the coefficient H was high (0.65) for only one of the studied indices: FMNS. This indicator turned out to be slightly lower (0.56 - 0.52) for the PNP, the SNP and the CPI. The value of H for SSMR and for RC_{1-3} and RC_{2-3} were even lower (0.29 - 0.20). It indicates the overwhelming dependence of these indicators on the external environment.

Thus, the results of studies, conducted on the same group of twins, showed the participation of genetic and environmental factors in the formation of individual features sensomotorics and typological characteristics of the central nervous system are manifested in different ratios. High genetic conditionality for FMNS (70%), and the relative advantage of genotypic factors (50%) - for the PNP, SNP and CPI was detected. The advantage of phenotypic factors is established for the indicators - SSMR and RC_{1-3} , RC_{2-3} . Holzinger's coefficient did not exceed 30% for them.

The high dependence of the functional mobility of the nervous processes on the genotype, discovered by us, allowed us to proceed to the study of the special preparedness of the wrestlers. Analysis of the representation of wrestlers with different levels of functional mobility of nervous processes revealed their clear dependence on the level of athletic skill (Fig. 1).

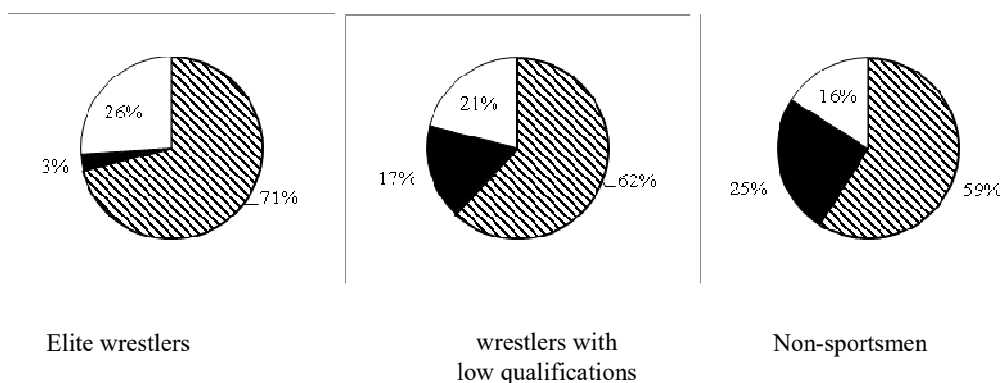


Fig. 1. Representation of persons with:

high - middle - and low - level of FMNP among wrestlers with different qualifications and not athletes

Thus, 26% of studied with high level of functional mobility of nervous processes were found in a group of elite wrestlers, while in the group "not athletes" - only 16%. At the same time, a small number of those surveyed with a low level (only 3%) entered the elite group, and they were 17% in the group of low-skilled wrestlers. They were much more among non-athletes - 25%. Thus, most people with high functional mobility of the nervous process were found among elite wrestlers. The results shown in Fig. 2. confirm this fact too.

Elite athletes had statistically significant high results of the investigated typological property - 128.4 [116.4; 136.3] signals/min. ($p < 0.05$) as shown in Fig. 2. Low-skilled wrestlers occupied an intermediate position for this indicator - 104.1 [97.6; 113.8] signals/min. Not athletes had the lowest level of functional mobility of nerve processes - 91.0 [86.3; 96.4] signals/min.

We made a video of the matches ($\frac{1}{4}$, $\frac{1}{2}$ of the final stage of the Championship of Ukraine) and counted the total number of technical techniques performed and analyzed the results of the fight by elite wrestlers. An

expert evaluation of competitive activity also was conducted depending on the level of functional mobility of the nervous processes.

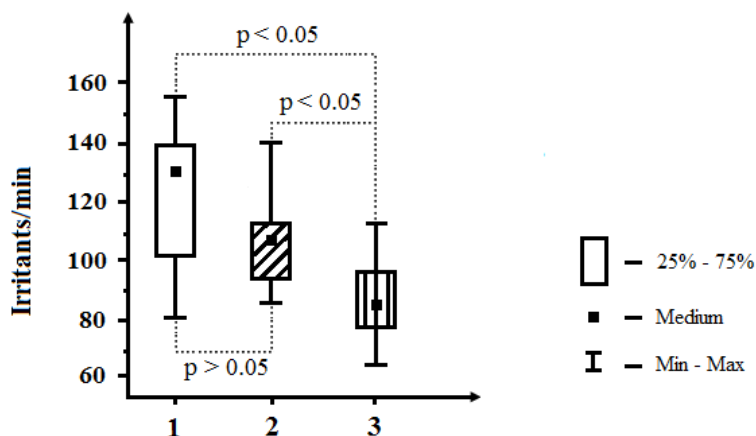


Fig. 2. Indicators of functional mobility of of nervous processes (Me (Q₂₅ - Q₇₅)) signals/min. for elite wrestlers -1, wrestlers with low qualifications -2 and not athletes -3.

For this, the group of elite wrestlers was divided into 3 groups depending on the level of functional mobility of the nervous processes by the method of sigma deviations: with high - 120-130, average - 100-118 and low level - 70-99 signals per minute. Different components of technical techniques were analyzed in these groups of the wrestlers (Table 2).

Table 2 Components of technical techniques for elite wrestlers with different levels of functional mobility of nerve processes (Me (Q₂₅ – Q₇₅))

Level of functional mobility of nerve processes	Total TTA for one wrestling	Total for fight	Techniques in stance	Turn-over	Techniques in parterre	Turning
High, 120-130 signals/min	234* [226.3; 243.4]	3.66* [2.3; 4.6]	0.87 [0.6; 1.1]	0.51* [0.4; 0.7]	1.18* [0.8; 1.3]	1.1 [0.8; 1.3]
Average, 100-118 signals/min	218* [186.3; 226.1]	3.02 [2.1; 3.6]	0.78 [0.6; 1.0]	0.34 [0.2; 0.6]	0.97 [0.8; 1.1]	0.93 [0.6; 1.2]
Low, 70-99 signals/min	135 [126.4; 156.7]	2.92 [1.8; 3.4]	0.83 [0.5; 0.9]	0.32 [0.2; 0.5]	0.88 [0.6; 1.1]	0.89 [0.6; 1.0]

Note: * - significant differences (p<0,05) between the studied parameters for groups with high, average and low functional mobility of nervous processes.

Wrestlers with a high level of functional mobility of the nervous processes were more active and possessed a greater arsenal of tactical techniques than athletes with its low level, which can be stated by the total number of technical techniques for one fight (p<0.05). Receptions in parterre significantly prevailed over other technical and tactical methods, which is noticeable from the analysis of the fight. The quantity of technical receptions on average for one fight in parterre was the largest for elite wrestlers, confirming the specificity of the modern Greco-Roman wrestling. Above all, athletes with a high level of functional mobility were able to gain more points and defend themselves during in parterre fight than athletes with a low level of investigated individual-typological characteristics of the central nervous system. In general, elite wrestlers with a high level of functional mobility of the nervous processes demonstrated higher technical and tactical skills during competitions, both in parterre and in stance, than athletes with low level of investigated typological qualities.

Competitive potential of elite wrestlers was conducted and analyzed by independent experts. They evaluated the competitive activity of elite wrestlers for groups with different levels of functional mobility. The experts evaluated the arsenal of «crown» techniques in the rack and in parterre, the athlete's ability to demonstrate activity throughout the fight, an arsenal of «crown» attacks, possession of reliable protection (using the 10 point system) during the competition (Table 3).

Table 3 An expert assessment of the competitive activities of wrestlers with different level of functional mobility of nervous processes (Me (Q₂₅ – Q₇₅))

Levels of FMNP	Assessment (points)
High	8.1 [6.7; 9.4]*
Average	7.5 [6.1; 8.7]
Low	4.1 [3.3; 6.4]

Note: * - significant differences ($p < 0,05$) between expert assessments for groups with high and low functional mobility of nervous processes.

Wrestlers with a high level of mobility of the nervous processes were characterized by the best average score of competitive activity as seen from the results in Table. 3. Their index was - 8.1 [6.7; 9.4] points. The wrestlers with a medium and low levels got lower marks, respectively - 7.5 [6.1; 8.7] and 4.1 [3.3; 6.4] points ($p < 0.05$). The wrestlers with high functional mobility possessed a wider arsenal of TP, ability to fight in any conditions, attracted the increased interest of fans. They perceived, analyzed the duel more precisely and qualitatively and correctly acted in conditions of high psycho-emotional and physical stress.

Thus, athletes with a high level of functional mobility of the nervous processes demonstrated a higher competitive potential, an arsenal of attacking and defensive actions and activity throughout the duel, which was proved by the results of expert evaluations.

Discussion.

The purpose was to clarify the role of individual-typological characteristics of the central nervous system for achieving of high results in the Greco-Roman wrestling.

The task was to substantiate the hereditary conditionality of the individual-typological characteristics of the nervous system and how they relate to TP and to the effectiveness of competitive activities. We hypothesized the individual-typological characteristics of the higher divisions of the central nervous system, namely - FMNS, SNP, and PNP, as well as the characteristics of simple and complex sensorimotor reactions - SSMR, RC₁₋₃, RC₂₋₃ and time CPI can be the basis of an individual strategy of conducting wrestle. To test such an assumption, first of all, we conducted a study using the method of MZ and DZ twins. We found that simple and complex sensory-motor reactions did not reveal any dependence on genetic factors. While all the individual-typological characteristics of the central nervous system revealed a high hereditary dependence on the genotype. The functional mobility of the of nervous processes had the highest coefficient of heredity (H). Why was the functional mobility of the nervous processes associated with the technical readiness of the wrestlers? It is known that functional mobility characterizes the ability of the higher parts of the central nervous system to provide the maximum possible for a given individual level of performance of the mental load on the error-free differentiation of positive and inhibitory conditional signals. These signals follow one after the other and require both emergency switching actions and frequent changes in the time of the excitatory process on the inhibitory and vice versa (Makarenko et al., 2007; Lysohub et al., 2018, Romanenko et al., 2018). Proceeding from this, functional mobility of the nervous processes should be the most fully characterize the complex reaction of the nervous system the wrestlers, because it includes not only the speed of occurrence and stopping of excitation, the speed of transition of the state of excitation inhibition and, conversely, fast switching attention and irradiation and concentration. In addition, the functional mobility of the nervous processes of elite wrestlers reflects the speed of differentiation of afferent stimuli that enter the athlete's brain during fights (López-González et al., 2013; Korobeynikova et al., 2016). Also, the FMNS reflects the speed of formation of new and destruction of old temporary bonds, the speed of the movement of nervous processes, the speed of recovery and the functional readiness of the reflex apparatus to new reactions. Considering that functional mobility is a function of the neocortex (Lyzohub et al., 2017). Also, take into account that the formation of arbitrary movements is the process of constructing a multicomponent hierarchically organized system (Starosta et al., 2016), which includes all levels of the nervous system, among them the higher (the leading level of ensuring the formation of movements is the frontal lobe of the cerebral cortex (Edwards et al., 2013). It becomes clear why the dependence of technical preparedness and effectiveness of competitive activities of elite fighters on the highly genetically determined functional mobility of the nerve processes was established in our experiment. Probably, precisely this mechanism is the basis for understanding the interconnection of technical preparedness of wrestlers with the individual-typological characteristics of the central nervous system. Wrestling, with hereditary better performance of functional mobility, characterized by higher expert assessments of the effectiveness of wrestling and technical actions of the fight and other psychomotor functions than those surveyed with low typological performances of the nervous system. It is presumably other mechanisms are the basis of the interaction of the training process with the genetically determined individual-typological properties of the central nervous system too. The most successful explanation may be that the brain processes of wrestlers are improved through the activation of regulatory and structural genes. As a result, new functional intracellular and intercellular

relationships appear, new connections between neurons are established (Drozdovska et al., 2013; Korobeynikov et al., 2018).

Important results we obtained about the relationship of genetically determined individual-typological characteristics of the central nervous system with the technical training and the effectiveness of competitive activities for elite wrestlers. Thus, individual highly genetically determined characteristics of the central nervous system can be the selection criteria together with physical, mental, motivational, age-specific features (Kozina et al., 2017; Chernozub et al., 2018), which is proved by the results of our work. These criteria are the most informative regarding the prediction of the success of sports activities in the Greco-Roman wrestling.

In our opinion, one of the ways to achieve high results in the wrestling of the World level is, first of all, the selection of the most talented youth in terms of functional mobility of nervous processes. Secondly, to construct a training process taking into account the individual typological features of the central nervous system, which can increase the athletic skill of the wrestlers by attracting genetic and reserve capabilities of the organism.

Conclusions

Link between individual-typological characteristics of the central nervous system and achieving of high results in the Greco-Roman wrestling was revealed. One of the most genetically determined characteristic of nervous system in wrestlers is functional mobility of nerve processes.

Athletes who have hereditary better performances of individual-typological characteristics of the central nervous system, characterized by higher assessments of the effectiveness of wrestling and technical actions of the competition activity.

It is necessary for achieving high results in the wrestling needed:
to select the most talented youth according to the indicators of functional mobility of nerve processes and to build a training process taking into account the individually typological features of the central nervous system.

References

- Barbas, I., Fatouros, I. G., Douroudos, I. I., Chatzinikolaou, A., Michailidis, Y., Draganidis, D., ... & Katrabasas, I. (2011). Physiological and performance adaptations of elite Greco-Roman wrestlers during a one-day tournament. *European journal of applied physiology*, 111(7), 1421-1436. doi:10.1007/s00421-010-1761-7
- Bray, M. S., Hagberg, J. M., Perusse, L., Rankinen, T., Roth, S. M., Wolfarth, B., Bouchard, C. (2009). The human gene map for performance and health-related fitness phenotypes: the 2006-2007 update. *Medicine & Science in Sports & Exercise*, 41(1), 34-72. doi: 10.1249/MSS.0b013e3181844179.
- Chernenko-Kuragina, N. P. (2016). Physiological characteristics of mental activity of people with different individual typological properties of higher nervous activity at a low rate of processing information. *Cherkasy University Bulletin: Biological Sciences Series*, 120-126.
- Chernozub, A., Korobeynikov, G., Mytskan, B., Korobeynikova, L., Cynarski, W. (2018). Modelling Mixed Martial Arts Power Training Needs Depending on the Predominance of the Strike or Wrestling Fighting Style, *Ido movement for culture. Journal of Martial Arts Anthropology*, 18(3), 28-36. doi: 10.14589/ido.18.3.5.
- Chernozub, A., Danylchenko, S., Imas, Y., Kochina, M., Natalia, I., Korobeynikov, G., Korobeynikova, L., Potop, V., Cynarski, W. J., Gorashchenko, A. (2019). Peculiarities of correcting load parameters in power training of mixed martial arts athletes. *Journal of Physical Education and Sport*, 19, 481-488.
- Curby, D.G. (2016). Effect of uniform color on outcome of match at Senior World Wrestling Championships 2015. *International Journal of Wrestling Science*, 6(1), 62-64. doi:10.1080/21615667.2016.1210266
- Drozdovska, S. B., Dosenko, V. E., Ahmetov, I. I., Ilyin, V. N. (2013). The association of gene polymorphisms with athlete status in Ukrainians. *Biology of sport*, 30(3), 163-167. doi: 10.5604/20831862.1059168.
- Dudnyk, O.; Yarmak, O.; Dotsyuk, L.; Mykhaylyshyn, G.; Zoriy, Y.; Moseychuk, J. (2017). Assessment of human psychophysiological responses to intense exercise: a survey of Greco-Roman wrestlers and unqualified competitors. *Journal of Physical Education and Sport*, 17(3), 2089-2096. doi:10.7752/jpes.2017.s4212.
- Edwards, A. M., Polman, R. C. J. (2013). Pacing and awareness: brain regulation of physical activity. *Sports Medicine*, 43(11), 1057-1064. doi: 10.1007/s40279-013-0091-4.
- Iermakov, S., Podrigalo, L., Romanenko, V., Tropin, Y., Boychenko, N., Rovnaya, O., Kamaev, O. (2016). Psycho-physiological features of sportsmen in impact and throwing martial arts. *Journal of physical education and sport*, 16(2), 433-439. doi:10.7752/jpes.2016.02067
- Korobeynikov, G., Korobeynikova, L., Potop, V., Nikonorov, D., Semenenko, V., Dakal, N., Mischuk, D. (2018). Heart rate variability system in elite athletes with different levels of stress resistance. *Journal of Physical Education and Sport*, 18(2), 550-554. doi:10.7752/jpes.2018.02079.

- Korobeynikov, G., Glazyrin, I., Potop, V., Archipenko, V., Glazyrina, V., Dudnyk, O., & Dakal, N. (2019). Adaptation to endurance load in youths. *Journal of Physical Education and Sport*, 19(3), 1035-1040. doi:10.7752/jpes.2019.s3149.
- Korobeynikov, G., Cynarski, W. J., Mytskan, B., Dutchak, M., Korobeynikova, L., Nikonorov, D., Borysova, O., Korobeinikova, I. (2019). The psychophysiological state of athletes with different levels of aggression. *Ido Movement for Culture. Journal of Martial Arts Anthropology*, 19(1S), 62-66. doi:10.14589/ido.19.1S.10.
- Korobeynikova, L.G.; Makarchuk, M.Y.; Korobeynikov, G.V.; Mischenko, V.S., Zapovitryana, O.B. (2016). States of psychophysiological functions of elite athletes in different aging groups. *Fiziolohichniy zhurnal*, 62(6), 81-87.
- Kozina, Z., Prusik, K., Görner, K., Sobko, I., Repko, O., Bazilyuk, T., Korol, S. (2017). Comparative characteristics of psychophysiological indicators in the representatives of cyclic and game sports. *Journal of Physical Education and Sport*, 17(2), 648-655. doi: :10.7752/jpes.2017.02097.
- Kozina, Z., Chebanu, O., Repko, O., Kozin, S., Osiptsov, A. (2018). Influence of typological features of the nervous system on individual performance in running for short distances in athletes with visual impairment on the example of an elite athlete. *Physical Activity Review*, 6, 266-278.
- López-González, D.E., Miarka, B. (2013). Reliability of a new time-motion analysis model based on technical-tactical interactions for wrestling competition. *International Journal of Wrestling Science*, 3(1), 21-34.
- Lyzohub, V., Chernenko, N., Palabiyik, A. (2018). [Method of definitions mental performance during processing of information with different speed of presentation of stimuli](#). *Cherkasy University Bulletin: Biological Sciences Series*, 70-80 doi: 0.31651/20765835-2018-1-1-70-79
- Lyzohub, V., Chernenko, N., Palabiyik, A. Kozhemyako T., Bezkopilna S. (2019). [Age peculiarities of interaction of motor and cognitive brain systems while processing information of different modality and complexity](#). *Regulatory Mechanisms in Biosystems*, 103, 288-294 doi: [10.15421/021944](#)
- Lyzohub, V., Makarchuk, M., Yukhymenko, L., Zganyaiko, I., Koval, J., Kharchenko, D. (2017). Functional organization of visual-motor reactions of the different complexity levels in persons with auditory deprivation. *Cherkasy University Bulletin: Biological Sciences Series*, (1), 48-55.
- Lyzohub, V., Chernenko, N., Palabiyik, A. (2019). Neurophysiological mechanisms of regulation of sensorimotor reactions of differentiation in ontogenesis. *Journal of Cellular Neuroscience and Oxidative Stress*, 11(1), 805- 814.
- Makarenko, N. V., Lizogub, V. S., Yukhimenko, L. I. (2006). Reactions of the autonomic nervous system of students with different characteristics of higher nervous activity in the situation of examination stress. *Human Physiology*, 32(3), 368-370.
- Makarenko, M. V., Lyzohub, V. S. (2007). The speed of central information processing in humans with different properties of basic nervous processes. *Fiziolohichniy zhurnal*, 53(4), 87-91.
- Mirzaei, B., Curby, D. G., Rahmani-Nia, F., & Moghadasi, M. (2009). Physiological profile of elite Iranian junior freestyle wrestlers. *The Journal of Strength & Conditioning Research*, 23(8), 2339-2344.
- Podrigalo, L., Iermakov, S., Potop, V., Romanenko, V., Boychenko, N., Rovnaya, O., Tropin, Y. (2017). Special aspects of psycho-physiological reactions of different skillfulness athletes, practicing martial arts. *Journal of Physical Education and Sport*, 17(1), 519. doi: 10.15561/18189172.2017.0603
- Podrigalo, L., Cynarski W.J., Rovnaya, O., Volodchenko, O., Halashko, O., Volodchenko, J. (2018). Studying of physical development features of elite athletes of combat sports by means of special indexes. *Ido movement for culture. Journal of Martial Arts Anthropology*, 19(1), 51–57. doi: 10.14589/ido.19.1.5.
- Romanenko, V.; Podrigalo, L.; Iermakov, S.; Rovnaya, O.; Tolstoplet, E.; Tropin, Y.; Goloha, V. (2018). Functional state of martial arts athletes during implementation process of controlled activity - comparative analysis. *Physical Activity Review*, 6, 87-93. doi: [10.16926/par.2018.06.12](#).
- Sybil, M., Pervachuk, R., Zahura, F., Stelmakh, Y., & Bodnar, I. (2018). Considering the current balance between lactate and alactate mechanisms of energy supply in preparation of free style wrestlers. *Journal of Physical Education and Sport*, 18, 1826-1830. doi:10.7752/jpes.2018.s4267
- Starosta, W. (2016). Anthropokinesiology–new or old universal interdisciplinary human movement science?. *Coordination Abilities in Physical Education, Sports and Rehabilitation*, 11-21.