DOI: https://doi.org/10.17816/KMJ653398 EDN: BONJXJ

Approaches to Non-Pharmacological Modulation of Neural and Immune Communication: Therapeutic Potential of Vibration Stimulation

Igor V. Shirolapov, Olga N. Pavlova, Olga N. Gulenko, Polina M. Moskvitina
Samara State Medical University, Samara, Russia

ABSTRACT

Nowadays, principles of neuromuscular system activation using vibration-mediated, intensive reflex stimulation are employed in addition to conventional physical activity for clinical rehabilitation or sports performance. Studies show that vibration training is an effective, non-pharmacological way to improve various body functions, which can effectively rehabilitate movement disorders and muscle weakness, as well as treat hormonal and metabolic disorders, osteoporosis, cardiorespiratory disorders, and age-related disorders. Immune dysfunction and age-related changes are closely associated with neuroinflammation and neurodegeneration. Recent data demonstrate the positive effects of vibration training on immune responses and higher integrative brain functions, suggesting a promising therapeutic approach for treating nervous system diseases. This article evaluates the effects of vibration training for neuromuscular stimulation on cellular and molecular pathways involved in neuroimmune communications and systematizes the available data on the potential use of this non-pharmacological option for treatment of neurological and immune disorders. Various vibration training programs demonstrate their effectiveness and multifunctional performance in treating deficits and could be a promising addition to conventional exercise and physical rehabilitation options. However, the effects of proprioceptive stimulation by vibration training on the nervous system and the associated immune response remain to be elucidated. Therefore, research in various animal models and in human, as well as a comprehensive evaluation of the results and therapeutic effectiveness, will contribute to a deeper, more systematic understanding of this technology's effects on human health.

Keywords: neuromuscular system; vibration stimulation; proprioception; neuroimmune interactions.

To cite this article:
Shirolapov IV, Pavlova ON, Gulenko ON, Moskvitina PM. Approaches to non-pharmacological modulation of neural and immune communication: therapeutic potential of vibration stimulation. *Kazan Medical Journal.* 2025;106(3):422–431. DOI: 10.17816/KMJ653398 EDN: BONJXJ

Submitted: 05.02.2025 **Accepted**: 27.02.2025 **Published online**: 30.05.2025

ECO•VECTOR

DOI: https://doi.org/10.17816/KMJ653398 EDN: BONJXJ

Подходы к нефармакологической модуляции нервной и иммунной коммуникации: терапевтический потенциал вибрационной стимуляции

И.В. Широлапов, О.Н. Павлова, О.Н. Гуленко, П.М. Москвитина

Самарский государственный медицинский университет, г. Самара, Россия

АННОТАЦИЯ

В настоящее время наряду с традиционной физической нагрузкой в целях клинической реабилитации или для достижения спортивных показателей применяются принципы активации нейромышечной системы с использованием рефлекторной интенсивной стимуляции, опосредованной вибрационным воздействием. В ряде исследований вибрационная физическая нагрузка как немедикаментозный метод воздействия на различные функциональные системы организма продемонстрировала свою эффективность в реабилитации двигательных расстройств и мышечной слабости, в коррекции гормональных и метаболических нарушений, остеопороза, кардиореспираторной и возраст-ассоциированной патологии. Иммунная дисфункция и возрастные изменения тесно коррелируют с процессами нейровоспаления и нейродегенерации. Последние данные указывают на положительное влияние вибрационного тренинга на иммунный ответ и высшие интегративные функции мозга, а также демонстрируют терапевтические возможности при заболеваниях нервной системы. В настоящей статье анализируется влияние вибрационной стимуляции нейромышечной системы на клеточные и молекулярные пути, вовлечённые в нейроиммунные коммуникации, и систематизированы имеющиеся данные о потенциале такого воздействия для немедикаментозной коррекции неврологических и иммунных нарушений. Анализ исходов различных программ вибрационной физической нагрузки подтверждает эффективность и многофункциональность данного вмешательства для коррекции соответствующего дефицита и позволяет рассматривать его как многообещающее дополнение к традиционным упражнениям и методам физической реабилитации. Однако вопросы о конкретных механизмах, посредством которых интенсивная проприоцептивная стимуляция в условиях вибрационного тренинга может влиять на различные аспекты функционирования нервной системы и иммунный ответ, остаются открытыми. Поэтому изучение данной технологии с помощью разнообразных модельных организмов и у человека, а также комплексное исследование результатов воздействия и всесторонняя оценка терапевтической эффективности будут способствовать более глубокому и системному пониманию особенностей её влияния на здоровье человека в целом.

Ключевые слова: нейромышечная система; вибрационная стимуляция; проприоцепция; нейроиммунные взаимодействия.

Как цитировать:
Широлапов И.В., Павлова О.Н., Гуленко О.Н., Москвитина П.М. Подходы к нефармакологической модуляции нервной и иммунной коммуникации: терапевтический потенциал вибрационной стимуляции // Казанский медицинский журнал. 2025. Т. 106, № 3. С. 422–431. DOI: 10.17816/KMJ653398 EDN: BONJXJ

Рукопись получена: 05.02.2025 **Рукопись одобрена**: 27.02.2025 **Опубликована online**: 30.05.2025

ЭКО•ВЕКТОР

INTRODUCTION

Vibration training (VT) involves the use of a specialized platform to expose the body to mechanical vibrations of a certain frequency and amplitude, leading to various physiological responses that contribute to positive effects and clinical benefits after short- or long-term stimulation [1]. During vibration physical exposure, skeletal muscles rapidly contract and relax reflexively at a certain frequency, activating muscle metabolism and improving stretch reflex by activation of muscle spindles [1–3]. This vibration load increases production of nitric oxide and enhances systemic blood circulation, which potentiates oxygen and nutrient delivery to organs and tissues throughout the body [4–6]. Vibration stimulation (VS) initiates endocrine responses and can increase the synthesis and secretion of hormones and growth factors, of which many contribute to skeletal muscle mass maintenance and development. Moreover, VT increases bone density, stimulates bone remodeling, and shows potential to improve neuromuscular function, which positively affects balance and sensorimotor coordination [7–13]. After a single and repeated course of vibration physical exercise (VPE), decreased pain in chronic dorsalgia, osteoarthritis, and fibromyalgia and improved bronchial patency were recorded, which may be associated with its inhibitory effect on neurons of the spinothalamic tract and vagal effects [14–16]. Overall, VT is a relatively new alternative to traditional exercises and physical rehabilitation, which has therapeutic potential, versatility, and proven effectiveness [17–19].

This study aimed to summarize and analyze current data on the mechanisms and clinical application of vibration physical effects to systematize available information on the cellular and systemic effects of intense neuromuscular activation induced by VS on the immune response and integrative functions of the brain.

A search for publications was performed in PubMed, Scopus, and RSCI using search queries and keywords. The systematic search included articles published over the past 20 years (2005–2025). The following keywords and their combinations were used: whole-body vibration, WBV, WBV training, WBV exercises, WBV therapy, vibration, nervous, immune, immunity, neurological, neuroimmune, brain, and cognitive. Based on the stated search objective, abstracts of reports, meeting minutes, books, clinical cases, and case series were excluded.

MECHANISMS OF PHYSIOLOGICAL SYSTEMS ACTIVATION

In the neuromuscular system, the mechanism of action of VT involves mechanical high-frequency stimulation of the proprioceptive system using specialized platforms and devices [20]. It is based on vibrational somatosensory perception, which is a widespread phenomenon in nature; this innate ability of animals has evolutionary significance, strengthening the biological connection of the organism with the environment [20, 21].

The human somatosensory system is sensitive to mechanical stimulation, most commonly found in oscillatory form, with a frequency ranging from 1 Hz to approximately 100 kHz [14]. High-frequency (>100 Hz) and high-intensity (>10 mm) vibrations can lead to negative consequences, including musculoskeletal disorders or increased risks of developing vibration disease; however, low-frequency (up to 50 Hz) and low-amplitude (<10 mm) vibrations have demonstrated positive functional effects, particularly for therapeutic and rehabilitation purposes [22–24].

VS-based mechanical action promotes intensive neurogenic adaptation [3, 18]. In such cases, stimulation of muscle spindle proprioceptors is several times higher than during traditional physical activity [25]. Therefore, VPE results in muscle–hypothalamic axis activation, which causes a rapid increase in the secretion of anabolic humoral factors, including somatotropin, insulin-like growth factor-1, and testosterone, and stabilization of cortisol secretion [26]. Improvement of physical performance with this type of exposure is based on neuromuscular adaptation; VS causes a reflex reaction of skeletal muscles as a sequence of small, close to isometric, involuntary muscle contractions with a frequency equal to the stimulation frequency [2, 27]. According to electromyography data, such proprioceptive stimulation activates up to 100% of skeletal muscle fibers, with VPE causing rerecruitment of silent motor units and temporarily maintaining them at high activity even in fatigued muscles. In the fatigue that occurs during this process, the leading role is played by the peripheral mechanism with normal serum lactic acid levels, which do not significantly increase after VT [1, 27, 28].

VPE may be considered a conditionally passive physical exercise [13, 29]. VT requires less effort and is relatively effective, economical, and suitable for various conditions and can be adapted for clinical and home/household use. Therefore, for individuals facing physical limitations or having reduced motivation due to factors such as weakness and asthenia, psychophysiological disorders, and depression, VT is an accessible and effective technique for initiating and increasing physical activity [29–32].

As even acute and short-term effects of such exposure are accompanied by a twofold increase in blood flow in the vessels of muscles and skin, an increase in lymphatic drainage and venous return in the trained area of the body, and no pronounced systemic immunosuppressive effects are detected [33–36], VS has proven to be promising regarding effectiveness in high-performance sports and restorative medicine for patients of various age groups, including the elderly and senile [37–39].

NEUROIMMUNE COMMUNICATION

Nervous and immune regulation of functions have several communication pathways and intersystem relationships involved in maintaining the overall homeostasis of the body [40]. In a tonic mode, the brain sends its signals to the periphery to activate immune function; conversely, the immune system transmits information in the opposite direction to modulate the activity of the central nervous system [40–42]. Such intersystem interactions affect thermoregulatory processes, sleep and wakefulness, eating behavior, brain glymphatic activity, and hormonal status [43–46]. In neurodegenerative disorders such as Alzheimer and Parkinson diseases, the immune system also plays a significant role, being directly involved in pathogenetic mechanisms and indirectly affecting disease course and progression [42, 47]. In such neuroimmune interactions, various cytokines, such as interleukins IL-1β and IL-6, tumor necrosis factor TNF-α, transforming growth factor TGF-β1 and TGF-α, and other immune response-related factors (e.g., Toll-like receptors and prostaglandins), play a critical role [40, 48]. Immune-mediated proinflammatory and anti-inflammatory responses, along with oxidative stress, influence the delicate balance in neurodegenerative contexts. A study and analysis of the effects of VS on immune reactivity revealed the therapeutic potential of this intervention in conditions associated with immune dysfunction and its broader implications for neurodegenerative disorders and neuroinflammatory processes [47, 48].

This review aimed to increase scientific awareness and study and analyze the complex pathways and mechanisms modulated by pulsed VS, emphasizing on the molecular and cellular aspects related to the immune response and higher integrative functions of the brain.

MODULATION OF IMMUNE SYSTEM ACTIVITY

In preclinical studies in animal models, study of macrophages from abdominal adipose tissue showed that VS in the described regimens causes a significant increase in the number of M2 macrophages with anti-inflammatory function and restores the cytokine IL-10 level in diabetic mice to resting values in control mice [49]. Immunological data indicate that vibration loading alters regulatory T-cell differentiation in mice and remodels alpha and beta diversity of the gut microbiome [49]. VS potentially alters microbiota associated with innate and mucosal immunity, which promotes anti-inflammatory effects and eliminates adverse effects by downregulating the hyperinflammatory state [43, 49–51].

Chronic inflammation as a characteristic feature of aging contributes to various age-associated diseases [52]. Serum inflammation markers are correlated with chronic processes in old and senile age, which underlies the pathogenesis of several metabolic, cardiorespiratory, and neurodegenerative disorders [52–55]. In clinical studies, VT has demonstrated potential to modulate cytokine levels in the elderly, indicating a systemic anti-inflammatory effect and lack of immunosuppression [39, 53]. Following its exposure, the expressions of TLR2 and TLR4 receptors decrease, indicating possible biological mechanisms involved in the modulation of immune responses [56]. The identified immunological changes correlated with improved physical performance, revealing the holistic systemic effect on the participants' bodies [51, 56]. Evidence shows that traditional moderate physical activity may have anti-inflammatory effects [39, 42]. Physically active people have comparatively lower plasma concentrations of biological markers of systemic inflammation and heat shock proteins and lower proinflammatory cytokine production in mitogen-stimulated cultures, and peripheral blood monocytes express lesser Toll receptors in their membranes [42]. The effects of long-term VT on the immune response of elderly women have been studied [57, 58]. Significant changes in the cell-mediated and humoral immunity factors were noted after 12 weeks of training [57]. After 24 weeks of VPE, the main subpopulations of peripheral blood lymphocytes, expression of their activation markers, and serum concentrations of immunoglobulins and cytokines in elderly women maintained at the initial level [58]. According to the authors, obtained data indicate the stability of lymphocyte activation under such influence, which characterizes such physical activity as a weak stress factor for immune function in elderly people and allows for its wide use in medical rehabilitation [53, 58].

Therefore, VS effects are crucial in modulating immune response. Direct and indirect effects on the intestinal microbiome, glymphatic clearance of metabolites, and local immune-inflammatory responses in VPE alter T-cell differentiation, cause a shift in macrophages, and modulate proinflammatory and anti-inflammatory cytokine levels [59–61]. However, stress associated with excessive physical activity can disharmonize the immune function and contribute to decreased immune reactivity to infectious agents, and decreased immunological activation and immune inflammation can be one of the mechanisms that provide positive effects of regular, moderate physical exercise; therefore, any physical activity demonstrates dose-dependent effects on the immune response system and should be limited in intensity and duration, exceeding which causes general metabolic and immune disorders [37, 62–64].

MODULATION OF NERVOUS SYSTEM ACTIVITY

Initially, the practical use of VT was aimed at improving muscle and musculoskeletal function; however, as the clinical application of VS developed, the potential impact of this nondrug method on the nervous system became more evident [18, 21, 65, 66]. The fundamental and clinical effects of VS on various aspects of brain function have been studied in healthy volunteers and animals, including models of various neuroinflammatory and neurodegenerative diseases [65–70]. Studies in animal models have found that 5 weeks of VT induce a positive effect on the cognitive performance of 18- and 30-month-old rats; the treatment demonstrated potential in reducing anxiety, significantly improved spatial memory and rearing behavior, and increased the overall motor activity of experimental animals [71].

Complex studies of the effects of VS on neuronal function, synaptic protein expression, and neurotrophic factor levels in a rat model of chronic depression induced by restraint stress showed significant activation of neuroprotection and neuronal recovery [72]. The proposed mechanisms of such effects include inhibition of neuronal degeneration processes, reactive microgliosis and astrocyte atrophy, protective isolation of synapses, strengthening of neuronal connections, restoring impaired cellular memory, reducing dendritic and axonal damage, modulating the glymphatic pathway for removal of cerebral metabolic products, and increasing expression of neurotrophic factors [47, 73, 74]. In particular, VPE may promote neuroprotection by modulating the levels of neurotrophins and anti-inflammatory agents such as IGF-1, BDNF, and IL-10 [73]. In preclinical studies, VS has shown promising results in mitigating prefrontal cortex damage and dysfunction [75]. Moreover, activation of the SESN2/AMPK/PGC-1α signaling pathway, which alleviates oxidative stress and local inflammation, was identified as a key mechanism mediating this effect [75, 76].

Moderate physical exercise induces a positive effect on the psychophysiological status, motor activity, and cognitive abilities of the elderly [77, 78]. Moreover, in cases where traditional physical activity is impossible owing to various limitations and concomitant pathology, VPE can be used as a form of active-passive training to achieve the required results comparable to those in physical exercise and rehabilitation, including in relation to cognitive productivity [77–80]. In some clinical studies, when exposed to VS with a frequency of 30 Hz and a session duration of <30 min per day, 4 days a week for 5 weeks, elderly people showed positive results in the Stroop test, indicating an improvement in selective attention and inhibition [80]. In a study of young participants, despite the absence of cognitive impairment, even short-term exposure showed improvement in the Stroop Color and Word Test scores and a positive effect on executive cognitive functions [81]. These reveal the potential of VPE as an adjunct to cognitive enhancement therapy programs [81, 82]. Meta-analyses and narrative reviews reported that VT demonstrates improvements in motor skills, reaction time, information processing speed, sensorimotor integration, and global executive functions [65, 78, 83, 84]. The beneficial effects extended to patients with relevant deficits, including cognitive or sensorimotor coordination impairments [85–90]. Moreover, studies have shown improvements in attention, memory, and thinking in children with attention-deficit/hyperactivity disorder and in cognitive abilities and other higher integrative brain functions in patients with multiple sclerosis, Parkinson's disease, Alzheimer dementia, and stroke [83–90].

SUMMARY ANALYSIS OF THE POTENTIAL IMPACT OF TECHNOLOGY ON NEUROIMMUNE INTERACTIONS

According to experimental and clinical studies, VS in the appropriate modes modulates the nervous regulation processes and higher integrative functions of the brain, including improvement of balance, coordination of movements and neuromuscular function, and development of cognitive performance and global executive functions, which determines the therapeutic potential and effectiveness of the method for people with neurological disorders [65, 71, 78, 83, 91–94]. Descriptive and systematic analyses of the outcomes of such effects on cellular and molecular pathways involved in immune and neural communication demonstrated the efficacy of VPE as a nondrug intervention to correct the corresponding deficit, which remains a debatable participant. The results may be beneficial in planning the design and protocols of future studies investigating such effects [76, 95, 96].

VS directly and indirectly affects the immune function by modulating T-cell differentiation and cytokine profile and initiating positive changes in the gut microbiome [27, 33, 40, 43, 49, 97–99]. This technology impacts the levels of proinflammatory and anti-inflammatory markers, which together shows a regulatory role in the immune response and systemic reactions [27, 33, 98]. The beneficial effects of VT in various neurological disorders may be mediated by cellular pathways that play a significant regulatory role in neuroinflammation, neuroprotection, and neurotransmission [40, 69, 89, 99]. Thus, at the molecular level, VS demonstrates involvement of several inflammatory/anti-inflammatory biomarkers (IL-1, IL-6, IL-10, CRP, and TNF-α) and neurotransmitters, such as acetylcholine, norepinephrine, dopamine, and serotonin, and neurotrophic factors, particularly TNFR-1, TNFR-2, IGF-1, and BDNF, in the modulation [27, 40, 58, 97–99].

Despite evidence of numerous clinical effects of VPE, the specific mechanisms by which intense proprioceptive stimulation in VPE modulates functional responses of the nervous system and immune response require further scientific investigation and discussion [27, 47, 53, 77]. By increasing scientific awareness, which is a basic goal of descriptive and systematic reviews, the present study can serve as an additional impetus for critical analysis of the available body of data, search for new solutions and relationships, and stimulation of basic and applied research of acute and long-term effects of VS. Further study of the effect of VPE in animal models and in humans of different age groups will contribute to a deeper understanding of the mechanisms of influence not only on neuroimmune communication but also on human health in general.

CONCLUSION

Experimental and clinical data show positive effects of VT on the immune response and higher integrative functions of the brain and demonstrate broad therapeutic potential. The present study combines and systematizes the available data of the last 20 years on the cellular and systemic effects of intense neuromuscular activation induced by VS on immune function and the central nervous system and emphasizes the importance of studying the fundamental mechanisms of such effects for the development of more optimal protocols for experimental and clinical studies in this area.

ADDITIONAL INFORMATION

Author contributions: Sh.I.V.: conceptualization, writing—original draft, writing—review & editing; P.O.N.: writing—review & editing, supervision; G.O.N.: investigation, methodology; M.P.M.: investigation, writing—original draft. All authors approved the version of the manuscript to be published and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
Ethics approval: Not applicable.
Funding sources: No funding.
Disclosure of interests: The authors have no relationships, activities, or interests for the last three years related to for-profit or not-for-profit third parties whose interests may be affected by the content of the article.
Statement of originality: This work was created using fragments of our own text and previously published data ([Pyatin V.F., Shirolapov I.V., Zhestkov A.V., Nikitin O.L., Limareva L.V., Zubova I.A. Immune Indexes of Peripheral Blood in Elderly Women During Acceleration Exercise (Whole Body Vibration): A Pilot Twelve-Week Trial. Medical Immunology (Russia). 2010;12(4–5):413–416. (In Russ.); [Pyatin V.F., Zhestkov A.V., Shirolapov I.V., Nikitin O.L., Limareva L.V., Zubova I.A Adaptive Capabilities of the Immune System of Elderly Women Under Uniformly Accelerated Training: Results of A 24-Week Study. Allergology and immunology. 2010;11(1):42–47]). References are provided in the corresponding section.
Data availability statement: The editorial policy regarding data sharing does not apply to this work, as no new data was collected or created.
Generative AI: No generative artificial intelligence technologies were used to prepare this paper.
Provenance and peer review: This paper was submitted unsolicited and reviewed following the standard procedure. The review process involved two external reviewers, a member of the editorial board, and the in-house scientific editor.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. Ш.И.В. — разработка концепции, написание черновика рукописи, написание рукописи — рецензирование и редактирование; П.О.Н. — написание рукописи — рецензирование и редактирование, научное руководство; Г.О.Н. — проведение исследования, разработка методологии; М.П.М. — проведение исследования, написание черновика рукописи. Все авторы одобрили рукопись (версию для публикации), а также согласились нести ответственность за все аспекты работы, гарантируя надлежащее рассмотрение и решение вопросов, связанных с точностью и добросовестностью любой её части.
Этическая экспертиза. Неприменимо.
Источники финансирования. Отсутствуют.
Раскрытие интересов. Авторы заявляют об отсутствии отношений, деятельности и интересов за последние три года, связанных с третьими лицами (коммерческими и некоммерческими), интересы которых могут быть затронуты содержанием статьи.
Оригинальность. При создании настоящей работы были использованы фрагменты собственного текста и данные, опубликованные ранее ([Пятин В.Ф., Широлапов И.В., Жестков А.В., и др. Иммунологические показатели периферической крови женщин пожилого возраста при равноускоренном тренинге: результаты 12-недельного исследования // Медицинская иммунология. 2010. Т. 12, № 4–5. С. 413–416]; [Пятин В.Ф., Жестков А.В., Широлапов И.В., и др. Адаптационные возможности системы иммунитета женщин пожилого возраста в условиях равноускоренного тренинга: результаты 24-недельного исследования // Аллергология и иммунология. 2010. Т. 11, № 1. С. 42–47]). Ссылки представлены в списке литературы.
Доступ к данным. Редакционная политика в отношении совместного использования данных к настоящей работе не применима, новые данные не собирали и не создавали.
Генеративный искусственный интеллект. При создании настоящей статьи технологии генеративного искусственного интеллекта не использовали.
Рассмотрение и рецензирование. Настоящая работа подана в журнал в инициативном порядке и рассмотрена по обычной процедуре. В рецензировании участвовали два внешних рецензента, член редакционной коллегии и научный редактор издания.

REFERENCES

1. Rittweger J. *Manual of vibration exercise and vibration therapy*. NYC, USA: Springer; 2020. 389 p. doi: 10.1007/978-3-030-43985-9
2. Pyatin VF, Shirolapov IV. Physical load acceleration — expansion of rehabilitation possibilities of restorative medicine. *Bulletin of restorative medicine*. 2009;29(1):25–29. EDN: MUJGPR
3. Rittweger J. Vibration as an exercise modality: how it may work, and what its potential might be. *Eur J Appl Physiol*. 2010;108(5):877–904. doi: 10.1007/s00421-009-1303-3 EDN: MYMPPL
4. Johnson PK, Feland JB, Johnson AW, et al. Effect of whole body vibration on skin blood flow and nitric oxide production. *J Diabetes Sci Technol*. 2014;8:889–894. doi: 10.1177/1932296814536289
5. Korolev VV, Pyatin VF, Eskov VM, Shirolapov IV. Features of restoration of heart rate variability after vibration physical load. *Bulletin of restorative medicine*. 2010;35(1):13–16. EDN: MUJHUL
6. Zuccarelli L, Baldassarre G, Winnard A, et al. Effects of whole-body vibration or resistive-vibration exercise on blood clotting and related biomarkers: a systematic review. *NPJ Microgravity*. 2023;9(1):87. doi: 10.1038/s41526-023-00338-4 EDN: NTSZDD
7. Kotelnikov GP, Piatin VF, Bulgakova SV, Shirolapov IV. Whole body vibration (acceleration) training increases bone mineral density and serum levels of osteocalcin in elderly women. *Adv Gerontol*. 2010;23(2):257–262. EDN: MSVIMD
8. Liu P, Li Y, Xiao Y, et al. Effects of whole-body vibration training with different frequencies on the balance ability of the older adults: a network meta-analysis. *Front Physiol*. 2023;14:1153163. doi: 10.3389/fphys.2023.1153163 EDN: KIKMVS
9. Pyatin VF, Shirolapov IV. Neuromuscular stimulation in conditions of vibrational physical activity for the prevention of osteoporosis. *Problems of Balneology, Physiotherapy and Exercise Therapy*. 2020;97(3):87–93. doi: 10.17116/kurort20209703187 EDN: FICCWK
10. Yin S, Liu Y, Zhong Y, Zhu F. Effects of whole-body vibration on bone mineral density in postmenopausal women: an overview of systematic reviews. *BMC Womens Health*. 2024;24(1):444. doi: 10.1186/s12905-024-03290-x EDN: EQRREC
11. Krause A, Lee K, König D, et al. Six weeks of whole-body vibration improves fine motor accuracy, functional mobility and quality of life in people

with multiple sclerosis. *PLoS One*. 2022;17(7):e0270698. doi: 10.1371/journal.pone.0270698 EDN: XOFRGV

12. Marín-Cascales E, Alcaraz PE, Ramos-Campo DJ, et al. Whole-body vibration training and bone health in postmenopausal women: a systematic review and meta-analysis. *Medicine*. 2018;97(34):e11918. doi: 10.1097/MD.0000000000011918

13. Rogan S, Taeymans J. Effects of stochastic resonance whole-body vibration on sensorimotor function in elderly individuals — a systematic review. *Front Sports Act Living*. 2023;5:1083617. doi: 10.3389/fspor.2023.1083617 EDN: AEDNXW

14. Oroszi T, van Heuvelen MJG, Nyakas C, van der Zee EA. Vibration detection: its function and recent advances in medical applications. *F1000Res*. 2020;9:F1000 Faculty Rev-619. doi: 10.12688/f1000research.22649.1 EDN: FYECFB

15. Pyatin VF, Shirolapov IV. Acute whole body vibration significantly increases maximal expiratory flow in man. *Herald of Tver State University. Series: Biology and Ecology*. 2009;(11):38–43. EDN: MTZOHH

16. Watson A, Wilkinson TMA, Freeman A. Evidence around the impact of pulmonary rehabilitation and exercise on redox status in COPD: a systematic review. *Front Sports Act Living*. 2021;3:782590. doi: 10.3389/fspor.2021.782590 EDN: FRRUJO

17. Simon AB, Bajaj P, Samson J, Harris RA. the clinical utility of whole body vibration: a review of the different types and dosing for application in metabolic diseases. *J Clin Med*. 2024;13(17):5249. doi: 10.3390/jcm13175249 EDN: GNLTBS

18. Bonanni R, Cariati I, Romagnoli C, et al. Whole body vibration: a valid alternative strategy to exercise? *J Funct Morphol Kinesiol*. 2022;7(4):99. doi: 10.3390/jfmk7040099 EDN: KKYKVA

19. Hu J, Wang Y, Ji X, et al. Non-pharmacological strategies for managing sarcopenia in chronic diseases. *Clin Interv Aging*. 2024;19:827–841. doi: 10.2147/CIA.S455736 EDN: IWWPXY

20. Krajnak K, Riley DA, Wu J, et al. Frequency-dependent effects of vibration on physiological systems: experiments with animals and other human surrogates. *Ind Health*. 2012;50:343. doi: 10.2486/INDHEALTH.MS1378

21. Cardinale M, Rittweger J. Vibration exercise makes your muscles and bones stronger: fact or fiction? *J Br Menopause Soc*. 2006;12(1):12–18. doi: 10.1258/136218006775997261 EDN: MDVQED

22. Eskov VM, Korolev VV, Polukhin VV, et al. Dynamics of parameters of attractors of motion of state vectors of the organism of elderly women under the influence of twelve-week vibration physical load. *Bulletin of new medical technologies*. 2009;16(3):66–69. EDN: LAMYMZ

23. Monteiro-Oliveira BB, Coelho-Oliveira AC, Paineiras-Domingos LL, et al. Use of surface electromyography to evaluate effects of whole-body vibration exercises on neuromuscular activation and muscle strength in the elderly: a systematic review. *Disabil Rehabil*. 2022;44(24):7368–7377. doi: 10.1080/09638288.2021.1994030 EDN: PMIYUN

24. Rittweger J, Ehrig J, Just K, et al. Oxygen uptake in whole-body vibration exercise: influence of vibration frequency, amplitude, and external load. *Int J Sports Med*. 2002;23(6):428–432. doi: 10.1055/s-2002-33739

25. Cochrane DJ, Stannard SR, Firth EC, Rittweger J. Acute whole-body vibration elicits post-activation potentiation. *Eur J Appl Physiol*. 2010;108(2):311–319. doi: 10.1007/s00421-009-1215-2 EDN: VXJOHH

26. Sanni AA, Blanks AM, Derella CC, et al. The effects of whole-body vibration amplitude on glucose metabolism, inflammation, and skeletal muscle oxygenation. *Physiol Rep*. 2022;10:e15208. doi: 10.14814/phy2.15208 EDN: JVGENR

27. Di Giminiani R, Rucci N, Capuano L, et al. Individualized whole-body vibration: neuromuscular, biochemical, muscle damage and inflammatory acute responses. *Dose Response*. 2020;18:1559325820931262. doi: 10.1177/1559325820931262 EDN: TCLZKB

28. Cochrane DJ, Loram ID, Stannard SR, Rittweger J. Changes in joint angle, muscle-tendon complex length, muscle contractile tissue displacement, and modulation of EMG activity during acute whole-body vibration. *Muscle Nerve*. 2009;40(3):420–429. doi: 10.1002/mus.21330

29. Piatin VF, Shirolapov IV, Nikitin OL. Vibrational physical exercises as the rehabilitation in gerontology. *Adv Gerontol*. 2009;22(2):337–342. EDN: MUZWIR

30. Li KY, Cho YJ, Chen RS. The effect of whole-body vibration on proprioception and motor function for individuals with moderate parkinson disease: a single-blind randomized controlled trial. *Occup Ther Int*. 2021;2021:9441366. doi: 10.1155/2021/9441366 EDN: QZHVEQ

31. Rauch F. Vibration therapy. *Dev Med Child Neurol*. 2009;51 Suppl 4:166–168. doi: 10.1111/j.1469-8749.2009.03418.x

32. Topaloğlu M, Ketenci A, Baslo B, Şahinkaya T. The effect of adding whole-body vibration exercises to home exercise program on muscle strength in patients with post-polio syndrome. *Turk J Phys Med Rehabil*. 2022;68(1):117–125. doi: 10.5606/tftrd.2022.7063 EDN: KSITOG

33. Shirolapov IV, Pyatin VF, Zhestkov AV, et al. Levels of proinflammatory cytokines TNFα and IL-8 under conditions of long-term proprioceptive stimulation. *Medical Immunology*. 2015;17(S):451. EDN: UQDESD

34. Cochrane DJ, Sartor F, Winwood K, et al. A comparison of the physiologic effects of acute whole-body vibration exercise in young and older people. *Arch Phys Med Rehabil*. 2008;89(5):815–821. doi: 10.1016/j.apmr.2007.09.055

35. Pyatin VF, Shirolapov IV, Khamzina GR, et al. Hemodynamic effects of proprioceptive stimulation in elderly people. *Modern problems of science and education*. 2015;(2–1):88. EDN: UHWXYN

36. Figueroa A, Jaime SJ, Alvarez-Alvarado S. Whole-body vibration as a potential countermeasure for dynapenia and arterial stiffness. *Integr Med Res*. 2016;5(3):204–211. doi: 10.1016/j.imr.2016.06.004

37. Inês Gonzáles A, Lavarda do Nascimento G, da Silva A, et al. Whole-body vibration exercise in the management of cardiovascular diseases: A systematic review. *J Body Mov Ther*. 2023;36:20–29. doi: 10.1016/j.jbmt.2023.04.057 EDN: SWONAF

38. Pyatin VF, Shirolapov IV, Zhestkov AV, Veretelnik EN. Increase in expiratory air flow rate in elderly women with a single vibration physical load. *Herald of Tver State University. Series: Biology and Ecology*. 2009;(13):38–43. EDN: MTZOPJ

39. Šarabon N, Kozinc Ž, Löfler S, Hofer C. resistance exercise, electrical muscle stimulation, and whole-body vibration in older adults: systematic review and meta-analysis of randomized controlled trials. *J Clin Med*. 2020;9(9):2902. doi: 10.3390/jcm9092902 EDN: UKEXEZ

40. Toader C, Tataru CP, Munteanu O, et al. Revolutionizing neuroimmunology: unraveling immune dynamics and therapeutic innovations in CNS disorders. *Int J Mol Sci*. 2024;25(24):13614. doi: 10.3390/ijms252413614 EDN: HCTSAD

41. Lavrov OV, Pyatin VF, Shirolapov IV. Stress-induced features of immunological parameters in people with differentiated vegetative-hormonal clusters. *Medical Immunology*. 2013;15(3):283–288. EDN: QCRQCL

42. Rankin LC, Artis D. Beyond host defense: emerging functions of the immune system in regulating complex tissue physiology. *Cell*. 2018;173:554–567. doi: 10.1016/J.CELL.2018.03.013 EDN: VFHPVU

43. Wallrapp A, Chiu IM. Neuroimmune Interactions in the Intestine. *Annu Rev Immunol*. 2024;42(1):489–519. doi: 10.1146/annurev-immunol-101921-042929 EDN: OUEYVE

44. Shirolapov IV, Zakharov AV, Smirnova DA, et al. The significance of the glymphatic pathway in the relationship between the sleep-wake cycle and neurodegenerative diseases. *S.S. Korsakov Journal of Neurology and Psychiatry*. 2023;123(9):31–36. doi: 10.17116/jnevro202312309131 EDN: IWJTUP

45. Lavrov OV, Pyatin VF, Shirolapov IV. Adaptive changes of the indices of the cardiovascular system and serum content of a number of hormones under examination stress condition. *Kazan Medical Journal*. 2012;93(3):461–464. EDN: OYVDCZ

46. Kovrov GV, Posokhov SI, Chernikova AG, et al. Validation of ballistocardiography data for predicting the sleep efficiency in healthy individuals and patients with insomnia. *S.S. Korsakov Journal of Neurology and Psychiatry*. 2024;124(10):60–66. doi: 10.17116/jnevro202412410160 EDN: VVTQDP

47. Suk HJ, Buie N, Xu G, et al. Vibrotactile stimulation at gamma frequency mitigates pathology related to neurodegeneration and improves motor function. *Front Aging Neurosci*. 2023;15:1129510. doi: 10.3389/FNAGI.2023.1129510/BIBTEX

48. Wunram HL, Oberste M, Hamacher S, et al. Immunological effects of an add-on physical exercise therapy in depressed adolescents and its interplay with depression severity. *Int J Environ Res Public Health*. 2021;18(12):6527. doi: 10.3390/ijerph18126527 EDN: RWWGAZ

49. Yu JC, Hale VL, Khodadadi H, Baban B. Whole body vibration-induced omental macrophage polarization and fecal microbiome modification in a murine model. *Int J Mol Sci*. 2019;20:3125. doi: 10.3390/IJMS20133125
50. Shirolapov IV, Gribkova OV, Kovalev AM, et al. The interactions along the microbiota-gut-brain axis in the regulation of circadian rhythms, sleep mechanisms and disorders. *S.S. Korsakov Journal of Neurology and Psychiatry*. 2024;124(5–2):79–86. doi: 10.17116/jnevro202412405279 EDN: BGDKNU
51. Ma Y, He M, Qiang L. Exercise therapy downregulates the overexpression of TLR4, TLR2, MyD88 and NF-κB after cerebral ischemia in rats. *Int J Mol Sci*. 2013;14:3718–3733. doi: 10.3390/IJMS14023718
52. Shirolapov I, Zakharov A, Smirnova D, et al. Aging brain, dementia and impaired glymphatic pathway: causal relationships. *Psychiatria Danubina*. 2023;35(Suppl. 2):236–244. Available from: https://www.psychiatria-danubina.com/UserDocsImages/pdf/dnb_vol35_noSuppl%202/dnb_vol35_noSuppl%202_236.pdf
53. Blanks AM, Rodriguez-Miguelez P, Looney J, et al. Whole body vibration elicits differential immune and metabolic responses in obese and normal weight individuals. *Brain Behav. Immun. Health*. 2020;1:100011. doi: 10.1016/j.bbih.2019.100011 EDN: YKDGUZ
54. Shirolapov IV, Zakharov AV, Bulgakova SV, et al. Glymphatic dysfunction in the pathogenesis of neurodegenerative diseases and pathological aging. *Genes and cells*. 2023;18(4):309–322. doi: 10.23868/gc546022 EDN: IPOLTQ
55. Bulgakova SV, Kurmaev DP, Treneva EV, et al. Influence of nutrition and epigenetics on the development of neurodegenerative diseases in elderly and old people. *Experimental and Clinical Gastroenterology*. 2024;(8):89–95. doi: 10.31146/1682-8658-ecg-228-8-89-95 EDN: WWLGGX
56. Rodriguez-Miguelez P, Fernandez-Gonzalo R, Collado PS, et al. Whole-body vibration improves the anti-inflammatory status in elderly subjects through toll-like receptor 2 and 4 signaling pathways. *Mech Ageing Dev*. 2015;150:12–19. doi: 10.1016/J.MAD.2015.08.002
57. Pyatin VF, Shirolapov IV, Zhestkov AV, et al. Immunological indices of peripheral blood of elderly women during uniformly accelerated training: results of a 12-week study. *Medical Immunology*. 2010;12(4–5):413–416. EDN: LLOAQU
58. Pyatin VF, Zhestkov AV, Shirolapov IV, et al. Immune responses to acceleration (whole body vibration) training: a 24-weeks trial among elderly women. *Allergology and immunology*. 2010;11(1):42–47. EDN: MVCUBD
59. Ahuja G, Arauz YLA, van Heuvelen MJG, et al. The effects of whole-body vibration therapy on immune and brain functioning: current insights in the underlying cellular and molecular mechanisms. *Front Neurol*. 2024;15:1422152. doi: 10.3389/fneur.2024.1422152 EDN: IFEUMJ
60. Shirolapov IV, Maslova OA, Barashkina KM, et al. Entomophagy as an alternative source of protein and a new food strategy. *Kazan Medical Journal*. 2023;104(5):733–740. doi: 10.17816/KMJ123526 EDN: FOYULU
61. Shirolapov I, Zakharov A, Gochhait S, et al. Aquaporin-4 as the main element of the glymphatic system for clearance of abnormal proteins and prevention of neurodegeneration: a review. *WSEAS Transactions on Biology and Biomedicine*. 2023;20:110–118. doi: 10.37394/23208.2023.20.11 EDN: JTGOEX
62. Zago M, Capodaglio P, Ferrario C, et al. Whole-body vibration training in obese subjects: a systematic review. *PLoS One*. 2018;13(9):e0202866. doi: 10.1371/journal.pone.0202866 EDN: YJTPKH
63. Lavrov OV, Shirolapov IV, Pyatin VF. Stress-induced hormonal reactions in students. *Bulletin of new medical technologies*. 2012;19(4):110–112. EDN: PJTGGJ
64. Shirolapov IV, Pyatin VF, Lavrov OV. Features of immunological indicators under examination stress. *Medical Immunology*. 2012;14(1–2):133–138. EDN: OPHKFD
65. Boerema AS, Heesterbeek M, Boersma SA, et al. Beneficial effects of whole body vibration on brain functions in mice and humans. *Dose Response*. 2018;16:1559325818811756. doi: 10.1177/1559325818811756
66. Arenales Arauz YL, Ahuja G, Kamsma YPT, et al. Potential of whole-body vibration in Parkinson's disease: a systematic review and meta-analysis of human and animal studies. *Biology*. 2022;11:1238. doi: 10.3390/BIOLOGY11081238 EDN: EMMBOJ
67. Shirolapov IV. On the mechanism of non-drug bronchodilation in young and elderly people. *Postgraduate Bulletin of the Volga Region*. 2009;(3–4):170–174. EDN: KVDSEX
68. Arauz YLA, van der Zee EA, Kamsma YPT, van Heuvelen MJG. Short-term effects of side-alternating whole-body vibration on cognitive function of young adults. *PLoS One*. 2023;18:e0280063. doi: 10.1371/JOURNAL.PONE.0280063 EDN: SELXWY
69. Fischer M, Vialleron T, Laffaye G, et al. Long-term effects of whole-body vibration on human gait: a systematic review and meta-analysis. *Front Neurol*. 2019;10:627. doi: 10.3389/fneur.2019.00627
70. Kerr N, Sanchez J, Moreno WJ, et al. Post-stroke low-frequency whole-body vibration improves cognition in middle-aged rats of both sexes. *Front Aging Neurosci*. 2022;14:942717. doi: 10.3389/fnagi.2022.94271 EDN: WXXUUJ
71. Keijser JN, van Heuvelen MJG, Nyakas C, et al. Whole body vibration improves attention and motor performance in mice depending on the duration of the whole-body vibration session. *Afr J Tradit Complement Altern Med*. 2017;14:128–134. doi: 10.21010/ajtcam.v14i4.15
72. Peng G, Yang L, Wu CY, et al. Whole body vibration training improves depression-like behaviors in a rat chronic restraint stress model. *Neurochem Int*. 2021;142:104926. doi: 10.1016/J.NEUINT.2020.104926 EDN: OQSZVV
73. Pyatin VF, Kolsanov AV, Shirolapov IV. Recent medical techniques for peripheral nerve repair: clinico-physiological advantages of artificial nerve guidance conduits. *Advances in Gerontology*. 2017;7(2):148–154. doi: 10.1134/S2079057017020126 EDN: XNNECL
74. Raval AP, Schatz M, Bhattacharya P, et al. Whole body vibration therapy after ischemia reduces brain damage in reproductively senescent female rats. *Int J Mol Sci*. 2018;19(9):2749. doi: 10.3390/ijms19092749
75. Feng L, Li B, Cai M, et al. Resistance exercise alleviates the prefrontal lobe injury and dysfunction by activating SESN2/AMPK/PGC-1α signaling pathway and inhibiting oxidative stress and inflammation in mice with myocardial infarction. *Exp Neurol*. 2023;370:114559. doi: 10.1016/J.EXPNEUROL.2023.114559 EDN: DZDGUB
76. Oroszi T, de Boer SF, Nyakas C, et al. Chronic whole body vibration ameliorates hippocampal neuroinflammation, anxiety-like behavior, memory functions and motor performance in aged male rats dose dependently. *Sci Rep*. 2022;12:1–10. doi: 10.1038/s41598-022-13178-1 EDN: QTNHTH
77. Amonette WE, Boyle M, Psarakis MB, et al. Neurocognitive responses to a single session of static squats with whole body vibration. *J Strength Cond Res*. 2015;29:96–100. doi: 10.1519/JSC.0B013E31829B26CE
78. Yang H, Gao J, Wang HY, et al. The effects and possible mechanisms of whole-body vibration on cognitive function: a narrative review. *Brain Res*. 2024;1850:149392. doi: 10.1016/j.brainres.2024.149392 EDN: BVBNIO
79. Pyatin VF, Kolsanov AV, Shirolapov IV. Recent medical techniques for peripheral nerve repair: nerve guidance conduits update. *Adv Gerontol*. 2016;29(5):742–750. EDN: XXRTMF
80. Senderovich H, Bayeva N, Montagnese B, Yendamuri A. Managing fall prevention through exercise in older adults afflicted by cognitive and strength impairment. *Dement Geriatr Cogn Disord*. 2021;50(6):507–518. doi: 10.1159/000521140 EDN: MRFDFJ
81. Regterschot GRH, Van Heuvelen MJG, Zeinstra EB, et al. Whole body vibration improves cognition in healthy young adults. *PLoS One*. 2014;9:e100506. doi: 10.1371/JOURNAL.PONE.0100506
82. Fuermaier ABM, Tucha L, Koerts J, et al. Good vibrations — effects of whole body vibration on attention in healthy individuals and individuals with ADHD. *PLoS One*. 2014;9:e90747. doi: 10.1371/JOURNAL.PONE.0090747
83. Shantakumari N, Ahmed M. Whole body vibration therapy and cognitive functions: a systematic review. *AIMS Neurosci*. 2023;10:130. doi: 10.3934/NEUROSCIENCE.2023010 EDN: GRJNZA
84. Korovina ES, Glazkova EN, Shirolapov IV, et al. Sensorimotor potentiation of motor imagination as an activator of CNS plasticity. *Science and Innovations in Medicine*. 2016;(3(3)):33-38. EDN: YKMVRF
85. Bazanova OM, Balioz NV, Ermolaeva SA, et al. Study of psychophysiological indicators of sensorimotor Integration in PTSD. Justification of the choice of targets for biofeedback. *Fiziologiâ čeloveka*. 2024;50(3):63–80. doi: 10.31857/S0131164624030061 EDN: BUNHPP
86. Shirolapov IV, Zakharov AV, Bulgakova SV, et al. Alzheimer dementia as a consequence of the brain glymphatic system dysfunction. *Psychiatry, psychotherapy and clinical psychology*. 2023;14(3):291–300. doi: 10.34883/PI.2023.14.3.004 EDN: RHKPXK

87. Halmai B, Holsgrove TP, Vine SJ, et al. The after-effects of occupational whole-body vibration on human cognitive, visual, and motor function: A systematic review. *Appl Ergon*. 2024;118:104264. doi: 10.1016/j.apergo.2024.104264 EDN: YUAYLG

88. Zakharov AV, Bratchenko IA, Bratchenko LA, et al. Deep learning of surface-enhanced Raman spectroscopy data for multiple sclerosis diagnostics. *Eur Phys J Spec Top*. 2025. doi: 10.1140/epjs/s11734-024-01449-z EDN: WTPIUS

89. Chang CM, Tsai CH, Lu MK, et al. The neuromuscular responses in patients with Parkinson's disease under different conditions during whole-body vibration training. *BMC Complement Med Ther*. 2022;22(1):2. doi: 10.1186/s12906-021-03481-1 EDN: EPXWTW

90. Choi ET, Kim YN, Cho WS, Lee DK. The effects of visual control whole body vibration exercise on balance and gait function of stroke patients. *J Phys Ther Sci*. 2016;28(11):3149–3152. doi: 10.1589/jpts.28.3149 EDN: YEVQRX

91. Wen J, Leng L, Hu M, et al. Effects of whole-body vibration training on cognitive function: a systematic review. *Front Hum Neurosci*. 2023;17:854515. doi: 10.3389/FNHUM.2023.854515/BIBTEX EDN: DCLCWU

92. Pyatin VF, Sergeeva MS, Shirolapov IV. Blinking as a mechanism for controlling retinal illumination and the function of its photosensitive ganglion cells. *Biomedical Radioelectronics*. 2014;(4):67–68. EDN: SEAPAH

93. Escudero-Uribe S, Hochsprung A, Heredia-Camacho B, Izquierdo-Ayuso G. Effect of training exercises incorporating mechanical devices on fatigue and gait pattern in persons with relapsing-remitting multiple sclerosis. *Physiother Can*. 2017;69(4):292–302. doi: 10.3138/ptc.2016-19

94. Shirolapov IV, Zakharov AV, Shishkina AA, et al. Efficiency of computerized cognitive training for prevention of cognitive impairments and stimulation of neuroplasticity. *Adv Gerontol*. 2024;37(3):221–229. doi: 10.34922/AE.2024.37.3.007 EDN: EXVQXA

95. Gonçalves de Oliveira R, Coutinho HM, Martins MNM, et al. Impacts of whole-body vibration on muscle strength, power, and endurance in older adults: a systematic review and meta-analysis. *J Clin Med*. 2023;12(13):4467. doi: 10.3390/jcm12134467 EDN: WFQNUU

96. Van Heuvelen MJG, Rittweger J, Judex S, et al. Reporting guidelines for whole-body vibration studies in humans, animals and cell cultures: a consensus statement from an international group of experts. *Biology*. 2021;10(10):965. doi: 10.3390/biology10100965 EDN: YVESJM

97. Shirolapov IV, Zakharov AV, Smirnova DA, et al. The role of the glymphatic clearance system in the mechanisms of the interactions of the sleep-waking Cycle and the Development of Neurodegenerative Processes. *Neurosci Behav Physi*. 2024;54(2):199–204. doi: 10.1007/s11055-024-01585-y EDN: HZDLCQ

98. Moreira-Marconi E, Teixeira-Silva Y, Meirelles AG, et al. inflammatory biomarker responses to whole-body vibration in subjects with different clinical status: a systematic review. *Int J Environ Res Public Health*. 2022;19(22):14853. doi: 10.3390/ijerph192214853 EDN: IOLLIZ

99. Yin Y, Wang J, Yu Z, et al. Does whole-body vibration training have a positive effect on balance and walking function in patients with stroke? A meta-analysis. *Front Hum Neurosci*. 2023;16:1076665. doi: 10.3389/fnhum.2022.1076665 EDN: AEQNIV

AUTHORS' INFO

*** Igor V. Shirolapov**, MD, Cand. Sci. (Medicine), Assistant Professor, Head, Translational Research and Personalized Medicine Lab., Neurosciences Research Institute, Associate Professor, Depart. of Physiology;
address: 18 Gagarin St, Russia, Samara, 443079;
ORCID: 0000-0002-7670-6566;
eLibrary SPIN: 3939-3590;
e-mail: ishirolapov@mail.ru

Olga N. Pavlova, Dr. Sci. (Biology), Assistant Professor, Head, Depart. of Physiology;
ORCID: 0000-0002-8055-1958;
eLibrary SPIN: 6326-6884;
e-mail: o.n.pavlova@samsmu.ru

Olga N. Gulenko, Cand. Sci. (Biology), Assistant Professor, Depart. of Physiology;
ORCID: 0000-0001-6338-7095;
eLibrary SPIN: 6795-5163;
e-mail: o.n.gulenko@samsmu.ru

Polina M. Moskvitina, Assistant Lecturer, Depart. of Physiology;
ORCID: 0000-0002-0666-7442;
eLibrary SPIN: 5788-5795;
e-mail: p.m.moskvitina@samsmu.ru

ОБ АВТОРАХ

*** Широлапов Игорь Викторович**, канд. мед. наук, доцент, заведующий, лаб. Трансляционных исследований и персонализированной медицины НИИ нейронаук, доцент, каф. физиологии;
адрес: Россия, 443079, Самара, ул. Гагарина, д. 18;
ORCID: 0000-0002-7670-6566;
eLibrary SPIN: 3939-3590;
e-mail: ishirolapov@mail.ru

Павлова Ольга Николаевна, д-р биол. наук, доцент, заведующий, каф. физиологии;
ORCID: 0000-0002-8055-1958;
eLibrary SPIN: 6326-6884;
e-mail: o.n.pavlova@samsmu.ru

Гуленко Ольга Николаевна, канд. биол. наук, доцент, каф. физиологии;
ORCID: 0000-0001-6338-7095;
eLibrary SPIN: 6795-5163;
e-mail: o.n.gulenko@samsmu.ru

Москвитина Полина Михайловна, ассистент, каф. физиологии;
ORCID: 0000-0002-0666-7442;
eLibrary SPIN: 5788-5795;
e-mail: p.m.moskvitina@samsmu.ru

* Corresponding author / Автор, ответственный за переписку