УДК 616.89-008.46:615.825
https://doi.org/10.17816/RFD21227

PHYSICAL ACTIVITY AS A FACTOR INFLUENCING ON COGNITIVE DISORDERS

I.K. Chupriaev, S.D. Ponomareva, A.V. Yasakova, E.V. Frolova

North-Western State Medical University named after I.I. Mechnikov, Saint Petersburg, Russia

The article presents the results of modern research regarding the mechanisms of the positive effect of physical activity on cognitive functions, the benefits of aerobic exercise, and recommendations on physical activity for older adults with cognitive impairment.

Keywords: physical activity; cognitive disorders; older adults; aerobic exercise.

ФИЗИЧЕСКАЯ АКТИВНОСТЬ КАК ФАКТОР, ВЛИЯЮЩИЙ НА КОГНИТИВНЫЕ НАРУШЕНИЯ

И.К. Чупряев, С.Д. Пономарева, А.В. Ясакова, Е.В. Фролова

Федеральное государственное бюджетное образовательное учреждение высшего образования «Северо-Западный государственный медицинский университет им. И.И. Мечникова» Министерства здравоохранения Российской Федерации, Санкт-Петербург

В статье рассмотрены результаты современных исследований, касающихся механизмов положительного влияния физических нагрузок на когнитивные функции, преимущества аэробных нагрузок, эффективности рекомендаций по физической активности для пожилых людей с когнитивными нарушениями.

Ключевые слова: физическая активность; когнитивные нарушения; пожилые люди; аэробная нагрузка.

Background

According to the latest revision of the International recommendations for the diagnosis of mental disorders (Diagnostic and Statistical Manual of Mental Diseases — DSM-V), cognitive disorders include a decrease in the level of one or more higher mental functions that supports perception, storage, transformation and transmission of information [1] compared to the premorbid level.

There are two groups of cognitive disorders [2]: severe (dementia) and non-dementia (subjective, mild/ premeditated and moderate). According to the World health organization (WHO) 2015, there were more than 46 million people with dementia worldwide. In 2017, these figures increased to 50 million. Every year 7.7 million new cases of dementia are registered. This adversely affects society and the health system. It is predicted to increase to 131.5 million by 2050 [3].

Some agents that are effective in severe cognitive disorders have a significantly lower effect on cognitive disorders that do not reach the degree of dementia. This is probably due to various neurochemical changes that occur at the early and later stages of the pathological process [1]. In this regard, more attention is shunted toward non-drug methods of correcting cognitive disorders such as physical activity.

Definition and emphases

Physical activity is an integral part everyone's life. According to the WHO definition (2002), it refers to body motion generated by skeletal muscles that requires energy consumption. Physical activity affects not only the state of the musculoskeletal system, but cognitive abilities as well. Systematic physical activity reduces the risk of developing arterial

Received / Поступила: 17.01.2020 Revised / Одобрена: 26.02.2020 Accepted / Принята: 11.03.2020

hypertension, coronary heart disease, stroke, malignancies, and type 2 diabetes mellitus that are conditions with a high mortality rate [4]. Physical activity by energy efficiency of the body is divided into aerobic, anaerobic, and mixed. Aerobic (cardio) load is a set of exercises aimed primarily at strengthening the cardiovascular system and reducing body weight (running, swimming, cycling, and dancing). Anaerobic load (training), is aimed at developing and gaining muscle mass (strength training, lessons in the gym by simulators) [5].

We assessed physical activity using the Global physical activity questionnaire (GPAQ) developed by the WHO. According to the WHO recommendations, weekly physical activity is 600 MET (metabolic units measured in ml/kg min and reflect oxygen consumption per kilogram of body mass per minute). This value is equivalent to 150 minutes of a brisk walking or 75 minutes of jogging. GPAQ covers several components of physical activity such as intensity, duration, and frequency, It includes three types of physical activities: professional, transport-related physical activity and physical activity at leisure) [6].

Physical activity in terms of intensity is divided into moderate (dancing, housework, gardening, active games and sports with children/walking with pets, brisk walking) and high (running, active climbing, aerobics, fast cycling), depending on the experience of physical exercises and physical condition [4].

Sedentary lifestyle is associated with many chronic diseases and premature death. There is growing evidence that increasing the time during the day when a person is motionless or sedentary can increase the risk of chronic diseases and mortality. You need to know the intensity of a physical activity to assess its benefits, and the recommended "dose." However, current recommendations for physical activity base on independent physical measure, and this can be potential for errors. Thus, the strength of associations is probably underestimated.

In the meta-analysis of U. Erklund et al. [7] only studies with an accelerometer to assess physical activity were considered. Reports show that benefits of a physical activity are dose-dependent in comparison with a sedentary lifestyle, and this link maintains in an old age. All types of the intensity of a physical activity, including mild physical activity, correlate with a significantly reduced risk of death. The association between a physical activity and a risk of death is about twice as strong in studies using devices compared to the association in studies in which physical activity was determined by a self-reporting. The risk of death is statistically significantly higher if the time in a sitting position is daily 9.5 hours or more. Thus, any type and intensity of a physical activity in an old age is more useful than a sedentary lifestyle.

Recommendations for the use of a physical training in the elderly age

A chronic lack of a physical activity of the older adults is one of the significant pathogenesis in the development of frailty syndrome. The benefits of physical exercises for older adults increase functional activity, mobility and quality of life while reducing the risk of falls. Exercise programs are an effective means of preventing the progression of senile asthenia and preasthenia, as well as other geriatric syndromes (especially cognitive decline and deficits). For patients with frailty syndrome, regular physical activity is recommended in the volume and intensity depending on the functional capabilities of patient to improve/maintain their physical, functional, and cognitive status [8].

Patients with a senile asthenia need the following types of physical activity [9]:

– Resistance exercises;

– Strength training;

– Aerobic training (walking with a change of a time and direction, walking on a treadmill, climbing stairs, cycling);

– Exercises to maintain balance.

Physical activity programs for patients with frailty syndrome should be regular, long-term, adapted to the individual, and sufficiently intensive to improve muscle strength and ability to maintain balance. The intensity and/or duration of training should increase gradually. Training exercises were combined with exercises that simulate everyday activities for improving functional activity, resistance, and strength, such as stand–up and sit-down exercises, tandem walking, climbing stairs, transferring body weight from one leg to the other, walking in a straight line and balancing on one leg. Qualified specialists (doctors of a therapeutic physical culture) should compile training programs. Moreover, they should

regularly review and adjust them depending on the progress and changes in the condition of participants [10].

Influence of a physical training on cognitive functions

Exercise is one of the lifestyle factors identified as a potential means of reducing or slowing the progression of dementia symptoms. According to various publications, physical activity reduces the production of free radicals, prevents the development of arterial hypertension, with associated changes in the white matter of the brain [11]. It also reduces the volume of amyloid plaques in cerebral vessels and areas of the brain responsible for cognitive functions (hippocampus) [12], and slow down the processes of age-associated cognitive changes by stimulating neuroplasticity, inducing neurogenesis and increasing the volume of the hippocampus [13].

Some studies show that aerobic exercise improves brain blood flow, memory [14] and brain metabolism. There is an evidence that glucose uptake improves after aerobic training in the parietal and temporal regions of the brain [15]. It is noteworthy that regular physical exercise increases the level of BDNF (brain-derived neurotrophic factor, a brain neurotrophic factor that affects the synaptic plasticity and its signaling cascades [16]) and reduces the risk of cardiovascular diseases by increasing brain perfusion and oxygen flow to the brain while simultaneously reducing the blood lipid content and increasing brain volume [17]. Since disorders of an endogenous lipid metabolism and neurodegenerative diseases affect cognitive capabilities, increasing BDNF levels can be a preventive factor in the development of dementia and Alzheimer's disease. For example, Danish scientists studied the effect of physical activity on biomarkers with the involvement of 447 patients. We assessed physical activity using duration and intensity. We determined the level of markers, of a brain neurotrophic factor, cholesterol, testosterone, estradiol, dehydroepiandrosterone and insulin. We observed a positive effect on these markers in seven out of eight cases. Despite this, the biochemical effect of physical activity on the course of dementia and mild cognitive disorders was not reliably measured [18].

There are no simple recommendations on the types of physical activity based on intensity, duration. This makes it applicable for older adults with cognitive disorders of varying degrees of severity. For example, a systematic review published in the Cochrane collaboration database evaluated the results of 17 studies (search dates are August 2012 and October 2013) with 1067 participants. The purpose of the review was to find out whether exercise programs improves cognitive function (memory, reasoning power and spatial perception), daily life, behavior, and psychological state (depression, anxiety and arousal) for older adults with dementia. The authors tried assessing the impact of exercises on mortality, quality of life, care experience and the use of medical services as well as any adverse effects.

There is evidence that exercise programs can improve the daily activities of people with dementia, but several discrepancies erupted among the authors. These discrepancies were due to the heterogeneity of participants, physical activity programs, and measurement scales. Unfortunately, through the review, there was no evidence of a positive effect of exercises on cognitive abilities, psychological symptoms, and depression. There was no evidence for the other results listed. There was also no evidence about the dangers of the exercises. As a result, the authors rated the overall quality of the evidence underlying most of the results as very low [19]. This means physical exercise is beneficial for dementia seeing the conclusion made by the authors as follows: Firstly, it seems exercises moderately improved the cognitive abilities and efficiency of a person as well as everyday activities. Secondly, bedside individuals of dementia patients observed physical training programs to reduce the burden of a care laid on them. Thirdly, doctors should not avoid prescribing exercises to patients with dementia and may feel confident about it.

In order to evaluate the significant effects of treatment with physical training, it is necessary to improve the design of such studies.

In an attempt to understand the mechanisms that underlie the effects of physical training on cognitive function, researchers compared different types of exercises. Bossers et al. studied the training and subsequent effects of combining aerobic and strength training compared to only the aerobic training on cognitive and motor functions of dementia patients in a psychogeriatric nursing home. They sought to determine whether improvement of motor functions affects the improvement of cognitive

functions [20]. It turned out that patients with dementia who combined aerobic and strength training significantly slowed down the development of cognitive and motor disorders compared to patients on aerobic exercises only, and patients in the control group without training. However, we observed no mediating effects between an improved cognitive function and an increased motor activity.

The relationship between physical training and the development of Alzheimer's disease is presently ongoing. Experimental studies on animals that modeled for Alzheimer's disease reveal that physical activity prevents brain neuroplasticity disorders and memory loss [21].

Based on the results obtained by A. Strohle et al., a regular motor activity slows down the progression of cognitive disorders in Alzheimer's disease, and this effect varies from moderate to severe one [22]. However, we assessed the results of other studies. In particular, Hoffmann et al., reveal that no significant effect of moderate and high intensity aerobic exercises (one-hour sessions three times weekly for 16 weeks) was found on the results of neuropsychological tests, although the severity of clinical neuropsychiatric parameters significantly decreased for patients engaged in motor training [23].

There is also evidence that physical activity (aerobic training, stretching, and physical therapy) has a positive effect on the cognitive abilities of people who have suffered from a stroke. We achieved a positive effect in 12 weeks, and combined training programs gave the best results. The mean age of the participants was 62.5 years, 59% of which were men. We obtained a positive result even for patients with residual events of a stroke [24].

We also conducted studies with patients with a Parkinson's disease. An article published in NeuroRehabilitation [25] in 2017 shows a significant improvement in motor and cognitive functions of patients with Parkinson's disease at performing a non-traditional physical therapy such as dance.

We divided 16 patients with Parkinson's disease with a history of recent falls into two groups. Patients of one group received dance therapy, and patients of the second group received traditional rehabilitation. Nine patients engaged in dance therapy for an hour twice a week for ten weeks. (20 sessions), seven patients received a similar cycle of 20 group sessions of 60 minutes of traditional rehabilitation. Motor (Berg Balance Scale — BBS, Gait Dynamic Index — GDI, Timed Up and Go Test — TUG, 4 Square-Step Test — 4SST, 6-Minute Walking Test — 6MWT) and cognitive (Frontal Assessment Battery — FAB, Trail Making Test A & B — TMT A&B, Stroop Test) abilities were evaluated at the beginning of the study, after end of treatment and after eight weeks of monitoring.

In the group of patients engaged in dance therapy, the results of motor and cognitive tests significantly improved after treatment compared to patients from traditional rehabilitation and remained after the completion of the program.

A large Canadian study with 2,876 older adults aged 70 to 79, examined characteristics between walking speed and potential cognitive changes. It was found that slowing down the walking speed of people served as a predictor of a decrease in physical activity, and this result was independent on the initial physical condition. In addition, reduced walking speed in an old age was associated with an increased risk of a cognitive impairment and future mortality [26].

Another study aimed at assessing the impact of moderate-to-high-intensity aerobic and strength exercise on a cognitive impairment and other outcomes in patients with mild and moderate dementia. This was conducted in the UK as part of the National Dementia Registry. The study involved 494 people with dementia with 329 engaged in a program of aerobic and strength exercises including of social activity, and 165 engaged with regular activities to increase the social activity. The duration of physical training programs was four months. After a year of monitoring the results in repeated evaluations using neuropsychological scales (the ADAS-cog scale), there was no significant improvement in the group of patients engaged in physical training. However, participants in this group significantly improved the results of the six-minute walk test. The authors conclude that the program of moderate-to-high intensity aerobic and strength exercises does not slow down the development of cognitive disorders of patients with mild and moderate dementia, while improving physical fitness.

It is possible that the negative results described were associated with various mechanisms of dementia development. Nevertheless, the author of a large review on dementia [27] still includes aerobic and strength exercises in the list of therapeutic measures for dementia.

Conclusion

Despite numerous studies aimed at understanding the mechanisms of influence of physical activity on cognitive abilities, there is no simple scientific justification for the benefits of physical activity. In this regard, it is not possible to develop consensus guidelines for physical activity for older adults with cognitive disabilities of varying degrees of severity. It is necessary to improve the structure of research in order to study this issue.

References

1. Захаров В.В. Когнитивные расстройства без деменции: классификация, основные причины и лечение // Эффективная фармакотерапия. – 2016. – № 1. – С. 22–31. [Zakharov VV. Cognitive impairment no dementia: classification, major causes, and treatment. *Effective pharmacotherapy*. 2016;(1):22-31. (In Russ.)]

2. Яхно Н.Н., Захаров В.В., Коберская Н.Н., и др. «Предумеренные» (субъективные и легкие) когнитивные расстройства // Неврологический журнал. – 2017. – Т. 22. – № 4. – С. 198–204. [Yakhno NN, Zakharov VV, Koberskaya NN, et al. "Predumerennye" (sub"yektivnyye i legkiye) kognitivnyye rasstroystva. *Journal of neurology*. 2017;22(4):198-204. (In Russ.)]. https://doi.org/10.18821/1560-9545-2017-22-4-198-204.

3. Prince M, Wimo A, Guerchet M, et al. An analysis of prevalence, incidence, cost and trends. In: Alzheimer's Disease International. World Alzheimer Report 2015. The globalimpact of dementia. London; 2015.

4. World Health Organization. Global recommendations on physical activity for health. Guidelines approved by the guidelines review committee. Geneva: WHO; 2010.

5. Шевлягина А.М., Силантьева П.С. Польза аэробных и анаэробных нагрузок для организма человека / Научное сообщество студентов XXI столетия. Гуманитарные науки: сб. ст. по мат. LXI междунар. студ. науч.-практ. конф. № 1 (61). – Новосибирск, 2018. [Shevlyagina AM, Silant'yeva PS. Pol'za aerobnykh i anaerobnykh nagruzok dlya organizma cheloveka. (Collection of scientific articles) Nauchnoye soobshchestvo studentov XXI stoletiya. Gumanitarnyye nauki: sb. st. po mat. LXI mezhdunar. stud. nauch.-prakt. konf. No. 1 (61). Novosibirsk; 2018. (In Russ.)]

6. World Health Organization Noncommunicable diseases and their risk factors. Global action plan on physical activity 2018-2030: more active people for a healthier world. WHO; 2018. 104 p.

7. Ekelund U, Tarp J, Steene-Johannessen J, et al. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ*. 2019;366:l4570. https://doi.org/10.1136/bmj.l4570.

8. Chou CH, Hwang CL, Wu YT. Effect of exercise on physical function, daily living activities, and quality of life in the frail older adults: a meta-analysis. *Arch Phys Med Rehab*. 2012;93(2):237-244. https://doi.org/10.1016/j.apmr.2011.08.042.

9. Apóstolo J, Cooke R, Bobrowicz-Campos E, et al. Effectiveness of interventions to prevent pre-frailty and frailty progression in older adults: a systematic review. *JBI Database System Rev Implement Rep*. 2018;16(1):140-232. https://doi.org/10.11124/JBISRIR-2017-003382.

10. Izquierdo M, Lusa Cadore E. Muscle power training in the institutionalized frail: a new approach to counteracting functional declines and very late-life disability. *Curr Med Res Opin*. 2014;30:1385-1390. https://doi.org/10.1185/03007995.2014.908175.

11. Tarumi T, Zhang RJ. Cerebral blood flow in normal aging adults: cardiovascular determinants, clinical implications, and aerobic fitness. *J Neurochem*. 2018;144(5):595-608. https://doi.org/10.1111/jnc.14234.

12. Khodadadi D, Gharakhanlou R, Naghdi N, et al. Treadmill exercise ameliorates spatial learning and memory deficits through improving the clearance of peripheral and central amyloid-beta levels. *Neurochem Res*. 2018;43(8):1561-1574. https://doi.org/10.1007/s11064-018-2571-2.

13. Prakash RS, Voss MW, Erickson KI, Kramer AF. Physical activity and cognitive vitality. *Annu Rev Psychol*. 2015;66:769-797. https://doi.org/10.1146/annurev-psych-010814-015249.

14. Phillips C, Baktir MA, Srivatsan M, Salehi A. Neuroprotective effects of physical activity on the brain a closer look at trophic factor signaling. *Front Cell Neurosci*. 2014;8:170. https://doi.org/10.3389/fncel.2014.00170.

15. Lucas SJ, Cotter JD, Brassard P, Bailey DM. High-intensity interval exercise and cerebrovascular health: curiosity, cause, and consequence. *J Cereb Blood Flow Metab*. 2015;35(6):902-911. https://doi.org/10.1038/jcbfm.2015.49.

16. Alkadhi KA. Exercise as a positive modulator of brain function. *Mol Neurobiol.* 2018;55(4):3112-3130. https://doi.org/10.1007/s12035-017-0516-4.

17. Fungwe TV, Ngwa JS, Ntekim OE. Exercise training induced changes in nuclear magnetic resonance-measured lipid particles in mild cognitively impaired elderly african-american volunteers: a pilot study. *Clin Interv Aging.* 2019;14:2115-2123. https://doi.org/10.2147/CIA.S195878.

18. Jensen CS, Hasselbalch SG, Waldemar G, Simonsen AH. biochemical markers of physical exercise on mild cognitive impairment and dementia: systematic review and perspectives. *Front Neurol.* 2015;6:187. https://doi.org/10.3389/fneur.2015.00187.

19. Forbes D, Thiessen EJ, Blake CM, et al. Exercise programs for people with dementia. *Cochrane Database Syst Rev.* 2013;(12):CD006489. https://doi.org/10.1002/14651858.CD006489.pub3.

20. Bossers WJ, van der Woude LH, Boersma F, et al. A 9-week aerobic and strength training program improves cognitive and motor function in patients with dementia: a randomized, controlled trial. *Am J Geriatr Psychiatry.* 2015;23(11):1106-1116. https://doi.org/10.1016/j.jagp.2014.12.191.

21. Duzel E, van Praag H, Sendtner M. Can physical exercise in old age improve memory and hippocampal function? *Brain.* 2016;139(Pt 3):662-673. https://doi.org/10.1093/brain/awv407.

22. Strohle A, Schmidt DK, Schultz F, et al. Drug and exercise treatment of Alzheimer disease and mild cognitive impairment: a systematic review and meta-analysis of effects on cognition in randomized controlled trials. *Am J Geriatr Psychiatry.* 2015;23(12):1234-1249. https://doi.org/10.1016/j.jagp.2015.07.007.

23. Hoffmann K, Sobol NA, Frederiksen KS, et al. Moderate-to-high intensity physical exercise in patients with Alzheimer's disease: a randomized controlled trial. *J Alzheimers Dis.* 2016;50(2):443-453. https://doi.org/10.3233/JAD-150817.

24. Oberlin LE, Waiwood AM, Cumming TB, et al. Effects of physical activity on poststroke cognitive function a meta-analysis of randomized controlled trials. *Stroke.* 2017;48(11):3093-3100. https://doi.org/10.1161/STROKEAHA.117.017319.

25. De Natale ER, Paulus KS, Aiello E, et al. Dance therapy improves motor and cognitive functions in patients with Parkinson's disease. *Neurorehabilitation.* 2017;40(1):141-144. https://doi.org/10.3233/NRE-161399.

26. Quan M, Xun P, Chen C, et al. Walking pace and the risk of cognitive decline and dementia in elderly populations: a meta-analysis of prospective cohort studies. *J Gerontol A Bio Sci Med Sci.* 2017;72(2):266-270. https://doi.org/10.1093/gerona/glw121.

27. Fymat AL. Dementia: a review. *J Clin Psychiatr Neurosci.* 2018;1(3):27-34.

For citation: Chupriaev IK, Ponomareva SD, Yasakova AV, Frolova EV. Physical activity as a factor influencing on cognitive disorders. *Russian Family Doctor.* 2020;24(1):45-51. https://doi.org/10.17816/RFD21227.

Для цитирования: Чупряев И.К., Пономарева С.Д., Ясакова А.В., Фролова Е.В. Физическая активность как фактор, влияющий на когнитивные нарушения // Российский семейный врач. – 2020. – Т. 24. – № 1. – С. 45–51. https://doi.org/10.17816/RFD21227.

Information about the authors

Ilia K. Chupryaev — 6th year student, North-Western State Medical University named after I.I. Mechnikov, Saint Petersburg, Russia. E-mail: medwed6771@gmail.com.

Svetlana D. Ponomareva — 6th year student, North-Western State Medical University named after I.I. Mechnikov, Saint Petersburg, Russia. E-mail: dexter.white.c@gmail.com.

Информация об авторах

Илья Константинович Чупряев — студент 6-го курса, ФГБОУ ВО «Северо-Западный государственный медицинский университет им. И.И. Мечникова Минздрава России, Санкт-Петербург. E-mail: medwed6771@gmail.com.

Светлана Дмитриевна Пономарева — студентка 6-го курса, ФГБОУ ВО «Северо-Западный государственный медицинский университет им. И.И. Мечникова Минздрава России, Санкт-Петербург. E-mail: dexter.white.c@gmail.com.

Alexandra V. Yasakova — 6th year student, North-Western State Medical University named after I.I. Mechnikov, Saint Petersburg, Russia. E-mail: caplinasasa881@gmail.com.

Elena V. Frolova — DSc, Professor of the Department of Family Medicine, North-Western State Medical University named after I.I. Mechnikov, Saint Petersburg, Russia. SPIN-code: 1212-0030. E-mail: elena.frolova@szgmu.ru.

Александра Владимировна Ясакова — студентка 6-го курса, ФГБОУ ВО «Северо-Западный государственный медицинский университет им. И.И. Мечникова Минздрава России, Санкт-Петербург. E-mail: caplinasasa881@gmail.com.

Елена Владимировна Фролова — д-р мед. наук, профессор кафедры семейной медицины, ФГБОУ ВО «Северо-Западный государственный медицинский университет им. И.И. Мечникова Минздрава России, Санкт-Петербург. SPIN-код: 1212-0030. E-mail: elena.frolova@szgmu.ru.