

Perspectives for the application of physical therapy in neuropsychological rehabilitation

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Medical Studies 2025; 41 (2): 84–88

DOI: <https://doi.org/10.5114/ms.2025.149247>

Key words: cognitive functions, coordination exercises, movement, physiotherapy, somatognosia.

Abstract

Physiotherapy is used in numerous health care disciplines. The role of physiotherapy in supporting cognitive functions is invaluable. This article is a review of current scientific data regarding the perspectives for the use of physical exercises in neuropsychological rehabilitation. Current scientific data clearly indicate that physical exercises contribute to improving cognitive functioning both in people with neurological dysfunctions and in healthy volunteers. Specific physical exercises improve specific cognitive functions, which can also be used in targeted neuropsychological therapy. Scientific data indicate that passive exercises also improve the efficiency of cognitive processes, which is of great importance for planning comprehensive rehabilitation in people after advanced damage to the nervous system. The presented review provides a basis for more effective planning of holistic neurorehabilitation based on scientific data, which may lead to faster revalidation of patients, improved quality of their life, and more effective administration of health services.

Introduction

Physiotherapy, as a set of activities aimed at restoring or maintaining the body's fitness, is widely used in many health care disciplines. However, the structure of physiotherapeutic interactions depends on the specificity of the disease or dysfunction – different techniques are used in the case of rheumatic diseases, and different ones in the case of vascular problems or pulmonary diseases. Similarly, completely different goals are set for stroke rehabilitation than for recovery from spinal cord injuries. The dynamic development of physiotherapy allows for the effective treatment of an increasing number of dysfunctions and diseases, even combined ones. This is particularly important in the case of holistic neurorehabilitation, which often needs to take into account not only the motor component, but also the cognitive one [1]. Although holistic neurorehabilitation is dealt with by an interdisciplinary therapeutic team, more and more attention is being paid to how physical exercises – even passive exercises – used as part of physiotherapy can also affect the patient's cognitive component [2]. Understanding the multi-aspect nature of physiotherapy interventions may allow for more effective planning of neurorehabilitation, and supporting neuropsychological therapy through physical exercises may shorten the process of returning to psychomotor fitness.

Aim of the research

Nowadays, therapeutic programs increasingly include a holistic approach. This is especially impor-

tant in the context of neurological dysfunctions that manifest themselves at both the physical and cognitive levels. However, for neurorehabilitation activities to be holistic, therapeutic forms should be selected that support both motor and cognitive functions. This review aims to present the perspectives of using exercise therapy as a form of supporting cognitive functions. The review presents physiotherapy methods and techniques the effect of which on cognitive performance has been confirmed in scientific research. The review is also supplemented with an explanation of the most important biological mechanisms behind the relationship between movement and cognitive processes. The paper may be a compendium for physiotherapists, occupational therapists, and other specialists dealing with physical rehabilitation who want to use therapy methods and techniques that support not only motor skills, but also have a beneficial effect on cognitive functions. The paper may also serve as a compendium for neuropsychologists who would like to enrich the training of cognitive functions with forms of motor therapy that may intensify the effects of neuropsychological therapy or influence their maintenance.

The role of physiotherapy in neuropsychological rehabilitation

Neuropsychological rehabilitation involves restoring or compensating for impaired mental functions (cognitive, emotional, psychosocial, and behavioural), and in the context of cognitive neurorehabilitation it

focuses on improving perception, attention, memory, and executive functions (e.g. praxis) [3]. Current scientific evidence indicates that physical therapy can support all these cognitive functions; therefore, it can be an excellent complement to neuropsychological rehabilitation, being part of the holism of comprehensive neurorehabilitation.

Although physiotherapists cannot directly influence the nervous system, they can do a lot through indirect influences. One of the basic actions that a physiotherapist can take to influence the condition of the patient's cognitive apparatus is the optimisation of sensory stimulation, which allows for the integration of stimuli and the regulation of the level of sensory-perceptual activity [4], which is the basis for the development or restitution of individual functional domains, among others, as part of neuropsychological rehabilitation.

Sensorimotor stimulation

For the brain to function properly, it is necessary to organise (collect and select) the sensory impressions provided to the body, which can then be used for purposeful action. However, sensorimotor stimulation should be adapted to individual needs and health status and should take into account the patient's motor and cognitive-emotional conditions, because weak stimulation (in relation to the patient's receptive capabilities) will not result in a reaction, and intense stimulation may cause an excessive reaction [4–6]. The latest research also indicates that the sensory profile may also be genetically determined [7]. Optimal sensorimotor stimulation is important for building coordination between sensory systems, which affects the development of attentional functions, and can later be used to build functions such as achieving advanced movement patterns and building complex perception. Sensorimotor and coordination exercises also contain an element of planning and movement, as well as dynamic regulation of muscle tension and coordination of muscle work, which is important not only for building postural stabilisation and motor control, but also leads to the development of higher mental activities related to orientation in own body schema and praxis – one of the key executive functions [4–6, 8].

Psychomotor therapies

Among the groups of therapeutic methods in which physical exercises are closely related to the improvement of mental functioning, including cognitive functioning, there are psychomotor therapies for children. In the Belgian model developed by Procus and Block, it is assumed that the child gradually acquires the ability to control mental processes and self-mastery through anticipation and achieving coordinated purposeful movement. In this way, the nervous system as a whole is gradually integrated, which is re-

flected, among others, in the improvement of cognitive processes such as reasoning, memory, and speech [9, 10]. Another method of psychomotor therapy is Sherborne Developmental Movement, which involves dosing physical activity in such a way that it enables learning about one's own body and space, as well as optimal functioning in this space and cooperation with other people. In this way, Sherborne Developmental Movement influences the child's learning of their own motor skills, as well as building a sense of security and self-confidence [11]. Both the Procus and Block method and Veronica Sherborne's method also influence the knowledge of one's own body, which is very important in the context of the development of somatognosia and praxis, thus enabling the child to function optimally in everyday life [12].

Active movement and cognitive processes

However, improving cognitive functioning as a result of physical exercises is not exclusively the domain of psychomotor therapies. Each movement performed by the patient, with or without the help of a physiotherapist, causes a number of changes in the nervous system. Motor activity is, among other things, an epigenetic factor that stimulates the expression of the *BDNF* gene, thereby increasing the amount of the protein that determines nerve growth [13]. This leads to an increase in neuroplastic abilities, which translates into improved memory [14], including memory of sequences of motor activities in neurorehabilitation [15]. However, researchers emphasise that physical activity improves not only memory, but also other cognitive functions [16].

Studies of brain activity while performing exercises based on the proprioceptive neuromuscular facilitation (PNF) method have shown that three-plane movements of the limbs crossing the midline of the body (e.g. PNF patterns for the upper limbs) cause activation of the dorsolateral prefrontal cortex and the upper parietal cortex, and thus in this way they can also naturally stimulate the functions for which the above-mentioned cortical centres are responsible, in particular attention, cognitive control, and somatognosia [17].

The impact of motor activity on cognitive functioning is also visible in coordination exercises. They are characterised by multimodal sensory stimulation because they primarily involve the proprioceptive system, the tactile system, and in particular the vestibular system [18, 19]. Researchers point out that coordination exercises stimulate neuroplasticity in people after stroke [20] and that motor coordination is strongly related to cognitive activity [21, 22], which is most likely due to the functioning of the cerebellum, which, in addition to generating a motor response to coordination challenges, also stimulates such cognitive processes as shifting attention, working memory, and cognitive flexibility [23, 24]. Researchers empha-

size that vestibular stimulation itself can contribute to improving cognitive functioning [25].

One of the specific types of coordination exercises is bilateral integration therapy by Sheila Dobie OBE. This method involves practicing cooperation and coordination of both sides of the body, as well as performing sequential movements and dissociation exercises of the body sides. Bilateral integration also improves right-left differentiation and improves the quality of movement patterns crossing the midline of the body. In the later stages, the patient's task is to combine motor planning with visual and auditory processing, as well as to combine the performance of several motor activities at one time. Thanks to this, the patient learns not only adequate responses to challenges, but also problem-solving and the ability to organise the body in movement [26]. Research has shown that exercise programs based on the bilateral integration method improve, among others, interhemispheric cooperation, sequential memory, praxia, cognitive flexibility, attention, and academic skills [27, 28].

Assisted movement and cognitive processes

Not only fully autonomous active movement improves cognitive processes; movement performed in cooperation with a physiotherapist may have a similar effect. Guidance and facilitation of movement by a physiotherapist is primarily associated with proprioceptive stimulation. Proprioceptive stimuli run through the spinocerebellar pathways to the cerebellum, and then stimulate it to produce motor responses and to improve cognitive functioning [29, 30]. Moreover, it is noted that stimulation of the proprioceptive system is one of the most effective activities supporting cognitive processes also in people after brain damage [31].

It has also been shown that consciously performing a movement pattern at the motor level improves the mobility and balance, and in particular motor coordination, while at the cognitive level it improves attention functions, learning efficiency, and orientation in the body pattern. The added value of such exercises is also the impact on autonomic regulation [32]. Unconscious and mechanical repetition of a given movement (without its differentiation, purposefulness, or awareness) leads to habituation, i.e. a gradual decrease in the response to a movement stimulus, and thus reduces the therapeutic effect of motor learning as part of neurorehabilitation [33]. Therefore, awareness of the movement performed is a very important element of exercises that should be taken care of in neurorehabilitation, during both active exercises and assisted exercises performed with the help of a physiotherapist.

Passive movement and cognitive processes

Research clearly shows that improvement in cognitive functioning is influenced not only by active

and assisted movement, but also by passive movement. It turns out that passive exercises, which in clinical practice are performed only to maintain range of motion and prevent degenerative changes in muscles, can play an important role in the neurorehabilitation of cognitive functions. The mere passive movement of the patient's limb by a physiotherapist activates numerous cortical centres that are responsible for, among others, cortical body representations, bilateral coordination, sensory differentiation, attentional functions, praxia, and spatial reasoning [2].

It has also been noticed that passive exercises improve cognitive functioning in the field of executive functions [34]. This is most likely due to the fact that concentrating attention on the motor act performed contributes to the improvement of neuromuscular coordination, which also translates into improved mental activity [35]. The patient's involvement and concentration on a specific movement also stimulate neuroplastic processes, which not only increases the effectiveness of motor learning but also the activation of cortical centres [36, 37].

Conclusions

Current scientific data clearly indicate that physiotherapy can also be used as an element of neurorehabilitation of cognitive functions. Its impact on both the patient's motor skills and their mental functions once again indicates the holism and interdisciplinary nature of physiotherapy as a therapeutic method. Almost every action a physical therapist undertakes triggers a neural response that leads to both a motor and cognitive response. The fact that physiotherapy activities have an impact on cognitive functioning in almost every patient condition indicates that physiotherapy should be an integral element not only of holistic neurorehabilitation, but also of neuropsychological rehabilitation. Cooperation between a physiotherapist and a neuropsychologist may result in a significant increase in the therapeutic effects of cognitive function training. Moreover, the physiotherapist's awareness of how specific types of exercises or specific movements affect the patient's cognitive system may translate into much more effective rehabilitation planning, especially in the field of neurorehabilitation, but also neurodevelopmental rehabilitation. However, it should be remembered that motor functioning does not exhaust the physical aspect of health. It is also very important to take into account data on metabolic changes and diet because – as numerous studies indicate – these are factors significantly related to the health status of people suffering from neurological diseases [38, 39] and diseases affecting neurodevelopment [40]. Thanks to a better understanding of the interaction of the physical and mental spheres, the undertaken therapeutic activities will be multi-faceted and may lead to faster revalidation of the patients, which in turn may signifi-

cantly translate into the quality of life of neurological patients and more effective administration of rehabilitation services in health care systems.

Funding

No external funding.

Ethical approval

Not applicable.

Conflict of interest

The author declares no conflict of interest.

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Received: 17.09.2023

Accepted: 31.12.2023

Online publication: 3.04.2025