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Cognicise – a new model of exercise

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Abstract

Many physical activity centers for geriatrics and gerontology all over the world are examining the best fitted type of exercise for older people including endurance, resistance, stretching and cognitive intervention. Pro-health training is a special area of activity on the border of health prophylaxis, rehabilitation and even sports. The modern neuroscience provides a lot of evidence that in the older people exercises enhance plasticity of the brain networks. The aim of this review is to explicate the topic of cognicise training for older people that is combining of *cognitive* and *exercise* tasks.

KEYWORDS: cognicise, older adults, exercise, healthy aging.

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Introduction

It is predicted that in 2050 y., 40% of Poland population will be represented by people over 60 years old, and also in global view the coming ‘tsunami’ of aging of the society can be expected [30]. In this context, the issue of healthy aging is gaining importance since population aging is accelerating, parallel to prolonged life expectancy – especially that of the old-old aged 75-84 and the oldest-old aged over 85 – while decreasing in birth rate.

The classical view assumes that age-related decline in physical performance and cognitive deficits are irreversible as they are a consequence of changes in an aging body, including: cortical atrophy [29], neurotransmission dysfunction [28], reduced blood perfusion [45], and cognitive decline [17]. Therefore, physical and functional limitations as well as cognitive deficits must appear during aging process. However, more and more researchers indicate that physical activity (PA) and training itself cause a number of a favourable protective effect against some chronic illness or severity [6, 26].

Many centers for geriatrics and gerontology all over the world has been examining the best fitted exercise for older people, including the development of an effective training system for high-risk groups and intervention for dementia prevention [37]. Pro-health training of older people is a special area of activity on the border of health prophylaxis, rehabilitation and even sports, since the older people are much more diverse in terms of physical, cognitive and emotional condition, and are in different health conditions than young or middle-aged individuals. Moreover, the modern neuroscience provides a lot of evidence that in the older people PA enhances plasticity of the brain networks.

Thus, the aim of this short review is to look closer on one of many well designed and possible recommended propositions that is called the **cognicise** training, which is designed to improve the cognitive functions through appropriate training based on the appropriate stimulation in the form of exercise.

Multicomponent exercise intervention

According to Baar [3] exercise can be classified into three subclasses: resistance, endurance, and patterned movements. Resistance and endurance exercise is recognized as such stimulating the body that have a significant influence on muscle phenotype. In turn, patterned movement exercises concern mainly a motor program in the central nervous system (CNS) and result in relatively non-significant biochemical changes in muscles [3]. One of the well-known modifications is combined training (endurance and resistance in one single exercise) [16] that in certain cases and circumstances such combining seems adequate and thus is recommended not only as recovery or rehabilitation. There is strong empirical evidence of the relationship between the level of PA and risk of all-cause and cause-specific mortality [6], since an asymptote exists between energy lost during PA known as metabolic equivalents (METs) and age-adjusted mortality rates. It has been shown that mortality increases at MET values below ~9 in females and >10 in males, but is independent when MET values are higher values [6].

However, parallel to physical exercise the cognitive training is well recognized as having positive effect on CNS, cognitive tasks, and therefore widely recommended especially for older people as prevention against early dementia [37].

It is customary in the prevention training of the older people to be conducted both individually at home and in nursing homes aimed at helping the elderly, where either physical training or cognitive training is used, sometimes both alternately on different days of the week.

However interesting is combining multicomponent exercise intervention composed of exercise and cognitive task. Thus, as the fourth subclass of exercise the term **cognicise** should be added, classified into one of fourth subclasses: 1. resistance, 2. endurance, 3. patterned movements and 4. cognicise. The origin of this term is *cognitive* and *exercise* [37].

Physical activity stimulates plasticity of brain network

Physical inactivity plays a pivotal role in the development of neurodegenerative disorders. It is well known that the human brain is organized into divisible functional networks that are more active during rest and varied states of activities including cognition tasks or PA. During cognitive exercise some regions of the brain automatically increase activity, whereas others routinely decrease their activity [15]. Default Mode Network (DMN), a fronto-executive network (FE), and

a frontoparietal (FP) network, are the well-studied brain networks that communicate between different part of the brain and in consequence are negatively affected by aging that is associated with specific dysfunctions of the brain [41]. Voss et al. [41] demonstrated for the first time that aerobic training improves the resting functional performance of the aging brain. Moreover, the authors found strong evidence that PA increased functional connectivity within the brain networks, which seems highly significant to brain dysfunction in aging. Also among stretching group increased functional connectivity in the DMN as well as in the FP network was observed reflecting experience-dependent plasticity and these intervention are recognized as the first study that demonstrated the existence of exercise-induced functional plasticity in the aging brain. Analogous results were found by other authors [25] after comparing different exercise models i.e. aerobic, resistance, and combined exercise: resistance + aerobic.

Exercise stimulates neural plasticity

Exercise influences to the body by many pathways including upregulating of expression of important molecules such as IGF-1 [11, 40] and brain-derived neurotrophic factor (BDNF) [32].

The other pathways include moderating plasticity in the hippocampus and cortex, as well as increasing resting state perfusion in the hippocampus [27], and increasing dendritic complexity and the number of dendritic spines in the dentate gyrus (DG) [12].

Moreover, animal models showed that aerobic exercises such as voluntary wheel running can significantly reverse declining neurogenesis and memory function [21, 38], improving pattern separation during novel object recognition [7].

However, much common information about the positive influence of aerobic exercise as well as environmental enrichment on improve cognition was originated from a rodent-based model (often studying DG, a sub-region of the hippocampus).

It was Whiteman [44] who showed positive influences of aerobic exercise and environmental enrichment for cognition, in particular for learning and memory [44]. A gray matter volume in a region of the right entorhinal cortex (EC) was positively associated with aerobic fitness.

It is assumed that intervention with voluntary exercise normalized hypothalamic inflammation, neurodegeneration, and glucose metabolism in the Alzheimer's disease (AD) animal model, suggesting that exercise prevents the progression of dementia and AD.

Cognicise

The key question for designing the optimal pattern of physical activity for older individuals is which models of PA are the best fitting for healthy aging process and can support body against dementia and other age related declines. The absolute pioneering research in the era of modern science highlighted that older athletes' performance on comparable tasks was substantially better than the older sedentary individuals, and even comparable to the performance of the young sedentary adults [34]. These study of Spirduso and Clifford presented in the *Journal of Gerontology* in 1978 are real fundament of understanding the role of PA in healthy aging.

The next conclusion is that aerobic exercises decrease the risk of cognitive impairment [19] since it is assumed that exercise enhances hippocampal neurogenesis [36] and cognitive function especially learning in aging [33]. A milestone paper was prepared by Verghese and colleagues and presented in *New England Journal of Medicine*. Authors examined the relation between leisure physical activities and leisure cognitive activities with the risk of dementia. In a numerous cohort of 469 subjects between 75 and 85 years of age stated, that leisure activities such as dancing, playing board games or musical instruments, were associated with a reduced risk of dementia [39]. The conclusion may be drawn that activation of CNS in a specific manner, by physical and cognitive activity, is more advantageous than non-stimulating of the nervous system by cognitive and physical inactivity [35].

The aforementioned studies show that physical activity, especially aerobic exercise, may increase structural and functional integrity in the regions of the brain that decline with age-related dysfunction [9].

To explain in which way exercise acts as CNS 'bodyguard', the following explanations were proposed: 1) neurogenesis and synaptic neural plasticity is caused by the release of neurotrophic factors [2]; 2) exercises cause the reduction of the free radicals in the hippocampus, and increase in superoxide dismutase and endothelial nitric oxide synthase (eNOS) [20]; 3) BDNFs are stimulated to regulate energy homeostasis and mediate beneficial effects of energetic challenges, on cognition, mood, cardiovascular function and peripheral metabolism [22]. The cognicise training is designed into multicomponent exercise intervention, which was reported to have benefits on cognitive improvement and reduction of brain atrophy based on randomized controlled trials. Moreover, Suzuki et al [37] suggest that to achieve synergistic effects of exercise and cognitive stimulation,

it might be recommended to design an intervention method "cognicise" as a multicomponent exercise program with cognitive loads, containing learning tasks during the exercises. It is well recognized that that regular physical exercise is beneficial in reducing the risk of cognitive decline in older adults [14, 18].

Cognitive stimulation such as for example learning tasks is considered as important in lowering the risk of cognitive decline. Thus, cognitive decline becomes essentially lower in individuals who are more intellectually active compare to inactive mentally individuals, and it is well proofed that multitasking positively stimulate the prefrontal cortex [18]. As a consequence according to Collette and Van der Linden [10] "cognicise" may generate synergistic effects for risk reduction of cognitive decline.

Cognicise training is programmed into multicomponent exercise in two variants that can be called Japanese and Polish models. The Japanese variant of cognicise intervention consists of physical exercise and cognitive exercise existing alternately. In turn, Polish model consists of such exercises where activity of both components are trained simultaneously in each exercise task [31]. For example during dancing, spinning, running on treadmill always exercising to the music, the cadence is adjusted to the beat of music and exercising person make some of given cognitive tasks (for instance including "shifted counting"). The idea behind this unusual way of counting consists in setting series of attentional "traps" for the individual [31] where the participant is counting from one to four, but each cycle of counting starts with a different (next adjoining) number, which means one should count:

- 1-2-3-4, 2-3-4-1, 3-4-1-2, 4-1-2-3, 1-2-3-4 etc. instead of

- 1-2-3-4, 1-2-3-4, 1-2-3-4, 1-2-3-4, 1-2-3-4 etc. [31].

Digits can be replaced with letters a, b, c, d or colors, which sometimes is preferred by exercising persons, especially those who do not like math.

Mind–body interventions

In the context of cognicise training it seems worthy to mention about the other techniques where empirical data that has emerged in support of the influence of mind–body interventions (MBIs) could be defined as techniques designed to enhance the mind's capacity to affect bodily function and symptoms [43].

Mind–body techniques are recognized as therapies that focus on the associations between the mind, brain, body, behavior and their influence on health and disease [42]. However, mind and behavior do not enter to the exactly same category that brain and body.

The databases are plenty of numerous evidence for the effectiveness of MBIs including Qigong, yoga, Tai Chi, relaxation response, awareness and breath regulation in improving physical and mental health [8]. However, molecular mechanisms of mentioned profits remain not fully recognized and described.

First of all, it attracts our attention that degeneration changes of basal forebrain complex (BFC) neurons are common symptom in patients with dementia and AD. It is supposed that it might be a consequence of the significant reduction in nerve growth factor (NGF), member of neurotrophin family [13]. This molecule is closely involved in work of the peripheral nervous system and the cholinergic neurons of the CNS [1].

Some medical interventions including NGF therapy are very limited because of the necessity of using extremely invasive methods. Such surgery interventions involve intracranial injection of DNA vectors that expresses human NGF. For this reason, non-pharmacological approaches of treatment always should rise our enthusiasm. Such alternative methods that should be studied including MBIs is e.g. yoga.

Well studied are variable yoga breathing (YB) techniques and salivary expressions of NGF in cognitively normal healthy volunteers [4]. Following 20 minutes practice of YB a significant increase in NGF levels was observed. This effect may suggest that yoga could be considered as adjunct method to treat dementia and AD [5]. Moreover, interestingly meditation diminished loss of brain volume with age [23, 24].

Conclusions

In conclusion, the available evidence highlights that exercise may be used in a preventative or mitigating manner for healthy aging. Moreover, it can be stated that cognitive training seems to be the promising and beneficial method, targeted especially for older individuals.

Conflict of interests

The authors declare no conflict of interest.

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