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Impact of physical activity on the development of dementia

Kornelia Pudło, Karolina Ochyra, Martyna Bukała, Jowita Frydrych, Gabriela Prucnal, Karolina Ryba, Katarzyna Znamirowska, Klaudia Zacher,

Anna Rakoczy, Patrycja Walkiewicz

Authors:

Kornelia Pudło

Independent Public Health Care Complex No. 1 in Rzeszów

ul. Czackiego 3, 35-051 Rzeszów, Poland

e-mail: kornelia.pud@gmail.com

https://orcid.org/0009-0007-1415-6048

Karolina Ochyra

Medical Center in Łańcut, Poland,

Ignacego Paderewskiego 5, 37-100 Łańcut, Poland

e-mail: karolina.ochyra@gmail.com

https://orcid.org/0009-0009-7525-3014

Martyna Bukała

Medical Center in Łańcut, Poland,

Ignacego Paderewskiego 5, 37-100 Łańcut, Poland

e-mail: martyna.bukala977@gmail.com

https://orcid.org/0009-0002-9288-4140

Jowita Frydrych

University Teaching Hospital them F. Chopin in Rzeszów, Poland

Fryderyka Szopena 2, 35-055 Rzeszów, Poland

e-mail: frydrychjowita@gmail.com

https://orcid.org/0009-0003-5416-7252

Gabriela Prucnal

University Teaching Hospital them F. Chopin in Rzeszów

Fryderyka Szopena 2, 35-055 Rzeszów, Poland

e-mail: gabriela.prucnal@onet.eu

https://orcid.org/0009-0003-6633-6498

Karolina Ryba

University Teaching Hospital them F. Chopin in Rzeszów

Fryderyka Szopena 2, 35-055 Rzeszów, Poland

e-mail: kryba3300@gmail.com

https://orcid.org/0009-0007-4305-8375

Katarzyna Znamirowska

University Teaching Hospital them F. Chopin in Rzeszów

Fryderyka Szopena 2, 35-055 Rzeszów, Poland

e-mail: katarzyna.znam678@gmail.com

https://orcid.org/0009-0005-6760-2174

Klaudia Zacher

Medical Center in Łańcut, Poland,

Ignacego Paderewskiego 5, 37-100 Łańcut, Poland

e-mail: klaudiazacher1@gmail.com

https://orcid.org/0009-0003-8839-9668

Anna Rakoczy

University Teaching Hospital them F. Chopin in Rzeszów

Fryderyka Szopena 2, 35-055 Rzeszów, Poland

e-mail: annaa.rakoczy@gmail.com

https://orcid.org/0009-0001-1096-161X

Patrycja Walkiewicz

University Teaching Hospital them F. Chopin in Rzeszów

Fryderyka Szopena 2, 35-055 Rzeszów, Poland

e-mail: patrycja.walkiewicz98@gmail.com

https://orcid.org/0009-0002-0492-9485

Abstract

Issues related to disease prevention are being increasingly addressed, particularly through the prevention of diseases by identification and verification of risk factors. One condition that is associated with an increasing incidence among the aging population is dementia, which places a burden on health care systems and the caregivers. The purpose of this study is to explore the relationship between physical activity and the development of dementia

based on the available literature. Understanding how exercise and sports can help prevent dementia may prove crucial in its prevention. Research indicates that physical activity has an impact on preventing and delaying the development of dementia by reducing cardiovascular risk factors and having a neuroprotective effect. However, the effectiveness of physical activity, the type of sport and environmental conditions plays a major role in this aspect. Notably, evidence suggests that contact sports and strenuous physical work can promote the development of dementia.

Materials and methods: The literature review includes articles from scientific databases (PubMed, ResearchGate) from 2002 to 2024.

Keywords: Dementia, Physical activity, Occupational physical activity, Alzheimer Disease, Neurocognitive Disorder, Cardiovascular risk factors, Neurodegeneration, Chronic traumatic encephalopathy

Introduction

Dementia is a syndrome of symptoms associated with progressive or chronic brain damage over time. It is associated with damage to brain tissue due to metabolism, inflammation, and synaptic failure [1], resulting in deterioration of memory, orientation, abstract thinking, counting, comprehension, communication and language functions. These symptoms are often accompanied by impaired behavior, emotional control and discouragement. Loss of cognitive functions affects a person's ability to function in society, there is an impairment in the performance of daily activities, and thus neglect of hygiene and nutritional status. Dementia occurs primarily in older adults, but can occur in younger people. In 2015, it was estimated that some 46.8 million people worldwide were living with dementia. The disease is a serious problem, as it is estimated that by 2050 the number of people with dementia worldwide will rise to 131.5 million [2]. It is diagnosed on the basis of patient interview, assessment of symptoms during physical examination, questionnaires assessing cognitive function, imaging studies and laboratory tests [3]. There are subtypes of dementia classified according to its cause. Causes of dementia can include drugs, toxins, head injuries, brain tumors, infections, epilepsy, metabolic and demyelinating diseases, degenerative brain diseases, or hereditary diseases. The most common subtypes of dementia are Alzheimer's disease,

vascular dementia, dementia associated with Lewy bodies, and frontotemporal dementia [4]. A distinction is made between modifiable and non-modifiable risk factors associated with deterioration of post-cognitive function. Non-modifiable ones include age, family history and the presence of the apolipoprotein Ɛ4 (APOE4) gene [5]. Modifiable ones, on the other hand, include diabetes, middle-aged obesity, hypertension, hyperlipidemia, current smoking, and traumatic brain injury [6].

According to the World Health Organization's definition, physical activity is defined as: "any bodily movement produced by skeletal muscles that results in energy expenditure" [7]. This includes aerobics, weight training, swimming, or household activities, among others. Therefore, everyone can find a suitable type of physical activity that aligns with their physical capabilities and personal interests. Growing public awareness is increasingly drawing attention to the direct impact of daily choices and lifestyles on health. The positive influence of physical activity on health has long been recognized. Studies have shown, among other findings, that a lack of regular physical activity is associated with increased mortality [8].
An interesting topic is the impact of exercise, sports and overall fitness on the probability of developing dementia. The number of studies showing a direct correlation between physical activity and dementia is constantly increasing. Among others, physical activity has been shown to be associated with a lower risk of dementia [9]. Consistent, regular physical activity can help counteract the development of dementia [10]. However, the intensity of exercise and the type play a significant role. Research has shown that the risk of developing dementia was lower among participants engaging in low, moderately high, and high levels of physical activity [11,12]. In contrast, muscle-strengthening exercise and aerobic exercise are preferred, when it comes to preventing and delaying dementia [13,14].

The purpose of this study is to highlight the role of physical activity as a factor in preventing dementia by reducing cardiovascular risk and neurodegeneration. The negative effects of contact sports and heavy occupational physical work on cognitive abilities will also be discussed.

Physical activity reduces cardiovascular risk

Dementia can result from pathology of the brain's blood vessels. This condition, known as vascular dementia, is caused by strokes resulting from vascular diseases. In order to correctly diagnose this dementia, it is essential to identify infarcts by neuroimaging

and link them to symptoms of dementia [15]. The most effective prevention of this type of dementia is to address cardiovascular risk factors [16]. These include diabetes, hypertension, hyperlipidemia, atrial fibrillation, obesity and smoking. Physical exercise can reduce levels of these risk factors by improving blood circulation in the central nervous system, protecting neurons through the delivery of oxygen and nutrients, and mitigating vascular pathology.

Physical activity and a healthy lifestyle reduce the risk of type 2 diabetes, which contributes to harmful neurophysiological changes. Exercise enhances tissue sensitivity to insulin, thereby reducing insulin resistance [10]. Insulin resistance contributes to cognitive impairment [17], and hyperglycemia leads to protein glycosylation, mitochondrial dysfunction and oxidative stress [9]. This may lead to damage to brain blood vessels and neurons. Physical activity also reduces inflammation and oxidative stress, which can negatively affect insulin-secreting pancreatic β-cells. Exercise improves glucose metabolism, thereby lowering blood glucose levels. Type 2 diabetes is associated with hippocampal dysfunction, as hyperglycemia has a toxic effect on the dentate gyrus [18]. An interesting phenomenon was shown in a study where, among people with type 2 diabetes, a higher number of steps per day was associated with larger hippocampal volume [19]. This brain structure is responsible for memory and learning. Therefore, physical activity in people with already diagnosed type 2 diabetes may have beneficial effects in preserving cognitive abilities.

Exercise reduces hypertension, which is a risk factor for cardiovascular disease. Aerobic exercises [20,21] such as swimming, cycling, and fast walking are particularly important. These may lead to reductions in both systolic and diastolic blood pressure. Exercise causes endothelial vasodilation by stimulating nitric oxide (NO) secretion [22]. Physical activity also helps prevent vascular damage by lowering blood pressure. Long-term elevated blood pressure can weaken vascular structure, increasing the risk of aneurysms and hemorrhagic strokes. Moreover, damaged endothelium promotes the development of atherosclerosis, which, by obstructing blood flow, can lead to ischemic stroke. Prescribing an individualized exercise plan can be a preventive and therapeutic tool in the treatment of hypertension.

Exercise also affects atherosclerotic cerebrovascular disease [23] by reducing LDL cholesterol and triglycerides. Studies have confirmed the positive effects of endurance training on serum lipid profile by decreasing triglycerides and LDL cholesterol, and increasing HDL cholesterol [24]. Excess cholesterol can lead to Alzheimer's disease

through gliosis and deposition of β-amyloid and Tau protein [25]. Regular physical activity positively impacts lipid metabolism in skeletal muscle by enhancing lipid uptake [26].
A healthy lipid profile prevents the development of atherosclerosis and inflammation, which can contribute to neurodegeneration. Obesity is a risk factor for both vascular dementia and other subtypes of dementia [27]. It promotes hypertension and lipid disorders. Exercise influences weight reduction by decreasing body fat and improving appetite regulation.

Physical activity also influences the proper functioning of the heart muscle, as moderate exercise improves heart rhythm and reduces the frequency of atrial fibrillation episodes [28]. Atrial fibrillation impairs ventricular filling and reduces ejection fraction. Irregular cerebral blood flow may limit oxygen delivery to neurons. In addition, atrial fibrillation increases the risk of stroke due to thrombus formation in the left atrium.

Neuroprotective effects of exercise

Exercise can increase levels of neurotrophic factors, and thus contribute to the formation of neurons, new synapses and new vasculature. Exercise may increase the production of brain-derived neurotrophic factor (BDNF), which protects neurons from damage, participates in their differentiation, extends their lifespan, and enhances synaptic transmission. Exercise also regulates the expression of numerous genes in the hippocampus, making it a key factor affecting brain physiology [29]. The hippocampus is one of the main sites of neuroplasticity in the brain. Exercise enhances neuroplasticity, the dysfunction of which is an early feature of Alzheimer's disease [30]. Alzheimer's disease is the most common form of dementia. It is a progressive primary degenerative disease of the brain caused by the deposition of pathological proteins (α-synuclein, tau proteins, β-amyloid). There is neuronal damage, loss of intercellular connections, and cerebral cortex atrophy. Over time, impairments in behavior, memory, language, and motor coordination progressively worsen. It often leads to death due to respiratory distress, malnutrition, dehydration, infections, and other complications. However, physical activity reduces mortality in people with Alzheimer's disease [31]. It has been shown that increased physical activity can reduce β-amyloid levels in a mouse model [32]. Animal studies have noted that exercise can mitigate the neurotoxic effects of stress in a rat model. In rats that had access to running wheels, exercise attenuated the destruction of dopaminergic neurons [33]. This finding may have implications for

individuals with Parkinson's disease, which is characterized by the degeneration of dopaminergic neurons in the substantia nigra.

Contact sports and cognitive impairment

Contact sports such as boxing, wrestling, karate, American football, soccer, basketball and field hockey are increasingly associated with an increased risk of long-term cognitive and metabolic consequences, including future obesity. These sports are associated with repetitive head injuries. Both concussive and subconcussive injuries can lead to inflammation, damage to neurons, oligodendrocytes and blood vessels. Repetitive trauma is associated with progressive tauopathy and chronic traumatic encephalopathy (CTE) [34]. Studies have shown various neuropathological abnormalities in athletes with post-traumatic encephalopathy. These include enlargement of the lateral ventricles, septal cavity, thalamic notch deposition of perivascular pigment-laden macrophages in the white matter of the frontal lobe, decreased brain mass, extensive diffuse deposits of neurodegenerative proteins including hyperphosphorylated tau protein [34,35,36]. Clinical differentiation of CTE can be difficult due to the overlap of neurological symptoms with other dementia subtypes. CTE is characterized by disturbances in behavior (e.g., impulsivity, explosiveness), mood (e.g., suicidal thoughts, apathy, anxiety), motor function (e.g., ataxia, parkinsonism), and a progressive clinical decline in memory and executive function. Over time, cognitive deficits may advance to dementia [34]. Postmortem analyses of the brains of professional American football players revealed that occupational performance may delay symptom onset, potentially masking early cognitive decline [37]. Additionally, postmortem analysis of 202 brains of deceased American football players revealed CTE in the majority of cases. The majority of semi-professional and professional college players had severe CTE pathology [36].

The study also compared recreational athletes with professional athletes. Former amateur boxers, football players, and wrestlers demonstrated higher rates of dementia compared to the general population, supporting speculations about the possible negative impact of these sports. Additionally, professional American football and soccer athletes experienced higher rates of neurodegenerative disorders. This is due to the higher intensity of training and competition compared to the amateur group [38]. Among soccer players, heading the ball repeatedly during their soccer careers pose a risk for developing dementia later in life [39].

Outfield players, who are more frequently involved in physical collisions in addition to repeated heading of the ball, are more at risk than goalkeepers. This contributes to head-to-head, head-to-body and head-to-ground injuries. The duration of injury exposure in contact sports has been linked to parkinsonism and dementia [40]. A study among former professional Scottish soccer players reported higher rates of neurodegenerative disease mortality, and goalkeepers were prescribed dementia medications at lower rates than outfield players [41]. However, another cohort study found that former contact sports participants had fewer risk factors for cardiovascular disease compared to the general population. Specifically, they exhibited lower rates of diabetes, hypertension, and cigarette smoking [42].

Heavy occupational physical work as a cause of dementia development

Available studies indicate that prolonged intensive occupational physical work may be a significant risk factor for cognitive decline, particularly in the elderly. In older adults, high physical demands at work have been linked to cognitive impairment. This may be due to the fact that strenuous physical work is associated with less decision-making freedom, which is detrimental to cognitive function [43]. Additionally, stress involving physical demands and working conditions has been linked to lower hippocampal volume and poorer memory performance [44]. Cognitive dysfunction may be caused by the overlap between the burden of hard physical work and mental stress, which leads to metabolic disturbances. Occupational stress is associated with lipid disorders [45], thereby increasing cardiovascular risk. Jobs involving heavy physical exertion, prolonged standing or walking, and shift work have been associated with an increased risk of Alzheimer's disease. [46]. Examples of occupations with high and moderate physical activity levels included nurses, care assistants, salespeople, farmers, and animal breeders [47]. An analysis of male workers showed that those who were highly physically active at work between the ages of 40 and 59 had a higher risk of dementia after the age of 60 compared to those with sedentary work patterns [48].

High levels of physical engagement in the workplace are associated with an increased risk of cognitive impairment. In contrast, higher levels of leisure-time physical activity are associated with a reduced risk of dementia [49]. Further research is required on the impact of leisure-time and occupational physical activity on health. Such studies should take into account the differences between occupational and leisure-time physical activity, in order

to verify healthier forms of exercise and workloads. Additionally, research must consider genetic differences, exposure to environmental factors, socioeconomic status, work duration, age, and sex. Promoting balanced physical activity and monitoring workloads is essential in the context of dementia prevention.

Conclusions

Based on a review of the literature, it can be concluded that physical activity plays a crucial role in the prevention of dementia, particularly by reducing cardiovascular disease risk and exerting neuroprotective effects. Regular and moderate exercise can delay the development of dementia and improve cognitive function in older adults. However, attention should be given to the type and intensity of activity, as contact sports and excessive, occupational physical strain may be associated with negative effects on brain health. The findings underscore the need for further research and public education to promote an informed approach to physical activity as an effective tool in the prevention of dementia.

Disclosure:

Author's contribution

Conceptualization: Kornelia Pudło;

Methodology: Kornelia Pudło, Gabriela Prucnal;

Software: Jowita Frydrych;

Check: Martyna Bukała, Karolina Ochyra;

Formal analysis: Katarzyna Znamirowska, Klaudia Zacher;

Investigation: Anna Rakoczy; Kornelia Pudło;

Resources: Patrycja Walkiewicz, Karolina Ryba;

Data curation: Maryna Bukała, Gabrela Prucnal;

Writing - rough preparation: Kornelia Pudło, Karolina Ochyra, Martyna Bukała;

Writing - review and editing: Kornelia Pudło, Karolina Ochyra, Martyna Bukała, Jowita Frydrych, Gabriela Prucnal, Karolina Ryba, Katarzyna Znamirowska, Klaudia Zacher, Anna Rakoczy, Patrycja Walkiewicz;

Visualization: Karolina Ochyra;

Supervision: Kornelia Pudło, Karolina Ochyra;

Project administration: Kornelia Pudło, Gabriela Prucnal, Karolina Ryba;

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