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Original Article

The role of physical activity and diet in preventing cognitive decline

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Abstract:
In old age there is a growing incidence of cognitive deficits. Several risk factors (intrinsic and extrinsic) can affects the brain health status of elderly people. In particular, physical inactivity, sedentary behaviour and metabolic disorders related to unhealthy nutrition, could contribute to the worsening of cognitive status. Unfortunately, drug treatments have not been successful in preventing or treating cognitive decline in the elderly.Non-pharmacological but ecological strategies are needed to reduce age-related physical decline and reduce disease-related cognitive impairment in the elderly. Exercise and diet are two protective mechanisms that may reduce the cognitive decline attributed to the normal aging process and protect against changes related to neurodegenerative diseases such as Alzheimer's disease. Changes in favour of a more active lifestyle and dietary changes can potentially improve risk factors for cognitive decline. In fact, both a healthy diet and physical activity contribute to the improvement of the cardiovascular and musculoskeletal system as well as counteracting oxidative stress and reducing inflammation processes. The purpose of this study was to summarize the scientific evidence relating to the role of exercise and diet in neuroprotection and the biological mechanisms that contribute to brain health and improve the quality of life of elderly. These data are needed before more definitive conclusions can be drawn about the effectiveness of these lifestyle interventions to reduce the risk of cognitive decline. Furthermore we wanted to extrapolate recommendations regarding the most appropriate types of physical activity and diet to maintain brain health, in an effort to help clinicians and health operators to promote healthier lifestyles.
Key Words: *Sport activity – Exercise – Sport nutrition – Nutrition – Diet– Cognitive impairment*

Introduction

Cognitive decline play a crucial role in daily functioning of older adult and it is a serious global public health problem in rapidly growing. Epidemiological data, released by the WHO, have reported that the total number of people with cognitive dysfunctions is expected to reach 82 million in 2030 and 152 million in 2050(Organization, 2019). In lifespan the human brain, undergoes age-related atrophy phenomena of the frontal, parietal and temporal regions (Jernigan et al., 2001). Unfortunately, these brain changes affect the cognitive abilities, causing the decline of memory and executive functions, the inability to perform tasks simultaneously that require a change of attention, difficulties in daily life activities, slower response times, reduction of information processing speed and reduction of inhibitory control (Glisky, 2007).

Cognitive decline is due to the combination of intrinsic and extrinsic risk factors (Organization, 2019). Intrinsic risk factors are related to the subject's characteristics, which include immutable biological features such as age, gender, race and genetic factors. Instead the modifiable risk factors mainly concerned people's lifestyle and include the physical inactivity or unhealthy diet.

Clinical and epidemiological data strongly suggest that poor dietary practices and insufficient levels of exercise, lifestyles typical of our modern society, increase the riskto develop cognitive deficits and many neurodegenerative diseases, such as Alzheimer's disease (AD)(Fratiglioni, Paillard-Borg, & Winblad, 2004).
Unfortunately, drug treatments have not been successful in preventing or treating cognitive decline in older adult, this highlights the need to use non-pharmaceutical approaches such as physical activity (PA) and healthy nutrition, to predict and prevent any risk factors or delay the manifestation of cognitive symptoms related to AD.
Metabolic chronic diseases are closely related to cognitive disorders, significantly contributing to arterial obstruction through atherosclerosis processes, and thus favoring ischemic brain damage. In recent decades, many researchers have focused their attention on the mechanisms underlying cognitive decline, highlighting the close relationship between neurodegeneration and nutrition. They suggested that since nutritional factors can influence brain health by acting on both metabolic and vascular risk factors, as well as inflammation and oxidative stress, it is clear that there is a link between nutrition and cognitive impairment. Pathological processes leading to

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neuronal loss begin their activity long time before clinical symptoms occur. A current challenge is to understand how eating habits, during the whole life of a person, may modify the risk and the severity of cognitive decline.
Also the sedentary behaviour and physical inactivity might induce the cognitive decline, instead the active lifestyle positively affect the cognitive process although the biological mechanisms which result in such effect are only poorly understood. Colcombe and Kramer (Colcombe & Kramer, 2003; Kramer & Colcombe, 2018) conducted the meta-analysis studies, to highlight that PA has effects on the cognitive function of non-demented older adults. The authors observed a significant effect of aerobic exercise training on cognitive functions and neuronal plasticity that are maintained throughout the lifespan. Studies about the association between PA and brain health, have found that more PA early in life is associated with greater brain volume later in life(Erickson et al., 2009, 2010). These studies revealed that people who practice high levels of aerobic activity had larger hippocampal volumes and exhibited better spatial memory performance associated with hippocampal volume. These results suggest that aerobic PA may offer a protective effect on the brain by modifying AD-related changes in brain structure.

There are several studies that have highlighted how specific nutrients or dietary patterns and specific PA or multimodal activities contribute to the improvement of vascularization, energy metabolism and oxidative stress processes, with a consequent positive impact on the maintenance of cognitive functions.
Here, we will discuss the clinical and experimental evidence showing how physical activity (PA) and diet may affect brain health and prevent neurodegenerative diseases.

The aim of this review is to describe the evidence for the beneficial effects of PA and diet as well as promoting PA and diet as an ecological approaches useful for improving people's quality of life. In addition, another aim was also to extrapolate recommendations regarding the type of PA and diet most appropriate for maintaining brain health.

Material & methods

Procedure

A systematic searches were conducted in the databases PUBMED and SCOPUS. In order to perform this research, we used a set of Keywords reported in Figure 1. In this figure the key point is represented by the AND block, which merges the other peripheral blocks, which contains the keywords and their synonyms separated by an OR condition. In this way, the search is made through the intersection of at least one word for each block. For the bibliographic research, the works published from 2015 to 2020 were selected. After a preliminary search the following exclusion criteria were applied: 1) exclusion of review articles; 2) exclusion of all studies that do not include healthy elderly people as target population; 3) exclusion of all studies written in a language other than English.

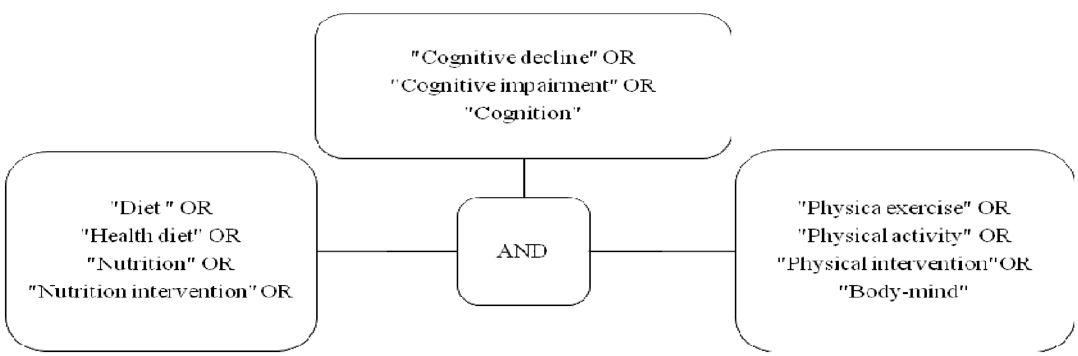

Fig.1 Set of Keywords

Results

After a preliminary search, 362 articles have been found about the effects of physical exercise on cognitive decline, while 220 articles about effects of healthy diet and cognitive decline we found. After the application of the exclusion criteria, 9 articles concerning the effect of PA on the brain for the prevention of cognitive decline were included in the study.

Furthermore 8 articles concerning the effect of healthy diet for the prevention of cognitive decline were included in the study.Table 1 provides an overview of the selected articles of the effects of physical activity for the maintenance of cognitive functions. In addition in Table 2 are reported the effects of healthy diet on brain functions.

Tab. 1 Summary of articles on the effects of physical activity for the maintenance of cognitive functions.

Authors (years)	Participants (Age)	Type of activity	Duration	Outcames
(Sun et al., 2015)	150 (68.3)	Tai Chi	2weeks × 6 months (60minutes)	Frontal Assessment Battery (FAB); Mini-Mental State Examination (MMSE)
(Sink et al., 2015)	1635 (70 to 89)	Moderate-intensity physical activity program	24 months	Digit Symbol Coding (DSC); Hopkins Verbal Learning Test
(Sáez de Asteasu et al., 2019)	370 (75)	Multicomponent exercise training programme	5–7 consecutive days (two sessions/day)	Mini-Mental State Examination (MMSE)
(Izquierdo et al., 2019)	370 (75)	Moderate-intensity resistance, balance, and walking exercises	2 daily sessions	Mini-Mental State Examination (MMSE); Mood Status; Questionnaire for quality of life (QoL); Confusion Assessment Method.
(Liu-Ambrose et al., 2015)	70 (74)	Aerobic exercise training	6 months of thrice-weekly	Global executive function;Stroop Test; Alzheimer's Disease Cooperative Study–Activities of Daily Living (ADCS-ADL) scale;
(Imaoka et al., 2019)	67 (75.2)	Multicomponent exercise training programme	45 min × 3 months	Mini-Mental State Examination (MMSE); Trail making test (TMT)
(Hwang et al., 2016)	456 (60)	Tai Chi	60 min × 6 months (every day)	Mini-Mental State Examination (MMSE); Geriatric Depression Scale
(Greblo Jurakic, Krizanic, Sarabon, & Markovic, 2017)	28 (66–78)	Resistance training; Pilates	Pilates 1 h × 8 weeks; Resistance training 30min × 8 weeks	Montreal Cognitive Assessment (MoCA)
(Gothe, Kramer, & McAuley, 2017)	118 (62)	Yoga	3 times × 8 weeks	Attention Network Test (ANT)

Tab. **2** Summary of articles on the effects of Diet for the maintenance of cognitive functions.

Authors (years)	Participants (Age)	Type of nutrition or diet	Duration	Outcames
(Calapai et al., 2017)	57 (55-75)	Cognigrape	12weeks	Mini-Mental State Examination (MMSE), Beck Depression Inventory (BDI); Hamilton Anxiety Rating Scale (HARS); Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) evaluations
(Danthiir et al., 2018)	194 (65-90)	Docosahexaenoic acid (DHA)	18 months	A battery of cognitive tests
(Kean et al., 2015)	37 (67)	Flavanone-rich orange juice	8 weeks	Executive function; Episodic memory test
(Külzow et al., 2016)	22 (50-75)	Omega-3	26 weeks	Visuospatial memory; Standard neuropsychological test
(Mastroiacovo et al., 2015)	90 (61-85)	Flavanol consumption	8 weeks	A battery of cognitive tests
(Nilsson, Salo, Plaza, & Björck, 2017)	20 (50-70)	Berry beverage with polyphenols	5 week	A battery of cognitive tests
(Scott, Rasmussen, Chen, & Johnson, 2017)	20 (63)	Avocado	6 months	A battery of cognitive tests
(Valls-Pedret et al., 2015)	447(60)	Mediterranean diet	5 years	A battery of cognitive tests

Dicussion

In this study we illustrated an overview of the effects of healthy diet and PA on brain functions in order to highlight the beneficial effects on cognitive performance in healthy elderly individuals.

Although with some exception, the results of cross-sectional, prospective and retrospective epidemiological studies, support a relationship between the cognitive activity of older adults and PA. In literature, it is known that correct lifestyles and constant exercise are related to better performance on cognitive tasks such as greater executive control, better controlled attention, an improvement of spatial skills and the speed of information processing in older adults.

Movement has played a crucial role in the adaptability of the organism to the environment. Therefore, it is plausible to assume the presence of a retrograde flow of information with feedback functions to the central nervous system. The details of such a signalling system are still incomplete, but experimental observations suggest two fundamental mechanisms. Evidence indicates that events associated with energy balance can play a role in nervous functions. Brain metabolic responses to acute PA seems to extend beyond the regions specifically associated with skeletal motor, sensory, and cardiovascular autonomic control(Ide & Secher, 2000). Lactate taken up from skeletal muscle seems to act as an intercellular energy shuttle within the brain during high-intensity exercise. Exercise limits the use of glucose by the muscle to assure sufficient amounts for the increased brain metabolic needs.

However, there is also clear evidence for effects of PA on nervous functions that are only indirectly dependent, or independent on energy metabolism. In the hippocampus, exercise has been found to significantly increase the levels of a mitochondrial protein that promotes the adenosine triphosphate (ATP) synthesis. Vaynman et al. (Vaynman, Ying, Wu, & Gomez-Pinilla, 2006)proposed a model in which the presence of mitochondrial protein at the pre-synaptic and post-synaptic membranes could allow neuronal mitochondria to limit oxidative stress (OS), increase ATP production and modulate calcium levels. These results suggest the presence of fundamental mechanisms by which exercise affects key elements of energy metabolism that modulate substrates of synaptic plasticity underlying learning and memory.

From the evidence reported in this brief review, it may be deduced that multiple physiological mechanisms induced by PA may contribute to the conservation or improvement of brain functions and health. In the present study, the collection of articles highlighted a small effect of mind-body exercise on overall cognitive function. These evidences of the effect of mind-body exercise on overall cognition are congruent with previous reviews examining the effectiveness of Tai Chi, Pilates and Yoga on overall cognitive function. When participating in mind-body exercises, participants are committed to remembering movement patterns and sequences and this has benefits on the frontal lobe and regulation of executive function(Gothe et al., 2017; Hwang et al., 2016; Sun et al., 2015).

Therefore the physical exercise seems to have neuroprotective effects and reducing the risk of pathological processes and favouring phenomena of plasticity of the brain through neurogenesis and synaptogenesis, the effect of exercise is essential for better general brain health and for the recovery of cerebellar skills (Lardone et al., 2018; Montuori et al., 2019; Sorrentino et al., 2019). Specifically, moderate-intensity exercise (aerobic or resistance) (Colcombe & Kramer, 2003; Kramer & Colcombe, 2018; Liu-Ambrose et al., 2010)seems to be effective not only in promoting a state of physical health (Davide Di Palma, Raiola, & Tafuri, 2016; Napolitano, Ascione, & Di Palma, 2017; Napolitano, Perciavalle, & Ascione, 2017; D di Palma & Tafuri, 2016; Raiola, Lipoma, & Tafuri, 2015)butalso to promote brain health.

In the literature, various evidences are available on the effects of food components on brain health andin the previous section we reported some evidence.

Many evidences demonstrate effect of nutrients and/or diet on neuronal functions in particular high amount of cholesterol in neural membranes can regulate the level of β-amyloid (Aβ) in the brain (Simons et al., 1998). Moreover, cholesterol-enriched high-fat diet seems to promote Aβ deposition(Refolo et al., 2000). Many nutrients such as policosanol, have a direct control on cholesterol levels and a hypocholesterolemic activity (Menéndez et al., 2001).

An alternative approach to regard the relationship between food and cognitive decline is the evidence that neurodegenerative disorders such as AD may be delayed by cerebrovascular health caring low-salt diet and/or high dose folate associated with other strategies able to control hypertension could help in reducing risk for vascular events and AD (Luchsinger et al., 2005). Diet rich of anti-oxidant compound also could have relevant effect in decreasing risk of dementia due to the high contents of polynsatured fatty acids (PUFA) in neuronal membranes, while flavonors from fruits, cocoa beans and Ginko biloba was shown to reduce learning and memory impairment in rodents (Pu et al., 2007). The effect of diet can be appreciated when this in enriched with products such as alpha lipoic acid (in spinach, broccoli, peas and yeast) and Vitamin E (in vegetable oils, nuts) which improves memory deficits and promotes neurological performances in human (KONTUSH & SCHEKATOLINA, 2004).The findings described in Table 2 show that nutrition intervention has a positive impact on cognitive functioning of healthy older people. From this collection of papers, it appears that several nutrients exhibit a beneficial effect on brain health, but the interaction of specific foods and nutrients, especially in the MedDiet(Valls-Pedret et al., 2015), appears to have a fairly positive effect on cognitive performance in healthy elderly individuals. In fact, the MedDiet seems to be a nutritional model for healthy eating habits as it contains all the necessary nutrients: monounsaturated fatty acids, polyunsaturated fatty acids, antioxidants, vitamins and minerals. Furthermore, the combination of these nutrients positively influences pathological neurodegenerative processes such as oxidative stress, neuroinflammation, insulin resistance and reduced cerebral blood flow. In contrast, research implies that dietary patterns high in fat and sugar, with a high intake of meat / poultry or eggs, have negative and detrimental effects on cognitive functioning in old age.

Physical activity recommendations

Research studies on the relationship between brain health and physical activity have made it possible to develop guidelines for the promotion of health in the elderly. The World Health Organization (Organization, 2019; WHO, 2010), recognizing physical activity as a possible modifiable factor useful for promoting health in general, has disclosed the main guidelines for all healthy adults over 65 age, to improve both fitness cardiorespiratory and muscle, that brain functions. The elderly should do at least 150 minutes of moderate-intensity aerobic physical activity during the week or at least 75 minutes of vigorous-intensity aerobic physical activity during the week or an equivalent combination of moderate and vigorous intensity activity. To encourage additional health benefits, older adults should increase their moderate intensity aerobic exercise to 300 minutes per week or engage in 150 minutes of vigorous aerobic physical activity per week or equivalent combination of moderate and vigorous intensity activities.

The elderly, with mobility deficits, should carry out physical activity 3 or more days a week, to improve their motor ability and prevent the falls. In addition, in order to enhance muscle activity, elderly should carry out activities involving the main muscle groups 2 or more days a week. An improvement in cognitive performance, in particular executive functions, it has been shown following a participation in long-term resistance exercise programs (Liu-Ambrose et al., 2010).

Diet recommendations

Emerging results from preclinical and clinical studies show that in addition to lifestyle changes and a constancy in physical activity, diet can also be an important modifiable factor useful for the prevention of cognitive decline (Barnard et al., 2014). From these results, are emerged several recommendations, which include minimizing the intake of trans fats and saturated fats, dairy products and increased consumptions of vegetables, legumes (beans, peas, and lentils), fruits and whole grains. In addition, various dietary models are suggested in order to reduce or prevent the typical pathological signs of cognitive decline, including the ketogenic diet (Rusek, Pluta, Ułamek-Kozioł, & Czuczwar, 2019), the Mediterranean diet (Titova et al., 2013) and dietary approaches to reduce calorie consumption and improve the cardiovascular system and brain health.

Conclusions

PA and diet may act to modify risk factors related to the onset of cognitive decline. Both PA and diet represent a non-pharmacological but ecological approaches capable to act as useful protective mechanisms to reduce the age-related cognitive impairment in the elderly. However, further research seems to be needed to clarify how PA and diet affect brain functions or act directly on the structure and function of the brain for better prevention of brain disorders.

Conflicts of interest

The authors declare no conflict of interest.

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