

Mediterranean Diet and Cognitive Functions

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Mediterranean Diet (MedDiet) consists of a large number of vegetables, fruits, beans, legumes, whole grains, olive oil, seeds, herbs and spices, as well as fish, seafood, eggs, cheese and poultry and disrecommends unusual red meats and sweets. In particular, a high intake of fish and low intake of alcohol contributes to the delay of cognitive decline.

Keywords: Mediterranean diet ; older people ; cognitive impairment ; impact

1. Introduction

Globally, there is a sharp rise in the elderly population. In fact, in 2019 there were 703 million of the elderly at the age of 65+ years. By 2050, this number should be more than doubled and reach 1.5 billion ^[1]. Due to this demographic aging of the population, there is a higher incidence of worsen health conditions, such as impaired vision, hearing, but also a progressive decline of cognitive functions ^[2].

Cognitive functions are all mental processes that allow us to recognize, remember, learn and adapt to ever-changing environmental conditions. This includes, for example, learning, memory and thinking, receptive functions, such as perception of stimuli, their maintenance and sorting, as well as expressive functions, such as speech, writing, and drawing ^[3]. These are all symptoms of a neurodegenerative disorder known as dementia, associated with a loss of cognitive abilities ^[4]. Dementia is a progressive disorder, which gradually limits a persons' autonomy and self-sufficiency, and in later stages it might result in their disability ^[5]. Unfortunately, at the moment, it cannot be cured, but it can be only delayed by both pharmacological and non-pharmacological therapies ^[6]. The pharmacological therapies include four main drugs, such as acetylcholinesterase inhibitors (donepezil, galantamine, rivastigmine) or memantine (also an N-methyl-D-aspartate (NMDA) antagonist) and they can only improve the mental state of the affected person temporarily and only slow down the pathological process ^[7].

Therefore, it is necessary to try to prevent the development of brain degeneration. At present, there exist several non-pharmacological therapies, which have been proved to prevent the development of cognitive impairment in old age ^[8]. These involve physical activities, which should be done regularly at least three times a week, cognitive training, for example, solving crosswords, reading, or learning a foreign language, and a healthy diet ^[9], out of which Mediterranean diet seems to be a solution ^[10] since evidence suggests that greater adherence to Mediterranean diet (MedDiet) is associated with slower cognitive decline and lower risk of developing Alzheimer disease ^{[11][12]}.

Although the exact mechanism by which MedDiet positively affects cognitive function remains unknown, the findings suggest that this might be a multifactorial process ^[13]. The most important active molecules with a protective effect on nervous tissue or metabolism involve the influence of saturated fatty acids and the anti-inflammatory and antioxidant action of the whole group of active biomolecules present in this type of diet. The fact that the MedDiet is associated with caloric restriction and balanced nutrient intake, which in turn positively influences the overall physiological metabolic processes in the body (e.g., insulin resistance, blood glucose levels and lipid profile), also has a significant impact ^{[14][15]}. MedDiet consists of a large number of vegetables, fruits, beans, legumes, whole grains, olive oil, seeds, herbs and spices, as well as fish, seafood, eggs, cheese and poultry and disrecommends unusual red meats and sweets. In particular, a high intake of fish and low intake of alcohol contributes to the delay of cognitive decline ^[11].

Research indicates that adherence to MedDiet during midlife is associated with 36%–46% greater likelihood of healthy ageing ^{[16][17][18]}. For instance, Critselis and Panagiotakos ^[18] state that adherence to MedDiet among the elderly people is highly associated with healthy ageing since diets similar to that of MedDiet are connected with 269% greater likelihood of successful ageing and 33% reduction in mortality risk. Furthermore, Buglio et al. ^[19] maintains that MedDiet has a positive impact on hospitalized patients, i.e., it slows down their rate of stay length and in-hospital mortality.

2. The Effect of Mediterranean Diet on Cognitive Functions in the Elderly Population

The findings described above indicate that the adherence to MedDiet has a positive effect on both cognitively impaired and unimpaired older population, especially on their memory, both in the short and long run. In addition, the higher adherence to MedDiet proves to have a better impact on global cognitive performance of older people [20][21][22][23][24], which has been also evidenced in other research studies on the same issue [25][26].

Furthermore, Mantzorou et al. [22] expands that higher adherence to MedDiet was significantly associated with healthy younger age, female gender, higher educational level, and better anthropometric parameters. These findings are in line with other studies, e.g., Okubo et al. [27], who report that females are more concerned about their selection of individual nutrients since the dietary approach. In their study, they also discovered that especially females with a higher educational degree, going outdoors frequently and avoiding smoking and drinking alcohol had a better cognitive performance than the others. Overall, females of any age do care about their diet more than males of the corresponding age [21]. Moreover, de la Rubia et al. [28] confirm that this is also partly true for cognitively impaired female patients with AD, who recover more easily than male patients when exposed to MedDiet.

The results from the studies performed among Alzheimer's disease (AD) and Parkinson's disease (PD) patients and focused on the association of MedDiet on their cognitive functions reveal that this dietary pattern has a positive impact on the following cognitive domains: episodic, temporal orientation, semantic memory, language, attention, or concentration [28][29].

In addition, the findings indicate that enrichment of MedDiet with a higher dosage of some food, such as coconut oil [28], extra-virgin olive oil (EVOO) [24], or fresh, lean pork [29], might have a more significant impact on the improvement of cognitive performance among seniors than just MedDiet alone.

Research shows that particularly polyunsaturated fatty acids and flavonoids play an important role in the enhancement of cognitive performance among healthy older people [30][31]. In fact, fatty acids form the main components of the neurobiomembrane and thus interfere significantly in processes, such as nerve signal transduction and neurotransmission at synapses [32]. For example, Gu et al. [33] found that adequate intake of PUFA from fish was positively associated with gray matter volume in patients with Alzheimer's dementia. Strike et al. [34] reported that PUFAs (omega-3) improved white matter integrity and processing speed. Most prospective cohort studies on this topic [35][36] are relatively uniformly positive about the effect of fish consumption on cognitive decline. A neglected but nevertheless interesting molecule appears to be the antioxidant carotenoid astaxanthin. This biomolecule is produced by algae and is responsible for the dark red-orange color of salmon, shrimp and lobster meat. Astaxanthin crosses the blood-brain barrier and has effects on the central nervous system, including antioxidant, anti-inflammatory and antiapoptotic effects [37].

In addition, extra-virgin oil, particularly its component, secoiridoid oleuropein, might decrease the risk of cognitive decline [38]. There are not many studies dealing directly with the effect of EVOO on cognition [24]. The effect of low doses over short periods of time has not been studied at all, however, there are studies that have studied the protective effect of EVOO on brain structures over long periods of administration (e.g., 6.5 years) [39]. In the literature, EVOO supplementation has been reported to affect tests of cognitive function, even at low doses [39][40][41], while MedDiet containing EVOO may prevent cognitive decline over long periods of time and have a beneficial effect during the long prodromal phase of dementia [42].

Generally, a wide variety of anti-inflammatory and antioxidant substances form a very important group of MedDiet nutrition in terms of preserving human cognitive abilities. These include vitamins (A to E), folic acid, phenolic flavonoids (especially oleuropein) [38] and biomolecules of a lipophilic nature (especially alpha-tocopherol, beta-carotene) [23][24]. MedDiet also contributes to reduce symptoms of other chronic diseases, such as autoimmune diseases or cardiovascular diseases [43].

In addition to the classic MedDiet, which does not have a strictly defined calorie intake, calorie-deficient variants have also been tested. For example, Gepner et al. [44] combined the MedDiet and a low-carb diet, which reduced carbohydrate intake (initially < 40 g/day, then <70 g/day) and increased protein and fat intake. Another characteristic of this Med/LC diet was the low red meat content, with poultry and fish replacing beef and lamb.

Present research indicates that overall, a higher varied diet consisting of relevant dietary nutrients, such as MedDiet, and no single foods, has a more far reaching impact on cognitive performance of older inhabitants [21][23][45]. There are also other healthy diets, similar to MedDiet, which in fact reflect regional dietary habits. These include, for example, Nordic diet (NPDP) [46] or MedÉire diet [47], both emphasizing traditional, sustainable, and locally sourced foods in order to better

adopt and adhere to MedDiet dietary patterns among these people. Shakersain et al. [46] in their study showed that moderate-to-high adherence to the NPDP may predict a better-preserved cognitive function among older adults in Nordic countries in comparison with neurodegenerative delay, Mediterranean diet, dietary approaches to stop hypertension, and the Baltic Sea diet.

However, there are also studies, which find no association between the adherence to MedDiet and better cognitive performance among elderly [48][49]. This is, for example, true for the study by Hill [50], whose study shows that there is no connection between the adherence to MedDiet and beta-amyloid deposition in a cohort of healthy Australian women.

In conclusion, the adherence to MedDiet has a positive impact on both cognitively impaired and unimpaired older population. Furthermore, it brings other benefits, such as reduction of depressive symptoms, lowered frailty, as well as reduced length of hospital stays.

Future research should focus on more clinical trials, which would confirm the potential role of MedDiet MD in reducing the risk of cognitive impairment.

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