

Research Progress on the Relationship Between Dietary Inflammation Index and Geriatric-related Diseases

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Abstract: Along with the acceleration of aging in our country and the increased prioritization on healthy living, the prevention and treatment of senile diseases have become a hot topic. The Dietary Inflammation Index (DII) is a new tool for assessing dietary inflammation. This article reviewed the research processes on the association between DII and age-related diseases such as osteoporosis, cognitive impairment, cardiovascular disease, cancer, and so on. It is expected that DII can provide guidance on the daily diet of older people, prevent and treat age-related diseases, and improve their quality of life.

Keywords: Dietary inflammatory index; Aged; Geriatric-related diseases

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1. Introduction

Data from the Healthy China Action (2019–2030) plan pointed out that the older population aged 60 and above has reached 249 million, accounting for 17.9% of the total population, and nearly 180 million elderly people suffer from chronic non-communicable diseases^[1]. Recently, due to the accelerated aging of China's population, there has been an increasing association between chronic diseases and aging being the main factor^[2]. Age-related diseases refer to diseases related to aging. Dietary balance is the foundation for good health. The Dietary Guidelines for Chinese Residents (2022) pointed out that residents can adjust their nutritional intake to prevent chronic diseases and improve health literacy through balanced diets^[3]. By targeting older people and improving their dietary habits to prevent and treat age-related diseases, the establishment of a healthier China can be promoted.

Diet plays an important role in regulating chronic inflammation, and the Dietary Inflammation Index (DII) can be used to assess the relationship between an individual's diet and their inflammation levels^[4]. The DII has been widely used in clinical research globally. However, in China, the related research on DII mostly focuses on cancer, mainly on chronic metabolic diseases such as cardiovascular diseases. This article summarizes the correlation between DII and geriatric diseases to provide reasonable dietary guidance for elderly patients to help them reduce inflammation levels, thereby reducing the risk of certain chronic diseases, and providing new

insights into dietary health education for clinical workers.

2. The concept of DII

The DII is a tool that connects dietary patterns and inflammation levels to determine the impact of one's diet on the body's inflammatory response and is used to assess an individual's overall inflammation level. In 2009, Cavicchia et al. ^[5] discovered the regulatory effect of diet on inflammation based on the results of an extensive literature search and proposed DII for the first time. In 2014, Shivappa et al. ^[6] collected global databases, modified the dietary inflammation index scoring algorithm, and standardized individual intakes with global reference values, promoting the international use of the DII scoring table. DII mainly studies 45 food parameters that can alter the levels of systemic inflammatory response markers in the human body, including energy, nutrients, bioactive compounds, and foods/flavors. The calculation method of DII is $Z \text{ score} = (\text{daily intake of this dietary ingredient or nutrient} - \text{average global daily intake of this dietary ingredient or nutrient}) / \text{standard deviation of global average daily intake of this dietary ingredient or nutrient} \times \text{Inflammatory effect index of this dietary ingredient or nutrient}$. Based on the DII score, the diet is considered a pro-inflammatory diet when DII scores are above 0, while DII scores below 0 indicate an anti-inflammatory diet.

The larger the positive value, the stronger the pro-inflammatory effect of the food consumed. Common pro-inflammatory foods include red meat, processed products, fried and grilled foods, refined grains, sugars, foods rich in fat and Omega-6 unsaturated fatty acids, etc. The calculation method of the personal DII is by investigating the individual's dietary situation through questionnaires and then comparing it with the food composition table. According to the DII score of 45 food parameters ^[7], the sum of the DII scores of all foods can depict the overall inflammation levels of certain foods consumed, which is beneficial to study the relationship between diet patterns and inflammation levels.

3. The impact of diet on age-related diseases

Aging may be accompanied by a decline in taste function, which eventually affects one's dietary intake. This ultimately results in detrimental health effects and increases the risk of age-related diseases. Nutritional surveys have pointed out that older people consume fewer fruits and vegetables and prefer sweet and salty soft foods ^[8]. Such foods contain high levels of inflammatory factors, and excessive consumption will increase inflammation levels in the body. Common diseases in older people, such as neurological disease, Parkinson's disease ^[9], cardiovascular and cerebrovascular diseases, and atherosclerosis ^[10] are closely related to the body's inflammatory response. The Mediterranean diet is a dietary structure formed by analyzing the dietary characteristics of countries in the Mediterranean region. This dietary pattern exhibits high levels of anti-inflammatory effects and is beneficial in preventing and controlling chronic diseases ^[11]. Therefore, older people should reduce the consumption of high-fat, high-oil, and high-sugar foods such as fast food, desserts, candies, processed meats, refined grains, etc. Foods such as fresh vegetables and fruits, nuts, fish, whole grains, etc., should be consumed more as they can prevent age-related diseases.

4. DII and age-related diseases

4.1. DII and osteoporosis in older people

Wang et al. ^[12] showed through meta-analysis that higher DII was positively correlated with the risk of osteoporosis (RR = 1.31, 95% CI: 1.16–1.48). Yang ^[13] pointed out that DII scores negatively correlated

with bone density in older Chinese people. The higher the inflammation index, the lower the bone density. However, there exists a correlation between inflammatory factors and osteoporosis. Low bone density leads to an increased risk of osteoporosis. Osteoporosis is the main cause of fractures in older people, and hip fractures are a common occurrence in older people after falling. Some studies have pointed out that hip fracture is an important factor in affecting the quality of life of older people [14]. After the occurrence of a hip fracture, the ability to take care of themselves is reduced, their metabolism is slowed, bone healing time is prolonged, and they may be bedridden for long periods. This could lead to corresponding complications such as pressure ulcers, muscle atrophy, etc., which reduces their quality of life. A high pro-inflammatory diet will disrupt bone quality and cause osteoporosis in older people. Therefore, for older people with low bone density, in addition to supplementing calcium and vitamin D, they should also consume more fresh vegetables, fruits, etc., to improve the body's anti-inflammatory levels and maintain bone health. **Table 1** summarizes the DII scores of 45 food parameters.

Table 1. DII scores of 45 food parameters

Food/ingredient name	Pro-inflammatory index	Global average daily intake	Food/ingredient name	Pro-inflammatory index	Global average daily intake
Saturated fat (g)	0.373	28.600	Ginger (g)	-0.453	69.000
Total fat (g)	0.298	71.400	Tomato (g)	-0.14	0.370
Trans fat (g)	0.229	3.150	Folic acid (ug)	-0.19	273.000
Calories (kcal)	0.180	2056.00	Selenium (ug)	-0.191	67.000
Cholesterol (mg)	0.110	279.400	Monounsaturated fatty acids (g)	-0.009	27.000
Vitamin B12 (ug)	0.106	5.150	Thyme (mg)	-0.102	0.330
onion (g)	-0.301	35.900	Niacin, vitamin B3 (g)	-0.2462	25.900
Iron (mg)	0.032	13.350	Medicinal rosemary (mg)	-0.013	1.000
Egg white (g)	0.021	79.400	Flavanols (mg)	-0.467	17.700
Sugar (g)	0.097	272.20	Polyunsaturated fatty acids (g)	-0.337	13.880
Caffeine (g)	-0.110	8.050	Flavoenase (mg)	-0.25	17.700
Fiber (g)	-0.663	18.80	Riboflavin (mg)	-0.068	1.700
Ethanol (g)	-0.278	5.150	Anthocyanins (mg)	-0.131	18.050
Magnesium (mg)	-0.484	310.100	Flavan-3-ol (m g)	-0.415	95.800
Turmeric (mg)	-0.785	553.600	Flavin (mg)	-0.616	1.550
Green/black tea (g)	-0.536	1.690	Vitamin D (ug)	-0.446	6.260
β-Carrot (ug)	-0.584	3718.000	Isoflavin (mg)	-0.593	1.200
n-3 fatty acid (g)	-0.436	1.060	Thiamine (mg)	-0.098	1.700
Vitamin B6 (g)	-0.365	1.470	Black pepper (g)	-0.131	10.000
Zinc (mg)	-0.313	9.840	Vitamin A (mg)	-0.401	983.900
n-6 fatty acid (g)	-0.159	10.800	Vitamin E (mg)	-0.419	8.730
Eugenol (mg)	-0.140	0.010	Vitamin C (mg)	-0.424	118.200
Garlic (g)	-0.412	4.350			

4.2. DII and cognitive impairment in older people

In a cross-sectional study conducted by Zabetian-Targhi et al. ^[15], no relationship between DII score and overall cognitive function was observed. The underlying brain pathways are unknown. Charisis et al. ^[16] conducted a cohort study on randomly selected community residents over 65 years old in a Greek district and followed up with them for 3.05 years. The results showed that higher DII scores were associated with an increased risk of dementia. Zhou ^[17] pointed out that higher DII levels in older people in a certain district of Tianjin were related to a higher risk of mild cognitive impairment, and this was consistent with the findings of Li et al. ^[18]. Excessive consumption of pro-inflammatory foods further stimulates the inflammatory factors produced by the body to pass through the blood-brain barrier ^[19]. This affects the normal brain function as the brain nerves are affected. However, there are few studies on the relationship between DII and cognitive impairment in older people. In future studies, the sample size should be increased to study the mechanism of inflammation on brain cognitive function.

4.3. DII and chronic metabolic diseases

4.3.1. DII and chronic kidney disease

Mazidi et al. ^[20] analyzed the data of the National Health and Nutrition Examination Survey participants from 2005 to 2012 and investigated the relationship between DII and chronic kidney disease in American adults. It was pointed out that a pro-inflammatory diet was associated with decreased renal function and chronic kidney disease. Wu et al. ^[21] studied the relationship between DII and damp-heat syndrome in patients with stage 5 chronic kidney disease from the perspective of traditional Chinese medicine (TCM). It was determined that the DII score was an independent risk factor for damp-heat syndrome in patients with stage 5 chronic kidney disease. People who follow a pro-inflammatory diet tend to have increased inflammatory properties and are more likely to develop damp-heat syndrome. For every one-unit increase in DII score, the risk of damp-heat syndrome increases by 1.18 times. The disease develops chronically and progressively, and a chronic low-grade inflammatory state is a characteristic of chronic kidney disease. A pro-inflammatory diet will accelerate the development of chronic kidney disease ^[22], and old age is one of its risk factors ^[23]. Diet is an important regulator of body inflammation. Older patients with chronic kidney disease should focus on maintaining an anti-inflammatory diet.

4.3.2. DII and diabetes

Liu ^[24] believed that the inflammatory response was related to diabetes, and Fu et al. ^[25] pointed out that DII was significantly related to pre-diabetes in older people. A meta-analysis ^[26] included 48 articles with a total sample size of 1,687,424 subjects. No significant association was observed between DII and the risk of type 2 diabetes mellitus (T2DM) (OR = 1.03, 95% CI: 0.9–1.15). This may be because different studies have differences in the research design, background diseases, types, and quantities of dietary components used to calculate DII, covariate adjustment levels, and most importantly, differences in study quality. However, the theory that diet-related inflammation may increase the risk of T2DM is consistent with the findings of Motamedi et al. ^[26]. In the stratified analysis of dietary assessment tools, background diseases, and participant gender, DII was not significantly associated with T2DM. Diabetes is a chronic disease that requires tight control of blood sugar levels. Diet control is crucial for blood sugar management. Overweight and central obesity are risk factors for prediabetes in older people ^[24]. This may be related to obesity stimulating the body's inflammatory response. DII can be used to provide dietary guidance for older people to reduce the intake of pro-inflammatory foods and prevent obesity and diabetes. Timely intervention is required for older people with pre-diabetes to avoid the progression of the disease.

4.3.3. DII and non-alcoholic fatty liver disease

Moradi et al. ^[27] studied 20,643 adults in the United States with an average age of 47.3 years old. There was a significant correlation between increased DII scores and the occurrence of non-alcoholic fatty liver disease. Wang et al. ^[28] used a cross-sectional study to analyze the clinical data of 468 elderly and reached the same conclusion. Dietary patterns are the main cause of non-alcoholic fatty liver disease in older people. An Italian prospective study ^[29] showed that the Mediterranean diet benefits in combating non-alcoholic fatty liver disease. Combined with antioxidants, this diet promotes lipid metabolism and reduces the risk of non-alcoholic fatty liver disease. Adhering to the Mediterranean diet, exercising, and maintaining good lifestyle habits are crucial in preventing and treating non-alcoholic fatty liver disease.

4.3.4. DII and atherosclerotic disease

A study ^[30] based in South Korea studied the association between cardiovascular disease and DII in the Seventh Korean National Health and Nutrition Examination Survey. The results showed that within 10 years, elevated DII scores in Korean men were associated with atherosclerotic-related risk of cardiovascular disease. Mazidi et al. ^[31] studied the relationship between DII and the risk of cardiometabolic diseases in American adults and came to the same conclusion. Shivappa et al. ^[32] showed through a meta-analysis that individuals in the highest and lowest DII categories showed a 95% increase in the risk of cardiovascular disease morbidity and mortality. For every one-point increase in DII score, the risk of cardiovascular disease and mortality increased by 8%. Cardiovascular disease is the main cause of death in older people ^[33], and a high pro-inflammatory diet will increase the risk of carotid atherosclerotic plaque formation and accelerate the stenosis of the carotid arteries ^[34]. The incidence of coronary atherosclerotic disease is relatively high among middle-aged and older people, and dietary factors are the main risk factors for atherosclerotic disease ^[33]. DII can be used as a tool to predict the occurrence and mortality rate of cardiovascular disease. By using the DII, people can be guided to have a healthier diet and follow anti-inflammatory diets to offset the effects of pro-inflammatory diets. The inflammatory response produced by the body can prevent and alleviate atherosclerotic diseases, thus reducing the risk of cardiovascular diseases.

4.3.5. DII and cancer

Current studies ^[35] have proven that DII was significantly positively correlated with cancer such as digestive tract cancer, prostate cancer, lung cancer, bladder cancer, and colorectal cancer. A meta-analysis by Syed et al. ^[36] on the relationship between DII and colorectal cancer showed that for every one-point increase in DII score, the risk of colorectal cancer increased by 1.34 times. Ryu et al. ^[37] investigated the relationship between DII and overall cancer development risk in a large cohort study representing the general Korean population. The follow-up study was conducted for 7.9 years. The results showed that a higher DII score was associated with a higher risk of cancer in the Korean population. In a meta-analysis, Zhai et al. ^[38] pointed out that for every one-unit increase in DII, the risk of upper gastrointestinal tumors increased by 53%. Li et al. ^[39] showed that women in the highest DII category have a risk of reproductive system cancer that is 1.34 times higher than that of individuals in the lowest category. Currently, cancer poses a significant threat to human life, with the older bearing a high incidence of cancer ^[40]. There are many studies on the relationship between DII and cancer. Cancer is a disease mediated by an inflammatory response. A high pro-inflammatory diet will increase the risk of cancer. DII can be used as a tool to assess cancer risk, which also provides new ideas for cancer prevention and treatment. Reasonable dietary guidance is particularly important for people at high risk of cancer.

4.3.6. DII and geriatric frailty syndrome

Li et al. ^[41] investigated the relationship between DII and frailty in 162 hospitalized elderly patients. The results showed that age and dietary inflammation index were independent influencing factors of frailty. The greater the age (OR = 1.235, 95% CI: 1.155–1.473), the greater the DII, and the greater the risk of frailty (OR = 3.947, 95% CI: 1.074–14.512). Geriatric frailty syndrome is a clinical syndrome in which patients have increased vulnerability to adverse outcomes due to the decline in the reserved functions of various physiological systems of the body. This increases the vulnerability of the body and reduces the patient's ability to resist stress and maintain a steady state ^[42]. As China's population continues to age at a fast rate, the number of middle-aged and older people suffering from frailty syndrome continues to increase. The prevalence of frailty syndrome among people over 65 years old in Chinese communities is about 10% ^[43]. However, this can be reduced through correct dietary guidance.

5. Summary and outlook

Diet plays a key role in the regulation of inflammation. A long-term pro-inflammatory diet will increase the serum levels of inflammatory markers such as C-reactive protein, interleukin-1, and interleukin-6. One of the common risk factors for diseases related to older people is the excessive intake of a pro-inflammatory diet, which causes the accumulation of inflammatory substances in the body. Physiological changes caused by aging further aggravate the occurrence and development of the disease. In the future, suitable evaluation methods for older people can be developed. A tool for assessing the inflammatory potential of the human diet can be established. The pathogenesis of diseases that have been proven by research, such as cancer, cardiovascular disease, and chronic kidney disease, are all related to chronic inflammatory responses. However, the later effects of DII on elderly patients with T2DM have not yet been clarified. Further research is needed to determine whether a diet targeting DII components can clinically reduce the development of T2DM. Most research on DII and related diseases is based on cross-sectional studies. Research findings at a certain point in time may change as time goes by, and the research subjects themselves may change as well. Hence, the causal relationship of the research questions cannot be defined. More clinical studies are needed to prove whether all chronic inflammation response-mediated diseases can be alleviated and prevented through the adherence to an anti-inflammatory diet. In addition, China's population characteristics differ from those of other countries. The relationship between DII and certain diseases, such as DII and cognitive impairment in older people, chronic kidney disease, etc., needs to be further verified in the Chinese population.

Understanding the disease mechanisms from a dietary perspective can provide breakthrough directions for future disease prevention and control. By focusing on primary and secondary prevention, the dietary structures of older people should be improved to form dietary habits based on the Mediterranean diet and provide dietary guidance for the future development of healthy aging strategies. With the improvement of people's living standards, most daily delicacies use flavorings to stimulate people's taste buds but contain high sugar, salt, fat, and calories. It is necessary to address the enhancement of dietary structures in the face of such temptations.

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Disclosure statement

The authors declare no conflict of interest.

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