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The Application of Mediterranean Diet in Common Diseases during Adolescence

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Abstract. Adolescence marks a phase of drastic physiological and psychological transformations in individuals, characterized by the development of secondary sexual characteristics, significant hormone fluctuations, a heightened sense of independence, and shifts in social roles. This period is often plagued by health issues such as acne, obesity, and depression, which can profoundly impact adolescents' quality of life and future prospects. Given the potential drawbacks of traditional pharmacological treatments, including side effects, poor adherence, and high costs, it is imperative to seek out safe, effective, and easily incorporable supplementary or preventive strategies for daily life. This article delves into the mechanisms and clinical evidence supporting the Mediterranean diet pattern (centered around olive oil, fruits, vegetables, whole grains, and fish) in mitigating acne severity, tackling obesity and its metabolic complications, and alleviating depressive symptoms. Research has shown that the Mediterranean diet exerts a synergistic protective effect on common adolescent ailments through various pathways, including modulating the insulin/IGF-1 signaling pathway, enhancing lipid metabolism, decreasing systemic chronic inflammation, and optimizing gut microbiota composition. Moreover, it encapsulates the essence of sustainable healthy living and offers a pivotal pathway for the comprehensive management of adolescent conditions.

Keywords: Adolescence, Mediterranean diet pattern, acne, obesity, depression

1. Introduction

Adolescence marks a pivotal transition from childhood to adulthood, accompanied by profound changes in physiology, psychology, and social roles. Prior publications in the Lancet have advocated for broadening the definition of adolescence from the conventional 10-19 years to encompass the span of 10-24 years. During this vital phase, the endocrine system becomes highly active, with marked fluctuations in hormone levels, rendering adolescents vulnerable to a multitude of health concerns [1,2]. Acne, a prevalent skin condition, affects over 80% of adolescents worldwide. Beyond impacting appearance, it often triggers psychological burdens such as feelings of inferiority and social withdrawal [3]. The prevalence of obesity among adolescents globally is on a steady increase. Obesity not only elevates the risk of chronic diseases in adulthood but is also intricately linked to metabolic syndrome, skeletal issues, and psychological distress during adolescence.

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Furthermore, the recognition and incidence of depression among adolescents are escalating, emerging as one of the primary causes of morbidity and disability among adolescents globally.

These diseases are interrelated, and their occurrence and development are associated with multiple factors. Diet, as a highly malleable fundamental lifestyle factor, plays a crucial role in management of the common diseases during adolescence. However, modern dietary patterns (high in processed foods, high in sugar, high in saturated fats, and low in fiber) are prevalent, exacerbating the aforementioned health issues.

The Lancet-related article points out that in recent years, multiple scientific publications have been mentioning the concept of "gut health", aiming to call attention to dietary components that may affect human health. By recognizing and learning about dietary patterns beneficial to one's own health, people can prevent or improve certain diseases. The Mediterranean Diet (MD) has increasingly garnered academic attention due to the rich anti-inflammatory and the antioxidant properties, as well as its positive impact on metabolic health. It has become a potentially powerful weapon in addressing the health challenges of adolescence.

This article focuses on the potential and scientific basis of the Mediterranean diet in addressing three common health issues during adolescence: acne, obesity and depression. By examining its mechanisms of action and evaluating existing clinical evidence, it aims to provide theoretical references and practical guidance for optimizing adolescent health management and developing evidence-based nutritional and lifestyle intervention strategies.

2. Mediterranean Diet (MD)

MD, initially proposed by Key in the 1980s, is a classic healthy dietary pattern.

2.1. Olive oil

MD advocates olive oil as a cooking oil. It is a natural, cold-pressed vegetable oil that has not undergone chemical treatment. It is rich in vitamins and various trace elements, making it highly nutritious. The body can digest and absorb up to 98.4% of olive oil, making it known as the "ideal vegetable oil of the 21st century". Extra-virgin olive oil (EVOO), which has not undergone chemical treatment or processing, is a key source of unsaturated fatty acids such as docosahexaenoic acid (DHA) and arachidonic acid (AA). The intake of unsaturated fatty acids stabilizes the gut microbiota and increases the abundance of beneficial bacterial genera such as Acinetobacter and Bifidobacterium. At the same time, the phenolic compounds (OOPCs) in olive oil also enhance the diversity of certain gut bacteria beneficial to the human body [4-6].

2.2. Cereals, fruits and vegetables

Dietary fiber is a recognized nutrient beneficial to human health. Numerous studies have demonstrated that dietary fiber is of great significance to gastrointestinal health by regulating intestinal microbial flora. Another difference between MD and traditional diets lies in the extensive use of whole grains. Whole grains are rich in dietary fiber, which can reduce glycemic load and improve insulin sensitivity. Similar to other diets, MD recommends a high intake of fruits and vegetables to increase dietary fiber, reduce total calorie intake, and provide the body with sufficient trace elements. For instance, many wild yeast strains often prefer to adhere to the surfaces of the fruits and vegetables. Regular consumption of fruits and vegetables that have undergone simple processing can effectively help the human gut acquire yeast flora [7].

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2.3. Seafood and nuts

Seafood and nuts, which are primarily seafood and seafood products in the main side dishes of MD, are widely used. Seafood not only supplements rich high-quality protein but also contains a large amount of long-chain N-3 fatty acids, which exert anti-inflammatory and antioxidant effects. Other studies have found that individuals with higher nut intake have significantly higher levels of vitamins, folic acid, calcium, magnesium, and other trace elements compared to those with lower nut intake, and also have higher adherence to MD [4-6].

2.4. Other

MD recommends consuming moderate amounts of dairy products (primarily yogurt and cheese) daily. If milk is used, it is best to primarily consume skim milk. Additionally, MD recommends consuming moderate amounts of eggs weekly, as compared to other types of high-quality protein, eggs are relatively less expensive. For those who enjoy drinking alcohol, it is important to adhere to the principle of moderate consumption of wine, which is ≤150 ml/d for women and men aged >65 years, and ≤300 ml/d for men. Wine contains a large amount of polyphenols, which have antioxidant and antibacterial effects [6].

3. Application of MD in adolescent acne

Acne is a relatively common skin problem among adolescents, typically appearing on the cheeks, forehead, or back. According to the latest epidemiological survey, its prevalence has risen from 8563.4 cases per 100,000 people in 1990 to 9790.5 cases per 100,000 people in 2021 [8]. Various factors may contribute to the development of acne during adolescence, such as genetic factors, changes in hormone levels, unhealthy lifestyle habits, and environmental factors. If both or one of the parents have experienced acne during adolescence, the risk of their children developing acne will increase. This due to genetic factors may determine, to some extent, an individual's sensitivity to hormonal changes and the activity level of the sebaceous glands.

The core driving factor is the increase in androgen levels during puberty. Hormonal fluctuations are significant during puberty, especially the increase in androgens, which promote hair growth and oil secretion from sebaceous glands. Abnormalities in androgen receptors can also lead to increased sebum secretion. When these sebum mix with dust and dead skin cells on the skin surface, they form keratin plugs, which block the hair follicle opening and cause acne. When the environment inside the hair follicle becomes conducive to the growth of bacteria (especially Propionibacterium acne), inflammation is triggered, leading to the formation of acne. Elevated levels of the insulin and the insulin-like growth factor-1 (IGF-1) can indirectly promote androgen synthesis, enhance the sensitivity of sebaceous gland cells to androgens, and promote the proliferation of keratinocytes. Factors such as staying up late, experiencing significant mood swings, and lack of exercise may disrupt the normal function of the endocrine system, leading to hormonal secretion imbalances and exacerbating acne. Meanwhile, excessive intake of high-sugar, high-fat, and spicy foods can also stimulate abnormal secretion from sebaceous glands, promoting the formation of acne [9,10].

A case-control observational study conducted in France included 40 acne patients with moderate to severe (average age 19.75) and 40 healthy controls. MD compliance was assessed using the PREDIMED questionnaire. The results showed that among acne patients, MD compliance was significantly negatively correlated with GEA score (Spearman correlation coefficient P=0.047). The reason may be attributed to the rich content of olive oil, fruits, vegetables, etc. in MD, which are rich

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in unsaturated fatty acids and polyphenols, and can alleviate acne through anti-inflammatory mechanisms, supporting the overall strategy of acne management. It is worth noting that moderate red wine is recommended in MD, but in this study, drinking >7 glasses per week was significantly associated with increased acne severity. Therefore, it is necessary to reduce red wine intake [11].

In another clinical study, 35 acne patients aged 14-30 were enrolled and divided into a MD group (≥6 points, 27 cases) and a Western Diet (WD) group (<5 points, 8 cases) based on 14 questionnaire scores. A group of 15 healthy individuals served as controls. The study explored the impact of MD on the pathogenesis of acne and its association with serum IGF-1 levels. It shows that IGF-1 levels in acne patients were significantly higher than those in healthy controls (P=0.05), and the IGF-1 levels in the WD group were significantly higher (350.5 vs. 270.9 ng/mL, P=0.027). MD, which is rich in antioxidants (such as polyphenols and resveratrol in olive oil), has a low glycemic index, may exert a protective effect by inhibiting the IGF-1 pathway [10].

A study exploring the effects of ω-3 FA on acne patients found that 98.3% of patients were deficient in EPA/DHA at baseline (mean HS-Omega3 index was 4.9%), and the index significantly increased to 8.3% after intervention ($p<0.001$). The severity of acne improved (the proportion of comedo-type acne increased from 38.3% to 79.2%), confirming that ω-3 supplementation combined with dietary adjustments can correct the deficiency state and improve acne, providing a new strategy for non-prescription drug treatment [12].

4. Application of MD in adolescent obesity

Adolescent obesity refers to the excessive accumulation of fat in the bodies of adolescents, resulting in a body mass exceeding 20% of the standard body mass. Currently, obesity has become one of the common nutritional disorders among adolescents. It not only poses a serious threat to the health of adolescents but also serves as an important risk factor for obesity, diabetes, atherosclerosis and other diseases in adulthood. There are some challenges in the treatment of adolescent obesity, such as the prohibition of most Western medical weight-loss drugs for adolescents. Secondly, for children with poor self-control, once obesity occurs, it is difficult to change their lifestyle and environment. Moreover, obesity is prone to recurrence. Therefore, it is urgent to prevent and control adolescent obesity.

The complications associated with obesity during adolescence emerge early and are severe, often persisting into the adulthood. They pose a significant threat to the health of adolescents and adults, severely impacting public health. The prevalence range 32% -37% [13].

Adolescent obesity is closely related to adipose tissue, insulin resistance, and hyperandrogenemia. Leptin not only participates in appetite regulation and energy expenditure but also controls puberty development. A clinical study explored the interaction between MD and obesity genetic risk score (obesity-GRS) on obesity and metabolic syndrome (MetS) in European adolescents (n=605). The results showed that high MD adherence could reduce BMI, but this was only effective when individuals carried fewer obesity risk alleles (51.1% of males with ≤22 alleles, 98.7% of females with ≤27 alleles). Among female high MD adherents, 95.2% (≤26 alleles) had lower MetS scores, while only 9.9% (≤18 alleles) of males benefited. There was a significant gender difference, with females being more sensitive to gene-diet interaction. MD adherence had a significant interaction effect with obesity-GRS ($p<0.05$), but the protective effect was only evident under specific genetic backgrounds [14].

A study that included 15 RCTs with 7184 children or adolescents aged ≤18 years (MD group=3828, control group=3356) observed the effects of MD. The results showed that MD significantly reduced BMI (-14%) and the percentage of obese patients (including the abdominal

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obesity) [15]. A meta-analysis, incorporating six studies, revealed that participants with higher adherence to MD had a reduced BMI compared to those with the lower adherence (MD=0.33 kg/m^2) [16].

Plant-based foods represented by fruits and vegetables are renowned for the high volume and low-calorie density. Compared with the smaller-sized foods, consuming such food usually requires a longer eating time. This process may prolong the meal duration, promote the formation of a feeling of fullness, and help reduce total energy intake. The core components of MD are generally rich in dietary fiber, have high nutritional density but low energy density, and their intake is associated with a reduction in energy intake. In addition, specific bioactive compounds commonly found in MD have been proven to have the function of regulating and maintaining a healthy intestinal microbiota. These compounds can also enhance the integrity of intestinal barrier, which was often impaired in obese patients [17].

5. Application of MD in adolescent depression

Depression typically begins during adolescence. In recent years, the prevalence of adolescent depression has reached up to 25%, and it is on the rise, becoming the primary cause of morbidity and disability among adolescents. It has become one of the significant issues in global public health. Recent studies indicate that the lifetime prevalence of severe depression during adolescence is as high as 14%-20%. The etiology of depression is complex, involving genetic, neurobiological (such as monoamine neurotransmitter imbalance, HPA axis), environmental stress and also the psychosocial factors. Recent research reveals that chronic inflammation and the oxidative stress play a pivotal role in depression pathophysiology. For instance, elevated levels of pro-inflammatory factors can affect central nervous system function through the blood-brain barrier, while also increasing neurotoxic metabolites. Additionally, gut microbiota dysbiosis regulates neurotransmitter metabolism and immune responses via the "brain-gut axis," further contributing to the development of depression. A clinical study shows that modern dietary patterns and snack eating patterns are associated with depression among the Chinese adolescents. This underscores the importance of diet in the pathogenesis of adolescent depression [18-21].

Multiple studies have shown that MD may reduce the occurrence of depression during adolescence. A review involving 119 studies pointed out that adolescents adhering to the MD could reduce the risk of depression and alleviate its clinical symptoms [22]. The latest systematic review in 2025 shows that MD is a protective factor for mental health [23].

A one-year follow-up study in Greece involving 3,774 children OR adolescents with an average age of 7.8 years showed that for every 1-point increase in adherence to the MD pattern, the possibility of improvement in emotional function increased by 9% (OR=1.09,95%CI:1.02-1.17), and it could also enhance the overall quality of life. It is indicated that the impact of MD on adolescents can extend to the overall health level [24].

The reason might be that the olive oil advocated in the MD is rich in phenolic compounds with powerful anti-inflammatory and antioxidant activities. In addition, a rich intake of fruits and vegetables provides a large amount of non-nutrients such as flavonoids, saponins and carotene, all of which have strong antioxidant capabilities. At the same time, the high content of whole grains, legumes, fruits and vegetables provides rich dietary fiber, which is the main "food" for the beneficial bacteria in the intestines, helping to maintain a healthy intestinal microecology and thereby improving depression.

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6. Conclusion

The prevalence of acne, obesity and depression during adolescence poses a severe challenge to the current and future health of teenagers. The Mediterranean diet - centered on nutrient-rich plant-based foods, healthy fats (especially the olive oil and the fish), and whole grains - offers a highly promising solution to this challenge, such as reducing the severity of acne, lowering body mass index, and improving emotional state. However, research on the Mediterranean diet for common diseases during adolescence has made certain progress, but there are still deficiencies. It is no easy task to adhere to any dietary pattern for a long time, and the compliance of teenagers with the Mediterranean diet is not optimistic. Research on the Mediterranean diet for common diseases during adolescence is still in the initial exploration stage, and high-quality, long-term intervention studies targeting the adolescent population are still relatively insufficient. More well-designed large-scale studies are needed to provide more conclusive evidence. In the future, by building a health ecosystem that links "school - family - community - individual", MD can be transformed into operational and attractive daily practices, which is expected to significantly improve the quality of health during adolescence and lay a solid foundation for health in adulthood. Future research should focus on individualized program optimization, precise intervention and long-term benefit assessment, so that MD can radiate stronger vitality in promoting the health of adolescents in the new era.

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