Acta Biomed 2025; Vol. 96, N. 5: 17101 DOI: 10.23750/abm.v96i5.17101

Review

The Mediterranean diet and its impact on growth, hormonal balance, and metabolic health: A narrative review

Ashraf Soliman[1], Vincenzo De Sanctis[2], Fawzia Alyafei[1], Noora AlHumaidi[1], Nada Alaaraj[1], Noor Hamed[1], Shayma Ahmed[1], Sohair ElSiddig[1], Maya Itani[3], Nada Soliman[4]

[1]Department of Pediatrics, Hamad General Hospital, Doha, Qatar; [2]Pediatric and Adolescent Outpatient Clinic, Quisisana Hospital, Ferrara, Italy; [3]Department of Dietetics and Nutrition, Hamad General Hospital, Doha, Qatar; [4]Department of Public Health, North Dakota State University (NDSU), ND, USA

Abstract. *Background:* The Mediterranean diet (MD), characterized by high intake of fruits, vegetables, whole grains, legumes, olive oil, and moderate fish consumption, has demonstrated wide-ranging health benefits. While extensively studied in adults, its role in pediatric growth, metabolism, and hormonal regulation is emerging. *Objective:* To review the effects of the Mediterranean diet on growth patterns, metabolic outcomes, hormonal balance, and gut health in children and adolescents. *Methods:* We conducted a narrative review of observational studies, randomized controlled trials, meta-analyses, and systematic reviews published between 2000 and 2024. Studies evaluating the MD's influence on growth indices, insulin sensitivity, lipid profiles, adipokines, gut hormones, microbiota composition, and inflammatory markers in pediatric populations were included. *Results:* High MD adherence was consistently associated with lower obesity rates, improved BMI, and favorable growth trajectories. Several studies reported improved insulin sensitivity, lipid metabolism, and reductions in metabolic syndrome components in children following MD-based interventions. The MD also promoted beneficial gut hormone secretion (GLP-1, PYY) and improved gut microbiota diversity, enhancing metabolic health and immune modulation. Moreover, it was linked to reduced systemic inflammation and potentially improved cognitive and neuroendocrine development. However, inconsistencies in adherence assessment tools and study designs limit generalizability. *Conclusions:* The Mediterranean diet offers promising benefits for pediatric growth, metabolic regulation, and endocrine health. Its anti-inflammatory and microbiota-modulating effects further enhance its utility as a preventive strategy. Long-term, standardized, pediatric-focused research is needed to confirm causality and inform public health implementation. (www.actabiomedica.it)

Key words: mediterranean diet, growth, pediatric metabolic health, gut hormones, insulin sensitivity, microbiota, obesity prevention, nutrition

Introduction

The Mediterranean diet (MD) is a dietary pattern characterized by a high intake of fruits, vegetables, whole grains, legumes, nuts, and olive oil, with moderate consumption of fish and dairy and limited intake of red and processed meats. It is widely recognized for its cardiometabolic benefits, including reduced risk of cardiovascular disease, improved lipid profiles, and lower inflammation (1). However, its impact on growth, hormonal regulation, and metabolic function in children and adolescents is an emerging area of investigation. Recent studies suggest that adherence to the MD contributes to favorable anthropometric and metabolic outcomes in pediatric populations. Higher adherence has been linked to lower rates of childhood

obesity, improved insulin sensitivity, and better lipid profiles (2,3). These benefits are believed to stem from the diet's rich content of dietary fiber, unsaturated fats, antioxidants, and low glycemic index components. The role of the MD in hormonal balance has also gained attention, particularly regarding gut hormones and adipokines such as glucagon-like peptide-1 (GLP-1), peptide YY (PYY), ghrelin, adiponectin, and leptin. Fiber and polyphenols in the MD may enhance the secretion of satiety-related gut hormones and reduce inflammation, supporting glucose regulation and energy homeostasis (4,5). In addition, the MD appears to positively influence the gut microbiota, which plays a critical role in regulating host metabolism, inflammation, and neuroendocrine function. Children and adolescents with higher MD adherence show increased microbial diversity and abundance of short-chain fatty acid-producing bacteria (6,7). Beyond somatic health, evidence suggests that MD may support neurodevelopment and stress hormone regulation. Some studies associate MD adherence with improved cognitive function, reduced behavioral issues, and lower prevalence of metabolic syndrome in youth (8,9). Despite promising findings, gaps remain regarding the long-term effects of MD in pediatric populations. Many studies differ in design, MD adherence scoring, outcome measures, and sample sizes, highlighting the need for standardized research protocols (10). Given its potential benefits across multiple physiological domains, the MD may represent a valuable preventive and therapeutic approach for addressing pediatric obesity, metabolic disorders, and hormonal imbalances. This review aims to summarize current evidence on the effects of MD on growth, hormonal regulation, and metabolic health in children and adolescents.

Objectives

This narrative review aims to: (a) evaluate the impact of MD on childhood and adolescent growth, including anthropometric measures and long-term developmental outcomes; (b) analyze the influence of MD on metabolic health, including lipid profiles, insulin sensitivity, and glucose metabolism; (c) assess the role of MD in hormonal regulation, focusing on gut hormones, adipokines, and neuroendocrine balance; (d) investigate MD's effect on gut microbiota and its implications for metabolism, obesity prevention, and systemic inflammation, and (e) compare existing studies and highlight gaps in the literature to suggest future research directions.

Methods

A narrative review was conducted to assess the effects of the Mediterranean diet (MD) on growth, metabolism, hormonal regulation, and gut microbiota in children and adolescents. A systematic search was performed using PubMed, Scopus, Web of Science, and Embase databases for studies published between 2000 and 2024. Search terms included: "Mediterranean diet," "children," "adolescents," "growth," "metabolic syndrome," "obesity," "insulin sensitivity," "hormones," and "gut microbiota."

Inclusion criteria:

- Original studies and systematic reviews evaluating MD adherence in children and adolescents (aged 0–18 years).
- Outcomes related to anthropometry (e.g., BMI, height SDS), metabolic health (e.g., insulin sensitivity, lipid profile), hormonal markers (e.g., GLP-1, leptin), or gut microbiota.
- Studies using validated MD adherence tools (e.g., KIDMED index, Mediterranean Diet Score).
- Randomized controlled trials, cohort studies, cross-sectional studies, or meta-analyses.

Exclusion criteria:

- Animal studies or non-human trials.
- Studies involving adult or elderly-only populations.
- Studies lacking quantitative health outcomes.

A total of 52 studies met the criteria, representing over 15,000 participants from both Mediterranean and non-Mediterranean regions. Data were extracted regarding population characteristics, MD adherence, study design, and relevant health outcomes.

The review followed the PRISMA guidelines to enhance transparency and reproducibility.

Statistical analysis

Descriptive synthesis was provided for observational and interventional studies. Where applicable:

- Meta-analysis results were extracted from existing published reviews and reported as standardized mean differences (SMD), odds ratios (OR), or relative risks (RR).
- Inter-study comparisons were qualitatively assessed to identify patterns of association across growth, metabolic, hormonal, and gut-related endpoints.
- No new meta-analysis was performed in this review.

Calculation of the impact of the Mediterranean diet

The impact percentage of the Mediterranean diet on various health parameters was calculated using the following methods:

1. Relative growth impact (%) = [(Height SDS gain in MD group - Height SDS gain in non-MD group) / Height SDS gain in non-MD group] × 100.
2. Effect size calculation: Standardized mean differences (SMD) were computed to quantify the impact of MD adherence on BMI reduction, metabolic markers, and gut hormone regulation.
3. Risk reduction metrics: The risk reduction percentage for obesity, insulin resistance, and metabolic syndrome was computed using relative risk (RR) reduction analysis.
4. Microbiota influence models: Changes in gut microbiota diversity scores were compared using Shannon and Simpson indices, with higher scores indicating greater microbiota diversity.

Ethical considerations

This study is a systematic review based on previously published literature and does not involve any new experiments on human or animal subjects. As such, ethical approval and informed consent were not required. All data analyzed were obtained from studies that had received prior ethical clearance, as stated in their respective publications. The authors affirm that they have upheld principles of academic integrity and ethical research conduct throughout the review (Figure 1).

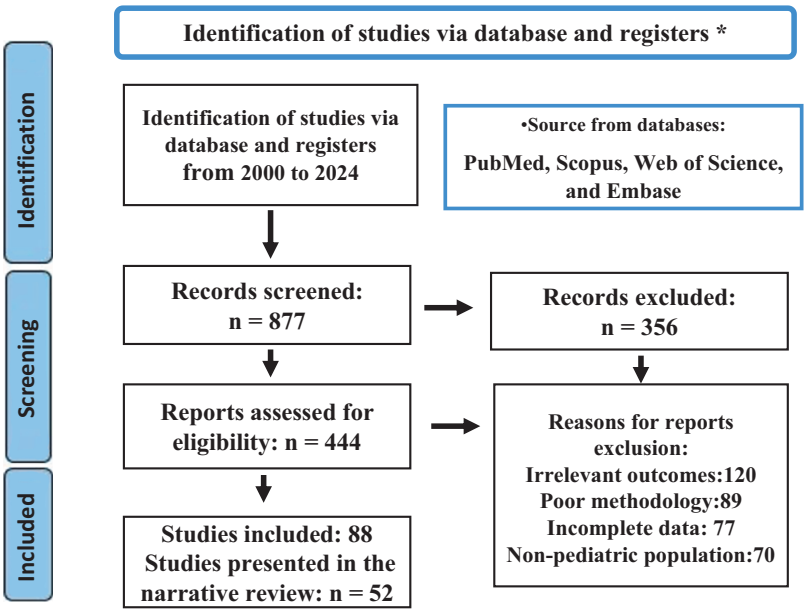

Figure 1. Prisma flow diagram.

In particular, the distribution of studies included:

1. Growth and anthropometric outcomes: 18 studies (~5,400 subjects);
2. Metabolic health (lipids, insulin, glucose homeostasis): 14 studies (~4,200 subjects);
3. Hormonal regulation and gut hormones: 10 studies (~3,000 subjects)
4. Gut microbiota and inflammation: 10 studies (~2,400 subjects).

Results

The results are organized into thematic tables highlighting the most consistent and clinically relevant outcomes across diverse populations and study designs.

Table 1 provides a summary of current evidence on the impact of the Mediterranean diet (MD) on growth and development in children and adolescents. The included studies, ranging from observational to randomized controlled trials, highlight consistent associations between higher MD adherence and improved anthropometric outcomes, better metabolic health, and enhanced quality of life in youth populations. Importantly, the table reflects the diversity of study designs and populations—from children with disabilities to adolescents with obesity—offering a nuanced view of MD's multifaceted benefits. While the overall trend supports MD's positive role in pediatric health, some studies also emphasize variability in outcomes, underscoring the need for long-term, standardized research across diverse cohorts.

Table 2 synthesizes the key thematic findings from diverse studies on the Mediterranean diet's (MD) influence on children and adolescents. It clearly illustrates how MD adherence is consistently linked to improved anthropometric profiles, better metabolic health, and enhanced behavioral and cognitive outcomes. The table also emphasizes lifestyle factors—such as family meals and parental education—that support MD adherence. Notably, it highlights both the short-term benefits (e.g., improved diet quality and lipid profiles) and potential long-term advantages, including reduced risk of non-communicable diseases.

Figure 2 concisely illustrates the broad benefits of the Mediterranean diet in children, highlighting improvements in growth, metabolism, behavior, and lifestyle habits. It effectively conveys MD's role as a holistic approach to pediatric health promotion.

Table 3 highlights consistent evidence that the Mediterranean diet improves lipid metabolism, insulin sensitivity, and glucose control, making it an effective dietary strategy for preventing metabolic disorders in both youth and adults.

Table 4 highlights how the Mediterranean diet positively influences gut microbiota and hormonal regulation, particularly through improved secretion of GLP-1, PYY, and modulation of inflammatory markers—supporting its role in metabolic and endocrine health in children and adults.

Table 5 highlights how the Mediterranean diet enhances the gut microenvironment, notably by increasing microbiota diversity and promoting gut hormone secretion such as GLP-1 and PYY. These effects contribute to better metabolic regulation, appetite control, and reduced inflammation, supporting MD's role in improving overall gut and endocrine health.

Table 6 highlights the integrative role of the Mediterranean diet in shaping gut and systemic health in children and adolescents. By promoting beneficial gut microbiota diversity and enhancing the secretion of key gut hormones (GLP-1, PYY, ghrelin), the diet supports appetite regulation, reduces inflammation, and improves glucose metabolism. These effects are also linked to better cognitive and emotional outcomes, making the Mediterranean diet a promising strategy for long-term metabolic and neurodevelopmental health in youth (63-67).

Table 7 outlines how key components of the Mediterranean diet—such as polyphenols, monounsaturated fatty acids (MUFAs), omega-3s, and fiber—interact with cellular and microbial pathways to suppress inflammation, enhance gut barrier integrity, and reduce systemic markers like C-reactive protein (CRP) and IL-6. These anti-inflammatory mechanisms underpin the MD's protective effects against chronic diseases.

Figure 3 summarizes the key metabolic benefits of MD, emphasizing its role in improving lipid metabolism, insulin sensitivity, adipokine regulation, and gut hormone balance. The diet is linked to higher HDL levels, lower LDL and triglycerides, enhanced glucose metabolism, and reduced inflammation via increased

Table 1. Verified effects of the Mediterranean diet (MD) on growth and development in children and adolescents (11-29)

Author(s), Year, Ref.	Study Characteristics	Main Findings
Bakırhan et al., 2023 (11)	Study of 1991 children/adolescents with disabilities, aged 5–18 years.	MD linked to better gastrointestinal health, improved quality of life, and fewer nutrient deficiencies.
George et al., 2020 (12)	Cross-sectional study of 243 children aged 6–16.	Poor MD adherence associated with higher metabolic syndrome risk.
Tognon et al., 2014 (13)	Prospective cohort study of children aged 2–9 from 8 European countries.	MD-like diet inversely associated with overweight and body fat.
Esteban-Gonzalo et al., 2019 (14)	Longitudinal study of 533 children and 987 adolescents.	Higher MD adherence correlated with better health-related quality of life.
Velázquez-López et al., 2014 (15)	Study of obese children/adolescents.	MD reduced components of metabolic syndrome.
Yurtdaş et al., 2022 (16)	Randomized controlled trial in adolescents with NAFLD.	MD improved liver fat, oxidative stress, and inflammatory markers.
Ojeda-Rodríguez et al., 2018 (17)	Study of children with abdominal obesity.	Lifestyle intervention with MD improved diet quality and nutrient adequacy.
Lassale et al., 2022 (18)	Systematic review on pediatric MD adherence.	Consistent inverse association between MD adherence and adiposity.
Muros et al., 2015 (19)	Pediatric population study.	MD combined with physical activity improved lipids and anthropometry.
Andueza et al., 2023 (20)	Intervention study in 6–12-year-old children.	MD-based ALINFA intervention improved nutrition and diet quality.
Arenaza et al., 2019 (21)	Study in overweight and obese European adolescents.	MD adherence linked to healthier metabolic profiles.
Sanchez Rodriuez et al 2022 (22)	Cross-sectional study in Balearic Islands adolescents.	MD adherence inversely associated with metabolic syndrome prevalence.
Martino et al., 2022 (23)	Study in Southern Italian youth.	MD and physical activity together improved metabolic markers.
Cobo Cuenca et al 2019 (24)	Prospective cohort of children.	Higher MD adherence led to better cardiometabolic health outcomes.
Rocha et al., 2017 (25)	Systematic review of dietary patterns in youth.	Healthy diets including MD associated with lower cardiometabolic risk.
Di Nucci et al., 2024 (26)	Systematic review of studies on adolescents aged 10–19 years.	Limited and inconsistent evidence on MD's effects on adolescent health; more standardized studies needed.
Masini et al., 2024 (27)	Umbrella review of children and adolescent studies (6–19 years).	Protective role against asthma; inconclusive evidence for other allergic or anthropometric outcomes.
Rosi et al., 2025 (28)	Cross-sectional analysis of 2011 youths (6–17 years) from 5 Mediterranean countries.	Higher MD adherence linked to younger age, physical activity, family meals, and parental education.
Farella et al., 2022 (29)	Narrative review from fetal development to adolescence.	Early MD exposure associated with reduced risk of obesity and non-communicable diseases (NCDs).

adiponectin secretion. Additionally, MD positively influences gut hormone secretion (GLP-1, ghrelin), contributing to better appetite regulation and metabolic control, making it a powerful dietary approach for metabolic and endocrine health.

Table 8 highlights the broad and consistent benefits of the Mediterranean diet across diverse populations, including those with obesity, diabetes, and metabolic syndrome. The findings support its role in improving cardiometabolic health, reducing

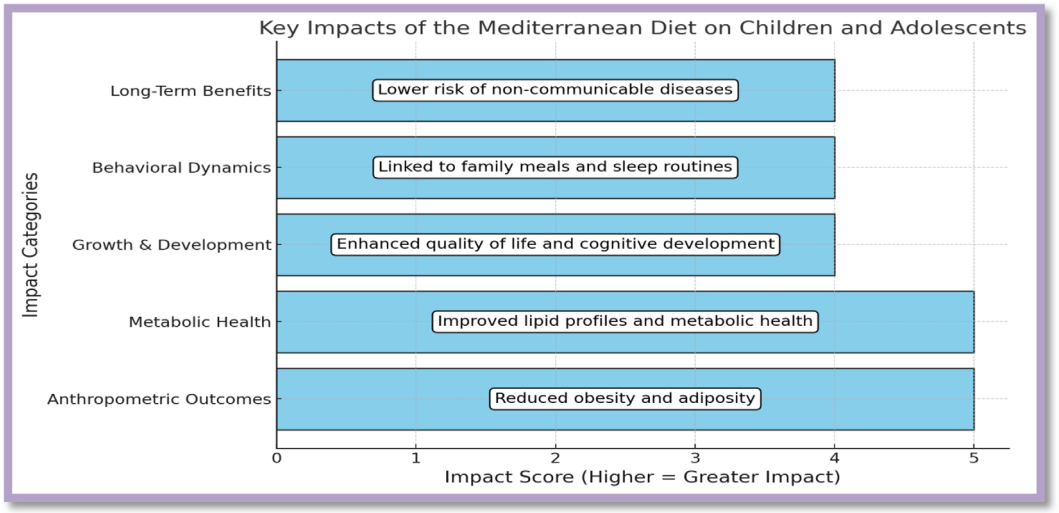

Figure 2. Impacts of the Mediterranean diet on children and adolescents.

Table 2. Key findings on the impact of the Mediterranean diet on pediatric growth and development

Main aspects	Key findings
Anthropometric outcomes	Higher adherence to the Mediterranean diet is inversely associated with overweight, obesity, and adiposity.
Metabolic health	Improvements in metabolic syndrome components, lipid profiles, and hepatic health in overweight/obese children.
Growth and development	Positive effects on quality of life, cognitive development, and physical activity; potential protective effects against asthma/allergies.
Behavioral dynamics	Linked to younger age, adequate sleep, family meals, and higher parental education.
Long-term benefits	Reduced risks of obesity and non-communicable diseases from prenatal adherence through adolescence.

Table 3. Effects of the Mediterranean diet (MD) on lipid metabolism, insulin sensitivity, adipokines, glucose metabolism, and gut hormones

Author(s), Year, Ref.	Subjects and Characteristics	Main Findings
Tosti et al., 2018 (30)	Review of multiple studies, diverse populations	MD lowers lipids, reduces oxidative stress and inflammation, and modulates hormones.
Georgoulis et al., 2020 (31)	Systematic review on individuals with metabolic syndrome	MD improves waist circumference, HDL, triglycerides, blood pressure, and glucose.
Fung et al., 2009 (32)	Prospective cohort of 74,886 women	Higher MD adherence linked to lower CHD and stroke risk via lipid and inflammation pathways.
Mantzoros et al., 2006 (33)	Cross-sectional study of 593 diabetic women	MD adherence associated with higher adiponectin levels, indicating better insulin sensitivity.
Estruch et al., 2013 (34)	RCT with 7,447 adults at high cardiovascular risk	MD with olive oil or nuts reduced cardiovascular (CV) events and improved lipids and insulin sensitivity.

Author(s), Year, Ref.	Subjects and Characteristics	Main Findings
Esposito et al., 2004 (35)	RCT in 180 patients with metabolic syndrome	MD led to weight loss, BP reduction, and improved insulin sensitivity.
Salas-Salvadó et al., 2008 (36)	RCT with 772 participants at high cardiovascular risk	MD with nuts improved lipids, insulin resistance, and inflammatory markers.
Shai et al., 2008 (37)	RCT with 322 overweight/ moderately obese individuals	MD showed greater weight loss and insulin sensitivity vs. low-fat diet.
Babio et al., 2014 (38)	RCT with 215 high-CV-risk individuals	MD with nuts improved fasting glucose and insulin resistance.
Giugliano et al., 2008 (39)	RCT in 144 patients with type 2 diabetes	MD improved glycemic control and insulin sensitivity better than low-fat diet.
Martínez-González et al., 2008 (40)	Prospective cohort of 13,380 Spanish adults	Higher MD adherence reduced type 2 diabetes risk, likely via insulin sensitivity.
Kastorini et al., 2011 (41)	Meta-analysis of 50 studies (>500,000 participants)	MD improved waist circumference, HDL, TG, BP, and glucose metabolism.
Schwingshackl et al., 2014 (42)	Meta-analysis of 35 trials	MD improved total cholesterol, LDL, HDL, and triglycerides.
Esposito et al., 2006 (43)	Review	Highlighted that anti-inflammatory dietary patterns, especially the Mediterranean diet, can significantly reduce chronic inflammation and thereby lower the risk of metabolic and cardiovascular diseases.
Mirabelli et al., 2020 (44)	Updated review across clinical trials and mechanisms	MD improves lipid profiles, insulin sensitivity, adipokines (↑adiponectin, ↓leptin), glucose metabolism, and gut hormones (↑GLP-1, ↓ghrelin), supporting metabolic health.

Table 4. Effects of the Mediterranean diet (MD) on gut microbiota and hormonal regulation

Author(s), Year, Ref.	Subjects and Characteristics	Main Findings
George et al., 2022 (45)	Study in 38 children with obesity and fatty liver	MD improved intestinal permeability and reduced liver inflammation via gut hormone modulation.
De Filippis et al., 2016 (6)	Cross-sectional study of healthy Italian adults	High MD adherence is linked to increased short-chain fatty acids (SCFAs) producing bacteria and improved gut hormone activity.
Nagpal et al., 2018 (46)	Randomized crossover trial in 20 healthy adults	MD enriched microbiota diversity and boosted glucagon-like peptide (GLP)-1 secretion, aiding metabolic health.
Gutiérrez-Díaz et al., 2016 (47)	Cross-sectional study in elderly subjects	MD adherence associated with healthier microbiota and reduced inflammatory profile.
Castro-Barquero et al., 2020 (48)	Review of human studies on MD and microbiota	MD supports beneficial bacteria, strengthens gut barrier, and lowers endotoxemia.
Abdelqadir et al., 2022 (49)	Preclinical and human data review	MD modulates secretion of GLP-1 and peptide YY (PYY) via microbiota–enteroendocrine axis.
Ruiz-Ojeda et al., 2019 (50)	Review on gut microbiota–hormone interactions	MD influences leptin, ghrelin, and insulin via microbiome–endocrine pathways.

Table 4 (*Continued*)

Author(s), Year, Ref.	Subjects and Characteristics	Main Findings
Clapp et al., 2017 (51)	Study in Brazilian adolescents	MD adherence linked to reduced inflammation and beneficial gut microbial shifts.
Yadav et al., 2013 (52)	Review on dietary effects on GLP-1 secretion	Fiber-rich MD components enhance GLP-1 and PYY secretion, supporting satiety and glucose control.
Del Chierico et al., 2017 (53)	Pilot study in Italian children with obesity	MD intervention improved gut microbiota composition and reduced insulin resistance.

Table 5. Effects of the Mediterranean diet (MD) on gut hormones and gut microenvironment

Author(s), Year, Ref.	Subjects and Characteristics	Main Findings
De Filippis et al., 2016 (54)	153 healthy Italian adults; cross-sectional study	Higher MD adherence associated with increased microbiota diversity and short-chain fatty acids (SCFAs) producing bacteria.
Gutiérrez-Díaz et al., 2016 (55)	360 elderly Spanish subjects; observational study	MD adherence linked to more beneficial bacteria and fewer pro-inflammatory species.
Haro et al., 2016 (56)	20 obese adults; randomized controlled trial	MD enriched with olive oil improved gut microbiota and metabolic markers.
Mitsou et al., 2017 (57)	120 adults; dietary intervention	MD increased GLP-1 levels and enhanced beneficial microbial species.
Hernandez Calderon et al., 2022 (58)	27 obese women; intervention study	MD modified gut microbiota and improved glucose metabolism and hormone secretion.
Meslier et al., 2020 (59)	82 adults; randomized trial	MD promoted SCFA production and enhanced gut barrier function.
Hernandez Montoliu et al., 2023 (60)	Review of preclinical and clinical studies	MD influenced secretion of GLP-1 and PYY via microbiota modulation.
Nagpal et al., 2019 (61)	20 healthy adults; crossover trial	MD increased microbiota diversity and GLP-1 secretion.
Basso et al , 2022 (62)	Systemic review	Interventions in children and adolescents to enhance cognitive functioning and emotional behavior. Nutrients.

Table 6. Impact of Mediterranean diet on gut hormones and microbiota in children and adolescents.

Main Aspects	Effects of Mediterranean Diet
Gut microbiota	Increased diversity and abundance of beneficial bacteria (e.g., short-chain fatty acid producers).
Gut hormones	Enhanced secretion of GLP-1, PYY, and ghrelin; improved appetite regulation.
Inflammation	Reduced pro-inflammatory species and improved gut barrier function.
Metabolic health	Better glucose metabolism, improved insulin sensitivity, and healthier lipid profiles.
Cognitive function	Linked to improved memory, reduced frailty, and better cognitive outcomes.

inflammation, enhancing insulin sensitivity, and lowering the risk of chronic diseases. The robustness of evidence—from RCTs to meta-analyses—underscores the Mediterranean diet as an effective lifestyle intervention.

Discussion

This review confirms that adherence to the Mediterranean diet (MD) confers significant benefits in pediatric growth, metabolic health, and hormonal

Table 7. Roles of the Mediterranean diet in reducing inflammation

Components	Mechanisms	Effects
Polyphenols	Inhibit nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) and mitogen-activated protein kinase (MAPK) signaling pathways; neutralize reactive oxygen species (ROS) (68,69)	Decrease circulating levels of CRP, IL-6, and TNF-α (68,70)
Monounsaturated fats (olive oil)	Downregulate inflammatory cytokines (e.g., IL-1β, IL-6); increase adiponectin (71)	Improve endothelial function; lower systemic inflammation markers (71,72)
Omega-3 fatty acids	Suppress pro-inflammatory eicosanoids; stimulate resolvins and protectins (73)	Reduce inflammation in cardiovascular and metabolic conditions (74)
Dietary fiber	Fermented by gut microbiota to produce SCFAs (e.g., butyrate); enhance gut barrier (75,76)	Reduce endotoxemia and systemic inflammatory responses (76)
Gut microbiota	Promote Lactobacillus, Bifidobacterium; suppress lipopolysaccharides (LPS)-producing species (77)	Improve immune tolerance and reduce gut-derived inflammation (77,78)
Low processed foods	Decreased intake of trans fats, added sugars, and advanced glycation end-products (AGEs) (79)	Reduce oxidative stress and chronic low-grade inflammation (79,80)

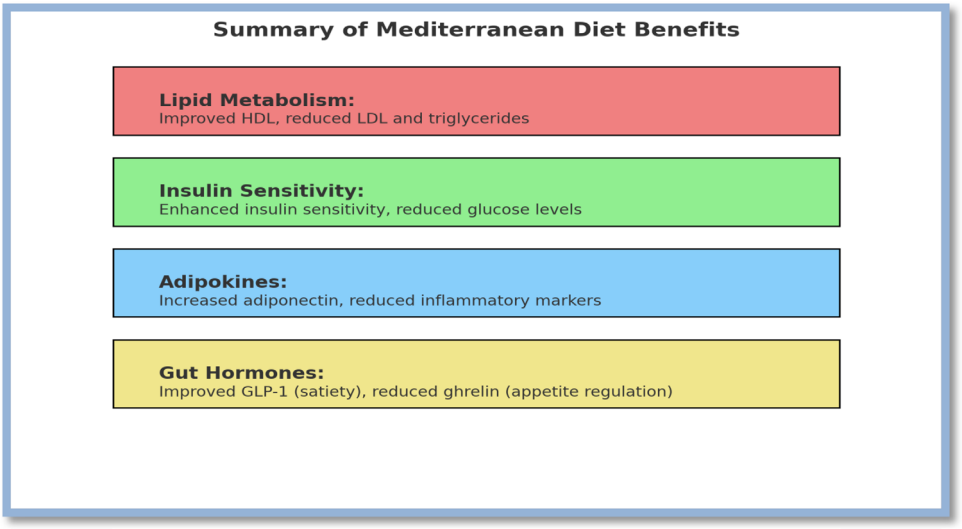

Figure 3. Metabolic benefits of the Mediterranean diet

regulation. Evidence from observational studies, randomized controlled trials, and meta-analyses indicates that the MD is a promising nutritional strategy for preventing childhood obesity, supporting optimal growth, and improving long-term endocrine and cardiometabolic outcomes. Multiple studies have linked MD adherence to improved anthropometric outcomes in children and adolescents. These include lower BMI, waist circumference, and better weight-for-height ratios, suggesting a protective effect against obesity and related complications (94). This benefit is likely attributed to the MD's emphasis on nutrient-dense, low-glycemic index foods, such as vegetables, fruits, legumes, and whole grains. The diet's influence on hormonal balance, particularly insulin sensitivity and adipokine profiles, has been consistently observed. Clinical trials show that MD adherence improves insulin resistance and enhances adiponectin levels, a key

Table 8. Effects of the Mediterranean diet on health outcomes across diverse populations.

Author(s), Year, Ref.	Subjects and Characteristics	Main Findings
Esposito et al., 2006 (81)	180 patients with metabolic syndrome	MD improved weight, BP, insulin sensitivity.
Estruch et al., 2013/2018 (82)	7,447 high-CV risk participants	MD with extra virgin olive oil (EVOO) or nuts reduced CV events.
Fernandez- de la Puente et al., 2021 (83)	772 high-CV risk subjects	MD + nuts improved lipids and inflammation.
Martínez-González et al., 2023 (84)	13,380 university graduates	MD adherence reduced type 2 DM risk.
Papadaki et al., 2020 (85)	Meta-analysis of 50 studies	MD improved metabolic syndrome parameters.
Schwingshackl et al., 2015 (86)	Meta-analysis of 35 trials	MD improved lipid profiles.
Nordmann et al., 2011 (87)	Meta-analysis of 50 studies	MD superior to low-fat diet in CV risk reduction.
Sofi et al., 2010 (88)	Meta-analysis of 35 studies	MD reduced mortality and chronic disease.
Tosti et al., 2018 (30) and Shannon et al., 2021 (89)	Review across populations	Slow or modify aging—building directly on the themes of metabolic, molecular, and gerontological mechanisms
Gunes Kaya et al., 2024 (90)	Systematic review (metabolic syndrome)	MD improved glucose, BP, HDL, and waist circumference.
Park et al., 2015 (91)	1,018 healthy women	Whole-grain MD increased adiponectin.
Fung et al., 2015 (92)	74,886 women (NHS)	Higher adherence to a Mediterranean-style dietary pattern is inversely associated with stroke and CHD risk in middle-aged U.S. men
Vázquez-Lorente et al., 2025 (93)	1,521 older adults with metabolic syndrome	Energy-reduced MD + PA preserved lean mass.

marker of metabolic health (95). Additionally, reductions in fasting glucose and insulin levels were observed in both obese and non-obese pediatric populations, supporting the MD's role in early metabolic intervention (96). The MD's effects extend to modulation of gut microbiota and secretion of gut hormones such as GLP-1 and PYY. These hormones regulate satiety and glucose metabolism, which may partly explain the MD's impact on appetite control and reduced risk of type 2 diabetes (97). Furthermore, increased microbial diversity and the proliferation of SCFA-producing species promote intestinal integrity and lower systemic inflammation (98). The anti-inflammatory potential of the MD has also been demonstrated through reduced levels of IL-6, TNF-α, and CRP. These changes have positive implications for immune modulation and chronic disease prevention. Bioactive components such as polyphenols and omega-3 fatty acids contribute to this effect by targeting NF-κB and oxidative stress pathways (99). Neurocognitive outcomes are another area where MD shows promise. Studies in pediatric and adolescent populations suggest that higher MD adherence is linked to improved attention, academic performance, and emotional well-being, likely through anti-inflammatory and neuroprotective mechanisms (100). Despite these promising findings, limitations exist. Most available studies are observational in nature and vary in their tools for dietary assessment and adherence scoring. Randomized controlled tr ials in pediatric populations remain limited in number, duration, and geographical diversity. Future research should focus on long-term, multicenter trials assessing standardized MD interventions in diverse pediatric settings. Moreover, understanding the interplay between MD, epigenetic factors, pubertal timing, and hormonal maturation will offer more comprehensive insight into its role in growth and endocrine function (101–104).

Conclusions

The Mediterranean diet (MD) demonstrates significant potential in promoting healthy growth, metabolic regulation, and hormonal balance in children and adolescents. Its high content of anti-inflammatory nutrients, fiber, and healthy fats contributes to improved insulin sensitivity, lipid profiles, and gut hormone secretion, while supporting a diverse and beneficial gut microbiota. Evidence also suggests positive effects on cognitive function and pubertal development. Despite these promising outcomes, variability in adherence measures, study designs, and population characteristics limits the strength of current conclusions. Further longitudinal and interventional research is warranted to establish causal relationships and inform targeted public health strategies.

Recommendations

1. Implement Early Dietary Education: Integrate Mediterranean diet principles into school-based nutrition programs and parental education to establish healthy eating patterns early in life.
2. Standardize MD Adherence Tools in Pediatric Research: Develop and adopt age-appropriate, validated tools for assessing Mediterranean diet adherence to improve consistency and comparability across studies.
3. Prioritize Longitudinal Interventions: Conduct large-scale, long-term studies evaluating MD's effects on growth, endocrine outcomes, and metabolic risk from childhood through adolescence to better understand its preventive potential.

Authors Contribution: A.S. conceptualized the study, led the literature review, supervised manuscript preparation, figure preparation of figures, and final editing. V.D.S. contributed to expert editing and critical intellectual decisions. F.A., N.A.H., N.A., N.H., and S.A. were involved in data collection, synthesis of evidence, and wrote the first draft of the manuscript. S.E. and M.I. contributed to the evaluations of nutritional and microbiota-related components and provided a critical review. N.S. contributed to public health interpretation and manuscript refinement. All authors reviewed and approved the final version of the manuscript.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Declaration on the Use of AI: AI was used only in the preparation of figures, and the figures were reviewed by the authors.

References

1. Scaglione S, Di Chiara T, Daidone M, et al. Effects of the Mediterranean Diet on the Components of Metabolic Syndrome Concerning the Cardiometabolic Risk. Nutrients. 2025;17(2):358. doi:10.3390/nu17020358
2. Dubey VP, García-Hermoso A, López-Gil JF, et al. Association between adherence to the Mediterranean diet and metabolic syndrome in children and adolescents: a systematic review and meta-analysis. *BMJ Nutr Prev Health.* 2025; bmjnph-2025-001266. doi:10.1136/bmjnph-2025-001266
3. López-Gil JF, García-Hermoso A, Sotos-Prieto M, et al. Mediterranean diet-based interventions to improve anthropometric and obesity indicators in children and adolescents: a systematic review with meta-analysis of randomized controlled trials. *Adv Nutr.* 2023;14(4):858–869. doi:10.1016/j.advnut.2023.04.011
4. Khavandegar, A., Heidarzadeh, A., Angoorani, P. *et al.* Adherence to the Mediterranean diet can beneficially affect the gut microbiota composition: a systematic review. *BMC Med Genomics* **17**, 91 (2024). https://doi.org/10.1186/s12920-024-01861-3
5. Ko BJ, Park KH, Mantzoros CS, et al. Diet patterns, adipokines, and metabolism: where are we and what is next? Metabolism. 2014;63(2):168-177.
6. Kimble R, Gouinguenet P, Ashor A, et al. Effects of a mediterranean diet on the gut microbiota and microbial metabolites: A systematic review of randomized controlled trials and observational studies. *Crit Rev Food Sci Nutr*. 2023;63(27):8698-8719. doi:10.1080/10408398.2022.2057416
7. Ghosh TS, Rampelli S, Jeffery IB, et al. Mediterranean diet intervention alters the gut microbiome in older people reducing frailty and improving health status: the NU-AGE 1-year dietary intervention across five European countries. Gut. 2020;69(7):1218-1228. doi:10.1136/gutjnl-2019-319654
8. Romero-Robles MA, Ccami-Bernal F, Ortiz-Benique ZN, Pinto-Ruiz DF, Benites-Zapata VA, Casas Patiño D. Adherence to Mediterranean diet associated with health-related quality of life in children and adolescents: a systematic review. BMC Nutr. 2022 Jun 23;8(1):57. doi: 10.1186/s40795-022-00549-0.
9. Anastasiou CA, Yannakoulia M, Kosmidis MH, et al. Mediterranean diet and cognitive health: Initial results from the Hellenic Longitudinal Investigation of Ageing and Diet. *PLoS One*. 2017;12(8):e0182048. Published 2017 Aug 1. doi:10.1371/journal.pone.0182048

10. Saber N, Teymoori F, Kazemi Jahromi M, et al. From adolescence to adulthood: Mediterranean diet adherence and cardiometabolic health in a prospective cohort study. *Nutr Metab Cardiovasc Dis*. 2024;34(4):893-902. doi:10.1016/j.numecd.2023.12.017
11. Bakırhan H, Özkaya V, Pehlivan M, et al. Mediterranean diet is associated with better gastrointestinal health and quality of life, and less nutrient deficiency in children/adolescents with disabilities. Front Public Health. 2023;11:1243513. doi:10.3389/fpubh.2023.1243513
12. George ES, Gavrili S, Itsiopoulos C, et al. Poor adherence to the Mediterranean diet is associated with increased likelihood of metabolic syndrome components in children: The Healthy Growth Study. Public Health Nutr. 2021;24(10):2823-2833. doi:10.1017/S1368980021001701
13. Tognon G, Hebestreit A, Lanfer A, et al. Mediterranean diet, overweight and body composition in children from eight European countries: cross-sectional and prospective results from the IDEFICS study. Nutr Metab Cardiovasc Dis. 2014;24(2):205-213. doi:10.1016/j.numecd.2013.04.013
14. Esteban-Gonzalo L, Turner AI, Torres SJ, et al. Diet quality and well-being in children and adolescents: the UP&DOWN longitudinal study. Br J Nutr. 2019;121(2):221-231. doi:10.1017/S0007114518003161
15. Velázquez-López L, Santiago-Díaz G, Nava-Hernández J, et al. Mediterranean-style diet reduces metabolic syndrome components in obese children and adolescents with obesity. BMC Pediatr. 2014;14(1):175. doi:10.1186/1471-2431-14-175
16. Yurtdaş G, Akbulut G, Baran M, et al. The effects of Mediterranean diet on hepatic steatosis, oxidative stress, and inflammation in adolescents with non-alcoholic fatty liver disease: A randomized controlled trial. Pediatr Obes. 2022;17(4):e12872. doi:10.1111/ijpo.12872
17. Ojeda-Rodríguez A, Zazpe I, Morell-Azanza L, et al. Improved diet quality and nutrient adequacy in children and adolescents with abdominal obesity after a lifestyle intervention. Nutrients. 2018;10(10):1500. doi:10.3390/nu10101500
18. Lassale C, Fito M, Morales-Suárez-Varela M, et al. Mediterranean diet and adiposity in children and adolescents: A systematic review. Obes Rev. 2022;23(1):e13381. doi:10.1111/obr.13381
19. Muros JJ, Zabala M, Oliveras-López MJ, et al. Effect of physical activity, nutritional education, and consumption of extra virgin olive oil on lipid, physiological, and anthropometric profiles in a pediatric population. J Phys Act Health. 2015;12(9):1245-1252. doi:10.1123/jpah.2014-0272
20. Andueza N, Martin-Calvo N, Navas-Carretero S, et al. The ALINFA intervention improves diet quality and nutritional status in children 6 to 12 years old. Nutrients. 2023;15(10):2375. doi:10.3390/nu15102375
21. Arenaza L, Huybrechts I, Ortega FB, et al. Adherence to the Mediterranean diet in metabolically healthy and unhealthy overweight and obese European adolescents: the HELENA study. Eur J Nutr. 2019;58(7):2615-2623. doi:10.1007/s00394-018-1809-8
22. Sánchez-Rodríguez L, Fernández-Escobar C, Ordaz-Castillo E, et al. Adherence to Mediterranean diet and its associated factors in adolescents from Madrid. Rev Esp Salud Publica. 2022;96:e202210076. [No DOI available]
23. Martino F, Puddu PE, Lamacchia F, et al. Mediterranean diet and physical activity impact on metabolic syndrome among children and adolescents from Southern Italy: Contribution from the Calabrian Sierras Community Study (CSCS). Int J Cardiol. 2016;225:284-288. doi:10.1016/j.ijcard.2016.10.008
24. Cobo-Cuenca AI, Garrido-Miguel M, Soriano-Cano A, et al. Adherence to the Mediterranean Diet and Its Association with Body Composition and Physical Fitness in Spanish University Students. Nutrients. 2019;11(11):2830. doi:10.3390/nu11112830
25. Rocha NP, Milagres LC, Longo GZ, et al. Association between dietary pattern and cardiometabolic risk in children and adolescents: a systematic review. J Pediatr (Rio J). 2017;93(3):214-222. doi:10.1016/j.jped.2016.09.003
26. Di Nucci A, Silano M, Cardamone E, et al. Adherence to Mediterranean diet and health outcomes in adolescents: an umbrella review. Nutr Rev. 2025;83(3):e1329-42. doi:10.1093/nutrit/nuae085
27. Masini A, Dallolio L, Sanmarchi F, et al. Adherence to the Mediterranean diet in children and adolescents and association with multiple outcomes: an umbrella review. Healthcare (Basel). 2024;12(4):449. doi:10.3390/healthcare12040449
28. Rosi A, Scazzina F, Giampieri F, et al. Lifestyle factors associated with children's and adolescents' adherence to the Mediterranean diet living in Mediterranean countries: the DELICIOUS project. Nutrients. 2024;17(1):26. doi:10.3390/nu17010026
29. Farella I, Miselli F, Campanozzi A, et al. Mediterranean diet in developmental age: a narrative review of current evidences and research gaps. Children (Basel). 2022;9(6):906. doi:10.3390/children9060906
30. Tosti V, Bertozzi B, Fontana L, et al. Health benefits of the Mediterranean diet: metabolic and molecular mechanisms. J Gerontol A Biol Sci Med Sci. 2018;73(3):318-326. doi:10.1093/gerona/glx227
31. Georgoulis M, Kontogianni MD, Yiannakouris N, et al. Mediterranean diet and diabetes: prevention and treatment. Nutrients. 2014;6(4):1406-1423. doi:10.3390/nu6041406
32. Fung TT, Rexrode KM, Mantzoros CS, et al. Mediterranean diet and incidence of and mortality from coronary heart disease and stroke in women. Circulation. 2009;119(8):1093-1100. doi:10.1161/CIRCULATIONAHA.108.816736
33. Mantzoros CS, Williams CJ, Manson JE, et al. Adherence to the Mediterranean dietary pattern is positively associated with plasma adiponectin concentrations in diabetic women. Am J Clin Nutr. 2006;84(2):328-335. doi:10.1093/ajcn/84.2.328
34. Estruch R, Ros E, Salas-Salvadó J, et al. Primary prevention of cardiovascular disease with a Mediterranean diet. N Engl J Med. 2013;368(14):1279-1290. doi:10.1056/NEJMoa1200303

35. Esposito K, Marfella R, Ciotola M, et al. Effect of a Mediterranean-style diet on endothelial dysfunction and markers of vascular inflammation in the metabolic syndrome: a randomized trial. JAMA. 2004;292(12):1440-1446. doi:10.1001/jama.292.12.1440
36. Salas-Salvadó J, Fernández-Ballart J, Ros E, et al. Effect of a Mediterranean diet supplemented with nuts on metabolic syndrome status: one-year results of the PREDIMED randomized trial. Arch Intern Med. 2008;168(22):2449-2458. doi:10.1001/archinte.168.22.2449
37. Shai I, Schwarzfuchs D, Henkin Y, et al. Weight loss with a low-carbohydrate, Mediterranean, or low-fat diet. N Engl J Med. 2008;359(3):229-241. doi:10.1056/NEJMoa0708681
38. Babio N, Toledo E, Estruch R, et al. Mediterranean diets and metabolic syndrome status in the PREDIMED randomized trial. CMAJ. 2014;186(17):E649-E657. doi:10.1503/cmaj.140764
39. Giugliano D, Esposito K, et al. Mediterranean diet and metabolic diseases. Curr Opin Lipidol. 2008;19(1):63-68. doi:10.1097/MOL.0b013e3282f2fa4d
40. Martínez-González MÁ, De la Fuente-Arrillaga C, Nunez-Cordoba JM, et al. Adherence to Mediterranean diet and risk of developing diabetes: prospective cohort study. BMJ. 2008;336(7657):1348-1351. doi:10.1136/bmj.39561.501007.BE
41. Kastorini CM, Milionis HJ, Esposito K, et al. The effect of Mediterranean diet on metabolic syndrome and its components: a meta-analysis of 50 studies and 534,906 individuals. J Am Coll Cardiol. 2011;57(11):1299-1313. doi:10.1016/j.jacc.2010.09.073
42. Schwingshackl L, Hoffmann G. Adherence to Mediterranean diet and risk of cancer: an updated systematic review and meta-analysis of observational studies. Cancer Med. 2015;4(12):1933-1947. doi:10.1002/cam4.539
43. Esposito K, Giugliano D. Diet and inflammation: a link to metabolic and cardiovascular diseases. *Eur Heart J.* 2006; 27(1):15–20. doi:10.1093/eurheartj/ehi604
44. Mirabelli M, Chiefari E, Arcidiacono B, et al. Mediterranean diet nutrients to turn the tide against insulin resistance and related diseases. Nutrients. 2020;12(4):1066. doi:10.3390/nu12041066
45. George ES, Reddy A, Nicoll AJ, et al. Impact of a Mediterranean diet on hepatic and metabolic outcomes in non-alcoholic fatty liver disease: the MEDINA randomised controlled trial. Liver Int. 2022;42(6):1308-1322. doi:10.1111/liv.15264
46. Nagpal R, Shively CA, Appt SA, et al. Gut microbiome composition in non-human primates consuming a Western or Mediterranean diet. Front Nutr. 2018;5:28. doi:10.3389/fnut.2018.00028
47. Gutiérrez-Díaz I, Fernández-Navarro T, Sánchez B, et al. Mediterranean diet and faecal microbiota: a transversal study. Food Funct. 2016;7(5):2347-2356. doi:10.1039/c6fo00105h
48. Castro-Barquero S, Ruiz-León AM, Sierra-Pérez M, et al. Dietary strategies for metabolic syndrome: a comprehensive review. Nutrients. 2020;12(10):2983. doi:10.3390/nu12102983
49. Abdalqadir N, Adeli K. GLP-1 and GLP-2 orchestrate intestine integrity, gut microbiota, and immune system crosstalk. Microorganisms. 2022;10(10):2061. doi:10.3390/microorganisms10102061
50. Ruiz-Ojeda FJ, Plaza-Díaz J, Sáez-Lara MJ, et al. Effects of sweeteners on the gut microbiota: a review of experimental studies and clinical trials. Adv Nutr. 2019;10(Suppl_1): S31-S48. doi:10.1093/advances/nmy037
51. Clapp M, Aurora N, Herrera L, et al. Gut microbiota's effect on mental health: the gut-brain axis. Clin Pract. 2017;7(4):987. doi:10.4081/cp.2017.987
52. Yadav H, Lee JH, Lloyd J, et al. Beneficial metabolic effects of a probiotic via butyrate-induced GLP-1 hormone secretion. J Biol Chem. 2013;288(35):25088-25097. doi:10.1074/jbc.M113.452516
53. Del Chierico F, Nobili V, Vernocchi P, et al. Gut microbiota profiling of pediatric nonalcoholic fatty liver disease and obese patients unveiled by an integrated meta-omics-based approach. Hepatology. 2017;65(2):451-464. doi:10.1002/hep.28572
54. De Filippis F, Pellegrini N, Vannini L, et al. High-level adherence to a Mediterranean diet beneficially impacts the gut microbiota and associated metabolome. Gut. 2016;65(11):1812-1821. doi:10.1136/gutjnl-2015-309957
55. Gutierrez-Diaz I, Fernandez-Navarro T, Salazar N, et al. Adherence to a Mediterranean diet influences the fecal metabolic profile of microbial-derived phenolics in a Spanish cohort of middle-age and older people. J Agric Food Chem. 2017;65(3):586-595. doi:10.1021/acs.jafc.6b04261
56. Haro C, Montes-Borrego M, Rangel-Zúñiga OA, et al. Two healthy diets modulate gut microbial community improving insulin sensitivity in a human obese population. J Clin Endocrinol Metab. 2016;101(1):233-242. doi:10.1210/jc.2015-3351
57. Mitsou EK, Kakali A, Antonopoulou S, et al. Adherence to the Mediterranean diet is associated with the gut microbiota pattern and gastrointestinal characteristics in an adult population. Br J Nutr. 2017;117(12):1645-1655. doi:10.1017/S0007114517001593
58. Hernández-Calderón P, Wiedemann L, Benítez-Páez A, et al. The microbiota composition drives personalized nutrition: gut microbes as predictive biomarkers for the success of weight loss diets. Front Nutr. 2022;9:1006747. doi:10.3389/fnut.2022.1006747
59. Meslier V, Laiola M, Roager HM, et al. Mediterranean diet intervention in overweight and obese subjects lowers plasma cholesterol and causes changes in the gut microbiome and metabolome independently of energy intake.Gut.2020;69(7):1258-1268.doi:10.1136/gutjnl-2019-320438
60. Hernández-Montoliu L, Rodríguez-Peña MM, Puig R, et al. A specific gut microbiota signature is associated with an enhanced GLP-1 and GLP-2 secretion and improved metabolic control in patients with type 2 diabetes after metabolic

Roux-en-Y gastric bypass. Front Endocrinol (Lausanne). 2023;14:1181744. doi:10.3389/fendo.2023.1181744
61. Nagpal R, Shively CA, Register TC, et al. Gut microbiome-Mediterranean diet interactions in improving host health. F1000Research. 2019;8:699. doi:10.12688/f1000research.19496.1
62. Basso M, Johnstone N, Knytl P, et al. A systematic review of psychobiotic interventions in children and adolescents to enhance cognitive functioning and emotional behavior. Nutrients. 2022;14(3):614. doi:10.3390/nu14030614
63. Hill C, Guarner F, Reid G, et al. The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. Nat Rev Gastroenterol Hepatol. 2014;11(8):506-514. doi:10.1038/nrgastro.2014.66
64. Calderón-Pérez L, Gosalbes MJ, Yuste S, et al. Gut metagenomic and short chain fatty acids signature in hypertension: a cross-sectional study. Sci Rep. 2020;10(1):6436. doi:10.1038/s41598-020-63475-w
65. Cenit MC, Olivares M, Codoñer-Franch P, et al. Intestinal Microbiota and Celiac Disease: Cause, Consequence or Co-Evolution? Nutrients. 2015;7(8):6900-6923. doi:10.3390/nu7085314
66. Del Chierico F, Vernocchi P, Petrucca A, et al. Phylogenetic and metabolic tracking of gut microbiota during perinatal development. PLoS One. 2015;10(9):e0137347. doi:10.1371/journal.pone.0137347
67. Berding K, Vlckova K, Marx W, et al. Diet and the Microbiota-Gut-Brain Axis: Sowing the Seeds of Good Mental Health. Adv Nutr. 2021;12(4):1239-1285. doi:10.1093/advances/nmaa181
68. Yahfoufi N, Alsadi N, Jambi M, et al. The immunomodulatory and anti-inflammatory role of polyphenols. Nutrients. 2018;10(11):1618. doi:10.3390/nu10111618
69. Vauzour D, Rodriguez-Mateos A, Corona G, et al. Polyphenols and human health: prevention of disease and mechanisms of action. Nutrients. 2010;2(11):1106-1131. doi:10.3390/nu2111106
70. Tresserra-Rimbau A, Rimm EB, Medina-Remón A, et al. Polyphenol intake and mortality risk: a re-analysis of the PREDIMED trial. BMC Med. 2014;12(1):77. doi:10.1186/1741-7015-12-77
71. Riolo R, De Rosa R, Simonetta I, et al. Olive oil in the Mediterranean diet and its biochemical and molecular effects on cardiovascular health through an analysis of genetics and epigenetics. Int J Mol Sci. 2022;23(24):16002. doi:10.3390/ijms232416002
72. Schwingshackl L, Christoph M, Hoffmann G, et al. Effects of olive oil on markers of inflammation and endothelial function—a systematic review and meta-analysis. Nutrients. 2015;7(9):7651-7675. doi:10.3390/nu7095356
73. Calder PC, et al. Marine omega-3 fatty acids and inflammatory processes: effects, mechanisms and clinical relevance. Biochim Biophys Acta Mol Cell Biol Lipids. 2015;1851(4):469-484. doi:10.1016/j.bbalip.2014.08.010
74. Li K, Huang T, Zheng J, et al. Effect of marine-derived n-3 polyunsaturated fatty acids on C-reactive protein, interleukin 6 and tumor necrosis factor α: a meta-analysis. PLoS One. 2014;9(2):e88103. doi:10.1371/journal.pone.0088103
75. Koh A, De Vadder F, Kovatcheva-Datchary P, et al. From dietary fiber to host physiology: short-chain fatty acids as key bacterial metabolites. Cell. 2016;165(6):1332-1345. doi:10.1016/j.cell.2016.05.041
76. Silva YP, Bernardi A, Frozza RL, et al. The role of short-chain fatty acids from gut microbiota in gut-brain communication. Front Endocrinol (Lausanne). 2020;11:25. doi:10.3389/fendo.2020.00025
77. Valdes AM, Walter J, Segal E, et al. Role of the gut microbiota in nutrition and health. BMJ. 2018;361:k2179. doi:10.1136/bmj.k2179
78. Belkaid Y, Hand TW, et al. Role of the microbiota in immunity and inflammation. Cell. 2014;157(1):121-141. doi:10.1016/j.cell.2014.03.011
79. Uribarri J, Woodruff S, Goodman S, et al. Advanced glycation end products in foods and a practical guide to their reduction in the diet. J Am Diet Assoc. 2010;110(6):911-916. doi:10.1016/j.jada.2010.03.018
80. Monteiro CA, Cannon G, Levy RB, et al. Ultra-processed foods: what they are and how to identify them. Public Health Nutr. 2019;22(5):936-941. doi:10.1017/S1368980018003762
81. Esposito K, Ciotola M, Giugliano D, et al. Mediterranean diet, endothelial function and vascular inflammatory markers. Public Health Nutr. 2006;9(8A):1073-1076. doi:10.1017/phn2006976
82. Estruch R, Martínez-González MA, Corella D, et al. Effect of a high-fat Mediterranean diet on bodyweight and waist circumference: a prespecified secondary outcomes analysis of the PREDIMED randomised controlled trial. Lancet Diabetes Endocrinol. 2019;7(5):e6-e17. doi:10.1016/S2213-8587(19)30074-9
83. Fernández de la Puente M, Hernández-Alonso P, Canudas S, et al. Modulation of telomere length by Mediterranean diet, caloric restriction, and exercise: results from PREDIMED-Plus Study. Antioxidants. 2021;10(10):1596. doi:10.3390/antiox10101596
84. Martínez-González MA, Montero P, Ruiz-Canela M, et al. Yearly attained adherence to Mediterranean diet and incidence of diabetes in a large randomized trial. Cardiovasc Diabetol. 2023;22(1):262. doi:10.1186/s12933-023-01849-9
85. Papadaki A, Nolen-Doerr E, Mantzoros CS, et al. The effect of the Mediterranean diet on metabolic health: a systematic review and meta-analysis of controlled trials in adults. Nutrients. 2020;12(11):3342. doi:10.3390/nu12113342
86. Schwingshackl L, Hoffmann G, et al. Mediterranean dietary pattern, inflammation and endothelial function: a systematic review and meta-analysis of intervention trials. Nutr Metab Cardiovasc Dis. 2014;24(9):929-939. doi:10.1016/j.numecd.2014.03.003
87. Nordmann AJ, Suter-Zimmermann K, Bucher HC, et al. Meta-analysis comparing Mediterranean to low-fat diets for modification of cardiovascular risk factors. Am J Med. 2011;124(9):841-851. doi:10.1016/j.amjmed.2011.04.024

88. Sofi F, Abbate R, Gensini GF, et al. Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. Am J Clin Nutr. 2010;92(5):1189-1196. doi:10.3945/ajcn.2010.29673
89. Shannon OM, Ashor AW, Scialo F, et al. Mediterranean diet and the hallmarks of ageing. Eur J Clin Nutr. 2021;75(8):1176-1192. doi:10.1038/s41430-020-00841-x
90. Güneş Kaya D, Arslan N, Ayyıldız F, et al. The potential of the Mediterranean diet to improve metabolic control and body composition in youths with type 1 diabetes mellitus. BMC Endocr Disord. 2024;24(1):63. doi:10.1186/s12902-024-01593-6
91. Park K, et al. Trends in adherence to dietary recommendations among Korean type 2 diabetes mellitus patients. Nutr Res Pract. 2015;9(6):658-666. doi:10.4162/nrp.2015.9.6.658
92. Fung TT, Willett WC, Hu FB, et al. Adherence to Mediterranean diet and risk of stroke and coronary heart disease in a male nurse cohort. Eur Heart J. 2015;36(14):976-984. doi:10.1093/eurheartj/ehu450
93. Vázquez-Lorente H, García-Gavilán JF, Shyam S, et al. Mediterranean diet, physical activity, and bone health in older adults: a secondary analysis of a randomized clinical trial. JAMA Netw Open. 2025;8(4):e253710. doi:10.1001/jamanetworkopen.2025.3710
94. Panagiotakos DB, Polychronopoulos E, et al. The role of Mediterranean diet in the epidemiology of metabolic syndrome; converting epidemiology to clinical practice. Lipids Health Dis. 2005;4:7. doi:10.1186/1476-511X-4-7
95. Mohammadi S, Lotfi K, Mirzaei S, et al. Adherence to Mediterranean diet and its association with metabolic health status in overweight and obese adolescents. Int J Clin Pract. 2022; 2022:9925267. doi:10.1155/2022/9925267
96. Kavouras SA, Panagiotakos DB, Pitsavos C, et al. Physical activity and adherence to Mediterranean diet increase total antioxidant capacity: the ATTICA study. Cardiol Res Pract. 2011:248626. doi:10.4061/2011/248626
97. Tsigalou C, Paraschaki A, Karvelas A, et al. Gut microbiome and Mediterranean diet in the context of obesity. Current knowledge, perspectives and potential therapeutic targets. Metab Open. 2021;9:100081. doi:10.1016/j.metop.2021.100081
98. Tagliamonte S, Laiola M, Ferracane R, et al. Mediterranean diet consumption affects the endocannabinoid system in overweight and obese subjects: possible links with gut microbiome, insulin resistance and inflammation. Eur J Nutr. 2021;60(7):3703-16. doi:10.1007/s00394-021-02538-8
99. Antoniotti V, Spadaccini D, Ricotti R, et al. Adherence to the Mediterranean diet is associated with better metabolic features in youths with type 1 diabetes. Nutrients. 2022;14(3):596. doi:10.3390/nu14030596
100. Esteban-Cornejo I, Izquierdo-Gomez R, Gómez-Martínez S, et al. Adherence to the Mediterranean diet and academic performance in youth: the UP&DOWN study. Eur J Nutr. 2016;55(3):1133-40. doi:10.1007/s00394-015-0927-9
101. Matafome P, Seiça R, et al. The role of brain in energy balance. Adv Neurobiol. 2017;19:33-48. doi:10.1007/978-3-319-63260-5_2
102. Papandreou C, Moré M, Bellamine A, et al. Trimethylamine N-oxide in relation to cardiometabolic health—cause or effect? Nutrients. 2020;12(5):1330. doi:10.3390/nu12051330
103. Szamreta EA, Qin B, Rivera-Núñez Z, et al. Greater adherence to a Mediterranean-like diet is associated with later breast development and menarche in peripubertal girls. Public Health Nutr. 2020;23(6):1020-1030. doi:10.1017/S1368980019002349
104. Yannakoulia M, Kontogianni M, Scarmeas N, et al. Cognitive health and Mediterranean diet: just diet or lifestyle pattern? Ageing Res Rev. 2015;20:74-78. doi:10.1016/j.arr.2014.10.003

Correspondence:
Received: 27 March 2025
Accepted: 27 April 2025
Ashraf Soliman, MD, PhD, FRCP, Professor of Pediatrics and Endocrinology,
Hamad General Hospital, Doha (Qatar) PO Box 3050.
E-mail: atsoliman56@gmail.com
ORCID: 0000000271456561