Adherence to the Mediterranean Diet and its association with the diagnosis, symptomatology and well-being of children and adolescents with special educational needs: a systematic review

Adesão à Dieta Mediterrânica e a sua associação com o diagnóstico, a sintomatologia e o bem-estar de crianças e adolescentes com necessidades educativas especiais: uma revisão sistemática

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Abstract

Introduction: Mediterranean diet (MD) is linked to improved health outcomes in children and adolescents. While prior research suggests that individual components of the MD, such as omega-3 fatty acids, may improve cognitive function and behavior in individuals with special educational needs (SEN), it is not known the association between adhering to MD and the symptomatology of SEN.

Objectives: To identify the association between adherence to the MD and the symptomatology and/or well-being of children and adolescents with SEN or its diagnosis.

Methods: Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a literature search was carried out on MEDLINE, Scopus, and Web of Science, from February to June 2024. A total of six studies were included according to the following criteria: studies written in English or Portuguese; participants ≤19 years old; evaluation of MD using specific scores; and SEN diagnosis and/or symptomatology/well-being. This systematic review was also registered at PROSPERO as CRD42024527230.

Results: Six studies were included, with a total of two SEN investigated. Studies found that higher adherence to the MD was associated with reduced symptoms of Obsessive-Compulsive Tics Disorder (OCTD) and Attention Deficit Hyperactivity Disorder (ADHD). Also, a lower likelihood of ADHD diagnosis or having ADHD was associated with children and adolescents adhering more to MD.

Conclusions: This review suggests that higher adherence to the MD is linked to lower prevalence and symptom severity of ADHD and OCTD in children and adolescents with SEN. However, future research is needed to confirm these results.

Keywords: childhood; adolescence; Mediterranean Diet; Special Educational Needs; systematic review

Resumo

Introdução: A dieta mediterrânica (DM) associa-se a melhorias de saúde em crianças e adolescentes. Embora pesquisas anteriores sugiram que componentes individuais da DM, como ácidos gordos ómega-3, possam melhorar a função cognitiva e o comportamento em indivíduos com necessidades educativas especiais (NEE), não se conhece a associação entre aderir à DM e a sintomatologia das NEE.

Objetivos: Identificar a associação entre a adesão à DM e a sintomatologia e/ou bem-estar de crianças e adolescentes com NEE ou o seu diagnóstico.

Métodos: Seguindo as diretrizes do PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*), conduziu-se uma pesquisa nas bases de dados *MEDLINE, Scopus* e *Web of Science*, de fevereiro a junho de 2024. Incluíram-se seis estudos de acordo com os seguintes critérios: estudos escritos em inglês ou português; participantes com ≤19 anos; avaliação da DM recorrendo a índices específicos; e diagnóstico de NEE e/ou sintomatologia/bem-estar. Esta revisão sistemática foi registada no PROSPERO como CRD42024527230.

Resultados: Seis estudos foram incluídos, investigando um total de duas NEE. Uma maior adesão à DM associou-se à redução dos sintomas de Perturbação Obsessivo-Compulsiva e Tiques (POCT) e de Perturbação de Hiperatividade/Défice de Atenção (PHDA). Uma menor probabilidade de diagnóstico de PHDA ou de ter ou não PHDA associou-se a uma maior adesão à DM em crianças e adolescentes.

Conclusões: Esta revisão sugere que uma maior adesão à DM se associa a uma menor prevalência e gravidade dos sintomas de PHDA e POCT em crianças e adolescentes com NEE. Pesquisas futuras são necessárias para confirmar estes resultados.

Palavras-Chave: infância; adolescência, Dieta Mediterrânica; Necessidades Educativas Especiais; revisão sistemática

Acronyms List

ADHD - Attention Deficit Hyperactivity Disorder

ASD - Autism Spectrum Disorder

DSM-IV TR - Diagnostic and Text Revision of Statistical Manual of Mental Disorders-Fourth Edition

DSM-V - Diagnostic and Statistical Manual of Mental Disorders, 5th Edition

IDEA - Individuals with Disabilities Education Act

KIDMED - Mediterranean Diet Quality Index for Children and Adolescents

MD - Mediterranean Diet

MDS - Mediterranean Diet Score

OCTD - Obsessive-Compulsive Tics Disorder

PICOS - Population, Indicator, Comparator, Outcomes, and Study type

PRISMA - Preferred Reporting of Items for Systematic Reviews and Meta-analyses

PROSPERO - International Prospective Register of Systematic Reviews

SEN - Special Educational Need

Index

Introduction

The Mediterranean diet (MD) has garnered considerable attention as a paradigmatic example of healthy eating, credited for its significant contributions to favorable health outcomes, improved biochemical indices, and heightened individuals' quality of life[1-4]. Generally, the MD can be characterized as a dietary pattern with abundant fruits and vegetables, whole grains, legumes, nuts, and olive oil, and a moderate consumption of fish, white meats, dairy, and wine[5, 6]. In children and adolescents, adherence to the MD has been decreasing worldwide[7]. However, this dietary pattern has been mainly associated with reduced inflammation, reduced sedentary behaviours, and increased quality of life in this age group[8].

Regarding Special Educational Needs (SEN), children and adolescents with these outcomes may encounter greater challenges in learning or accessing education than their peers. Consequently, the concept of SEN is essential in guaranteeing inclusive education, whereby all students, irrespective of their learning difficulties or disabilities, are provided with access to quality education and the requisite resources to achieve their full potential[9, 10].

Even though the definition of SEN may not be consensual between countries, some documents help identify some common conditions. The Individuals with Disabilities Education Act (IDEA) program from the United States of America comprises 14 disability categories: autism, deaf-blindness, deafness, developmental delay, emotional disturbance, hearing impairment, intellectual disability, multiple disabilities, orthopedic impairment, other health impairment, specific learning disability, speech or language impairment, traumatic brain

injury, and visual impairment[10]. Apart from that, the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-V), is also a widely used tool to diagnose various conditions that fall under the umbrella of SEN, since the definitions covered in this manual agree with the SEN categories of most countries[11].

Research indicates that nutritional interventions can significantly impact cognitive and behavioral outcomes in children and adolescents with SEN. For instance, it is reported that consuming omega-3 fatty acids from fish or monounsaturated fats from olive oil may support cognitive function and mood regulation in individuals with autism spectrum disorders (ASD)[12, 13]. Furthermore, in individuals diagnosed with attention deficit hyperactivity disorder (ADHD), the consumption of nutrient-dense foods, such as fruits, vegetables, and whole grains, in conjunction with a moderate intake of omega-3 fatty acids, has been observed to enhance attention and behavioral control[14-17].

Based on evidence suggesting that foods typical of a MD alleviate symptoms associated with SEN, it is reasonable to hypothesize that the MD as a whole, renowned for its balanced and nutritious components, may also have a beneficial impact on managing these conditions. However, although systematic reviews have been carried out about the influence of certain foods on some SEN, like ADHD and ASD[18, 19], there is still no summary of the literature regarding MD adherence and its impact on SEN in children and adolescents.

Objectives

This systematic review aims to identify the associations previously reported in the literature between adherence to the MD and the symptomatology and/or well-being of children and adolescents with SEN or its diagnosis.

Methods

Study Design

This systematic review was based on the Preferred Reporting of Items for Systematic Reviews and Meta-Analyses (PRISMA)[20], using PRISMA guidelines[21] and it was registered in the International Prospective Register of Systematic Reviews (PROSPERO), as CRD42024527230[22].

Search Strategy

This research was conducted from February to June 2024 in three databases namely — MEDLINE (PubMed®), Scopus, and Web of Science. The search expression was built by one reviewer, while the remaining reviewers confirmed the process. The following search expression was used in the Medline database: ("Mediterranean Diet" OR "Mediterranean-style Diet" OR "Mediterranean-like diet") AND ((child[MeSH Terms]) OR (adolescent[MeSH Terms])) AND (“mental well-being” OR “mental health” OR “well-being” OR (neurobehavioral manifestations[MeSH Terms]) OR “neurologic dysfunction” OR (Cognitive impairment[MeSH Terms]) OR depression OR depressive disorders OR anxiety OR stress OR "ADHD" OR (Attention Deficit Hyperactivity Disorder[MeSH Terms]) OR (Attention Deficit Disorders with Hyperactivity[MeSH Terms]) OR hyperactivity OR (autism spectrum disorder[MeSH Terms]) OR (Autistic disorder[MeSH Terms]) OR (Disruptive behavior disorders[MeSH Terms]) OR (Mood disorders[MeSH Terms]) OR (Learning disorders[MeSH Terms]) OR (dyslexia[MeSH Terms]) OR (dyscalculia[MeSH Terms]) OR dyspraxia OR dysphasia OR dysgraphia OR dyslalia OR “special educational needs” OR “special education” OR “TIC disorder” OR “Tourette” OR “trisomy 21” OR “down syndrome” OR “cerebral palsy” OR

(neurodevelopmental disorders[MeSH Terms]) OR (intellectual disability[MeSH Terms]) OR "high intellectual potential" OR "learning disabilities" OR "learning disability" OR "communication disorder" OR (motor disorders[MeSH Terms])). A similar expression was used in Scopus and Web of Science.

To help refine the terms relating to SEN included in the search expression, the DSM-V[11] was used based on the terms about neurodevelopmental disorders and referenced in the IDEA program[10]. The IDEA program categorizes students based on their disabilities and the special education they may need.

Eligibility Criteria

The eligibility criteria are shown in **Table 1**, according to the PICOS (Population, Indicator, Comparator, Outcome, Study type) criteria. In addition, only articles in English and Portuguese were considered.

Table 1. Eligibility criteria of the studies selected according to Population, Indicator, Comparator, Outcomes, and Study design (PICOS) format.

PICOS	Inclusion Criteria	Exclusion Criteria
Population	Children and adolescents ≤19 years old.	Population >19 years old or with a prior diagnosis of special dietary needs.
Indicator	Mediterranean Diet evaluation through scores like Mediterranean Diet Score, KIDMED, and Mediterranean Adequacy Index.	Mediterranean Diet presented but not associated with a special educational need; other dietary patterns evaluated; only specific food groups evaluated.
Comparator	Not applicable.	Not applicable.
Outcome	Diagnosis, symptomatology and/or well-being of children and adolescents with special educational needs.	Diagnosis, symptomatology and/or well-being of children and adolescents with special educational needs without considering the influence of their diet.
Study Design	Original studies.	Reviews, only abstracts, case studies of one individual, books, and paper conferences.

Study Selection and Data Extraction

Two reviewers applied the eligibility criteria and selected the studies for inclusion in this systematic review through title and abstract reading. In cases of disagreement, a third reviewer confirmed the selection. Then, two reviewers thoroughly evaluated the full-text studies to determine which ones should be included in this systematic review. When disagreements arose, a third reviewer assisted in the decision-making process, relying on the support of literature to find

coherence.

Following the establishment of exclusion and inclusion criteria, all selected article references underwent thorough examination to uncover additional pertinent information, employing the snowballing technique procedure[23].

The entire process of reviewing the articles and the reason for those that were excluded are shown in the PRISMA flowchart (**Figure 1**).

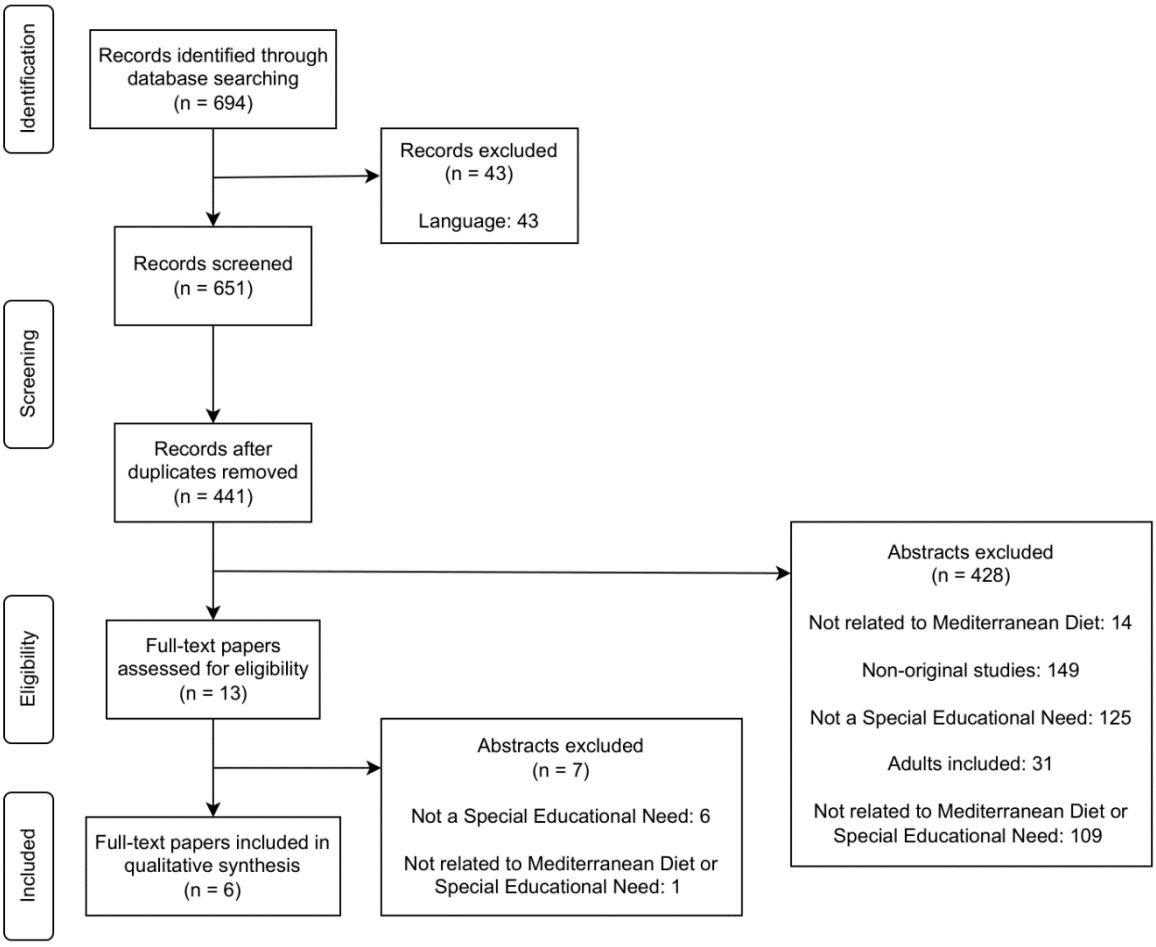

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) fluxogram.

All the necessary information to answer the study objectives has already been published within the papers, so no contact with authors was needed. There was no minimum number of studies to include in this review.

Table 2 presents the eligible studies included in this systematic review. The following topics are described: author, year; country; type of study; sample size,

age, and sex; Mediterranean Diet (instrument and adherence level); SEN (identification, prevalence and method for symptomatology); association found between MD and SEN; and the quality assessment score. **Table 3** summarizes the instruments used to assess the adherence to MD and its characterization.

Identified records were de-duplicated using Systematic Review Assistant De-duplication[24] followed by a manual search in Endnote[25]. Starting from 441 articles, 13 were selected after abstract screening and, of those, six were included in the qualitative synthesis (**Figure 1**).

Quality assessment

To assess the quality of all included cohort and case-control studies, the Newcastle-Ottawa Scale (NOS)[26] was applied, which provides an overall quality score ranging from 0 to 9 points. For cross-sectional studies, an adapted version of the NOS[27] was used, ranging from 0 to 8 points. This adapted version has been previously applied in the quality evaluation of other systematic reviews[28, 29].

Results

Six studies were examined and summarized in **Tables 2 and 3**, which included two cross-sectional studies[30, 31], three case-control studies[32-34], and one cohort study[35]. Collectively, the studies involved 868 participants aged between six[30, 32-34] and 18[34, 35] years old. Two of the studies were published between 2017 and 2018[31, 33], while the remaining four were published between 2019 and 2022[30, 32, 34, 35]. Geographically, four studies were conducted in Europe[30, 31, 33, 35] and two in Asia[32, 34]. One article provided data about children[32] and five articles included data on both children and adolescents[30, 31, 33-35] (**Table 2**).

For quality assessment, both the two cross-sectional articles and the one cohort article scored 7.00 points. The three case-control studies included had a mean score of 7.00 ± 0.82 (ranging from 6.00 to 8.00 points) (**Table 2**).

This systematic review identified two instruments for measuring adherence to the MD principles, as shown in **Table 3**. Within the instruments, five articles used the Mediterranean Diet Quality Index for Children and Adolescents (KIDMED), which stands out as being the most frequently used tool to assess adherence to the MD[30, 31, 33-35]. The other article employed the Mediterranean Diet Score (MDS), which was calculated based on the results of a food frequency questionnaire[32].

The selected studies explored the relationship between adherence to the MD with ADHD in five studies[30-34] and with Obsessive-Compulsive Tics Disorder (OCTD) in one study[35]. The outcomes of the studies diverge into the symptomatology of the SEN, which was studied in three studies[30, 34, 35], and the diagnosis itself in three studies[31-33] (**Table 2**).

For identification of ADHD, it was mostly used the Diagnostic and Text Revision of Statistical Manual of Mental Disorders-Fourth Edition (three out of six studies[31-33]), and for OCTD it was used the Yale Global Tic Severity Scale and Yale-Brown Obsessive Compulsive Scale[35]. Additionally, the sample of the articles that studied ADHD included 33%[32] to 100%[30] individuals with the outcome, whereas the one study about OCTD included 100%[35] of individuals with the outcome (**Table 2**).

Regarding ADHD diagnosis, two case-control studies[32, 33] found that higher adherence to the MD was linked to a lower likelihood of ADHD diagnosis. Also, one

Table 2 Characteristics of the included studies assessing adherence to the Mediterranean Diet and related outcomes in children and adolescents with special educational needs.

Author, year (reference)	Country	Type of study	Sample size, age, and sex	Mediterranean Diet (MD)		Special Education Needs (SEN)			Association between MD and SEN	Quality assessment score
				Instrument	Adherence level	Identification	Prevalence	Method for symptomatology		
Darabi Z *et al.*, 2022[32]	Iran	Case-control	n = 360 6-13 years old 76% male	Mediterranean Diet Score	The sample was divided by tertiles.	Diagnostic and Text Revision of Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV TR)	33% of the individuals diagnosed with Attention Deficit Hyperactivity Disorder (ADHD)	--------	Negative association was found between adherence to MD and ADHD diagnosis.	6[1]
Briguglio M *et al.*, 2019[35]	Italy	Cohort	n = 9 11-18 years old 100% male	KIDMED	Mean (SD): 3.0 (1.7)	Yale Global Tic Severity Scale and Yale-Brown Obsessive Compulsive Scale	100% of the individuals diagnosed with Obsessive-Compulsive Tics Disorder (OCTD)	--------	Negative association was found between adherence to MD and OCTD traits.	7[2]
Martin IS *et al.*, 2021[30]	Spain	Cross sectional	N = 57 6-16 years old 68% male	KIDMED	Poor adherence: Mean (SD): 49.9 (11.7) Medium adherence: Mean (SD): 45.0 (9.4) High adherence: Mean (SD): 41.6 (16.5)	Previously diagnosed with ADHD	100% of the individuals diagnosed with ADHD	Barratt Impulsivity Scale version 11c	Negative association was found between adherence to MD and impulsivity symptoms.	7[3]
Ríos-Hernández A *et al.*, 2017[33]	Spain	Case-control	n = 120 6-16 years old 57% male	KIDMED	ADHD Cases: Mean (SD): 6.2 (2.0) Poor adherence: 11.7% Medium adherence: 58.3% High adherence: 30.0% Controls: Mean (SD): 8.1 (1.8) Poor adherence: 0.0% Medium adherence: 36.7% High adherence: 63.3%	DSM-IV TR, ADHD Rating-Scale-IV and Kiddie Schedule for Affective Disorders and Schizophrenia-Present and Lifetime version	50% of the individuals diagnosed with ADHD	--------	Negative association was found between adherence to MD and ADHD diagnosis.	8[1]

(Continued)

Table 2 (Continued)

Author, year (reference)	Country	Type of study	Sample size, age, and sex	Mediterranean Diet (MD)		Special Education Needs (SEN)			Association between MD and SEN	Quality assessment score
				Instrument	Adherence level	Identification	Prevalence	Method for symptomatology		
Besenek M *et al.*, 2022[34]	Turkey	Case-control	n = 233 Aged 6-18 63% male	KIDMED	ADHD Cases: Mean (SD): 4.5 (2.5) Low adherence: 37.5% Medium adherence: 49.2% High adherence: 13.3% Controls: Mean (SD): 6.1(2.3) Poor adherence: 15.9% Medium adherence: 54.0% High adherence: 30.1%	Schedule for Affective Disorders and Schizophrenia for School Aged Children Kiddie-SADS-lifetime Version	48% of the individuals diagnosed with ADHD	Turgay DSM-IV Based Child and Adolescent Behavior Disorders Screening and Rating Scale – Parent form	Negative association was found between adherence to MD and ADHD diagnosis and inattention symptoms.	7[1]
Martín IS *et al.*, 2018[31]	Spain	Cross-sectional	n = 89 8-16 years old 57% male	KIDMED	With ADHD: Mean (SD): 6.4 (2.7) ≥7 points: 53.7% <7 points: 46.3% Without ADHD: Mean (SD): 7.9 (2.0). ≥7 points: 72.3 % <7 points: 27.7%	DSM-IV TR	46% of the individuals had ADHD	--------	Negative association was found between adherence to MD and having ADHD.	7[3]

[1]The NOS for case–control studies (ranging from 0 to 9 stars), [2]The NOS for cohort studies (ranging from 0 to 9 stars), [3]The NOS for cross-sectional studies (ranging from 0 to 8 stars).

Table 3 Overview of the tools mentioned in the literature and the comprehensive methods used to evaluate the Mediterranean Diet pattern in children and adolescents.

Instrument	Method for food assessment	Components in analysis	Scoring methods	Score Range	Adherence level	References
Mediterranean Diet Score	Food-Frequency Questionnaire	1) Vegetables, 2) legumes, 3) fruits and nuts, 4) grains, 5) fish, 6) meat, 7) poultry, 8) dairy products, 9) alcohol.	Each food group is assigned 0 or 1 points. (1) to (6) components: score 0 for intake lower than the median consumption; score 1 for intake equal or higher than the median consumption. (7) to (9) components: score 0 for intake equal or higher than the median consumption; and score 1 for intake lower than the median consumption.	Sum of the components ranging from 0 to 9.	Higher values indicate higher adherence.	[32]
KIDMED	16 items of 'yes' or 'no' questions	1) Fruit, 2) vegetables, 3) fish, 4) fast-food restaurants, 5) legumes grains, 6) pasta or rice, 7) cereal or grains for breakfast, 8) nuts, 9) olive oil, 10) breakfast, 11) dairy products for breakfast, 12) commercially baked goods or pastries for breakfast, 13) yogurts or cheese, 14) sweets and candy.	Concerning the Mediterranean diet, questions denoting a negative connotation (n = 4) were assigned a value of -1, and those with a positive aspect (n = 12) were scored +1.	Sum of the components ranging from -4 to 12.	High adherence: ≥8. Medium adherence: 4-7. Poor adherence: ≤3.	[30, 31, 33-35]

cross-sectional study[31] found a negative association between adherence to the MD and having ADHD. On the other hand, considering the symptomatology of ADHD, one study[30] reported that higher adherence to the MD may be related to fewer impulsivity symptoms in children diagnosed with ADHD, whereas one study[34] found that higher adherence to the MD may result in lower prevalence of ADHD and fewer inattention symptoms (**Table 2**).

Regarding OCTD, one study[35] suggested that higher adherence to the MD was associated with fewer symptoms of this outcome (**Table 2**).

Discussion

This review summarizes the relationship between MD adherence and symptomatology/well-being in children and adolescents with SEN. To evaluate adherence to the MD, the KIDMED index was predominantly used in Mediterranean countries[30, 31, 33-35], whereas the MDS was used in a non-Mediterranean country [32]. The KIDMED index, specifically developed for children and adolescents, was the most frequently used instrument to assess adherence to the MD, featuring in five out of six articles reviewed, which is appropriate since the primary focus of this review was on children and adolescents.

Several studies included in this review investigated the potential benefits of the MD for both OCTD and ADHD. For OCTD, one study found that higher adherence to the MD led to improvements in symptomatology[35]. For ADHD, the findings suggest higher adherence to MD may positively affect specific outcomes. Specifically, one study reported decreased impulsivity in individuals with ADHD[30], three studies observed a reduced likelihood of ADHD diagnosis[32, 33] or having ADHD altogether[31], and one study found a decrease in both diagnosis probability and inattentive symptoms[34].

Out of all the SEN studied, ADHD stood out as the SEN that was most extensively researched, with five out of six articles included focusing on it, which could be justified by its significant worldwide prevalence of approximately 8.0%[36], affecting about 84.8 million people in 2021[37]. In addition, there is a substantial body of research indicating an association between the symptoms of ADHD and the consumption of some specific foods[38, 39].

The studies included in this review indicate that promoting the MD could potentially offer benefits in reducing the risk or severity of ADHD symptoms in children and adolescents[30-34]. Notably, research has shown that adhering to a considered healthy dietary pattern — marked by high consumption of plant-origin sources of vitamins and minerals (such as fruits and vegetables) and by low consumption of processed or ultra-processed food may provide a protective effect against hyperactivity or ADHD occurrence in children[40]. This finding is under the principles of MD, which also emphasizes the inclusion of these types of foods.

Contrarily, other studies have shown that the overall sugar intake and the consumption of sugar-sweetened beverages are associated with increased symptoms of ADHD, particularly hyperactivity[38], and increased odds of ADHD[41]. These data appear to corroborate the findings of this review, albeit indirectly, in that they indicate that MD does not promote the consumption of this food type.

Research about the supplementation of omega-3 polyunsaturated fatty acids has shown promise in reducing the overall ADHD symptoms[39, 42, 43] and in improving attention and behavior[44, 45]. The data presented here aligns with the findings of the aforementioned review, which suggest that the MD, rich in omega-

3 from fish, could be a valuable nutritional approach for managing ADHD symptoms in children and adolescents[30, 34].

A link between oxidative stress and OCTD has been identified in the literature, with individuals diagnosed with OCTD displaying a systemic imbalance characterized by increased markers of oxidative stress[46, 47]. This finding has prompted researchers to investigate the potential of antioxidants as a supportive treatment for OCTD. Their studies suggest that the anti-inflammatory and free radical-scavenging properties of antioxidants may counteract the effects of oxidative stress and potentially improve OCTD symptoms[48]. This evidence strengthens the potential connection between diet and OCTD, suggesting that dietary interventions, such as MD, rich in fruits, vegetables, and whole grains, all of which are natural sources of antioxidants, could potentially influence a biological mechanism underlying OCTD, such as oxidative stress.

Another study on the influence of diet in OCTD highlights the importance of consuming foods rich in vitamins B12 and folate, which aid in the synthesis of neurotransmitters like serotonin, crucial for neuropsychiatric health[49]. Foods recommended for vitamin B12 include milk, fish, poultry, and eggs[50], while legumes, dark green leafy vegetables, and dairy products are suggested for their folate content[51]. The MD emphasizes the consumption of whole, minimally processed foods, including lean proteins, as well as a variety of vegetables and legumes, alongside with the dairy products consumed in moderation within this diet. By incorporating these nutrient-dense foods, the MD not only aligns with the study's dietary suggestions but also supports overall mental health and may offer benefits for individuals with OCTD by promoting the synthesis of essential neurotransmitters and providing a balanced, nutrient-rich eating pattern.

Nonetheless, in this review, only one study found evidence that the MD itself may alleviate symptoms of OCTD[35], and so it's important to note that, while promising, more studies are needed to confirm the effectiveness of MD as a mainstream treatment for OCTD.

While research on the impact of diet on SEN is ongoing, there is currently limited research specifically on the MD and its influence on outcomes for specific SEN, which this review couldn't find evidence for, such as autism spectrum disorders (ASD). However, research in ASD offers some compelling evidence regarding how the consumption of certain foods and the adherence to specific dietary patterns may influence the symptomatology of individuals with this condition[52, 53]. Studies have shown that children with ASD often have higher levels of inflammation and gastrointestinal issues due to an altered microbiome and disruption of the gut-brain axis, which can exacerbate their symptoms[54-56]. The MD has been linked to improved brain function, reduced inflammation, and enhanced gut health[57, 58], suggesting that by adopting a MD, these inflammatory markers could be reduced, potentially alleviating some of the behavioral and cognitive challenges associated with ASD.

Although current evidence does not support the use of vitamin D supplementation as a monotherapy for children with ASD, considering its long-term tolerability, and critical role in brain function and development, vitamin D might be a valuable complementary treatment for ASD[59]. Particularly, supplementation has shown benefits in reducing hyperactivity and irritability symptoms in children with ASD[60, 61]. Natural sources of vitamin D include fatty fish, meat, egg yolks, and dairy products[62], all of which are emphasized in the

MD. Accordingly, MD could provide a foundation for future dietary interventions aimed at managing ASD symptoms through nutritional support. Still, even though it seems that integrating a Mediterranean dietary approach might offer a valuable strategy for managing ASD symptoms, further studies specifically focusing on the effects of the MD on ASD are needed to confirm these potential benefits.

According to the review, nutritional interventions appear to offer benefits for children and adolescents with SEN, especially those who do not respond to medication or are too young for medication. Dietary adjustments, such as promoting a healthy and balanced diet like MD, can play a significant role in managing symptoms of these conditions. Indeed, evidence has shown that dietary patterns have a stronger association with health outcomes than any individual food item, as those consider the combined elements, relationships, and effects of foods on human health[63-65]. While dietary changes may not replace medication entirely, they can be a valuable complementary approach. Therefore, collaborating with healthcare professionals, including nutritionists, could help tailor future dietary interventions to best support children and adolescents with SEN. Further investigation is necessary to refine and validate nutritional interventions, ensuring they are evidence-based and useful for diverse types of SEN.

This systematic review represents a significant contribution to the field of pediatric nutrition, as it is the first comprehensive attempt to assess the existing literature on the association between adherence to the MD and various health aspects in children and adolescents with SEN. A key strength of the review lies in the rigorous quality assessment process employed to evaluate all the included studies, as well as the detailed follow-up of the entire PRISMA methodology. However, the heterogeneity of the studies, which employed diverse

methodologies, populations, interventions, and outcome measures, restricts our ability to draw definitive conclusions. While providing valuable insights, the limited number of studies requires caution in drawing general conclusions, which underscores the need for further research to confirm the findings and enhance their reliability. Additionally, three of the six studies included were cross-sectional, making it impossible to establish causal relationships.

This review identifies promising evidence for the potential benefits of MD in managing ADHD and OCTD symptoms. However, further well-designed prospective studies are necessary to track changes over time in ADHD and OCTD symptoms alongside with measuring the adherence to the MD, which could help establish a possible causal relationship between the MD and symptom improvement. Future research should not only corroborate these findings but also explore how adherence to the MD, as assessed by validated scoring systems, influences other SEN like ASD, where preliminary evidence suggests an association between its symptomatology and specific MD components.

Conclusions

This review consistently demonstrates that better adherence to the MD is associated with a lower prevalence and severity of symptoms of SEN in children and adolescents. Specifically, adherence to the MD may decrease the likelihood of being diagnosed with ADHD and can also alleviate symptoms of ADHD and OCTD. While research suggest that dietary interventions promoting the MD could be advantageous in managing or potentially lowering the risk of SEN, future research is still necessary to confirm these findings and explore whether the MD could be beneficial for other SEN as well.

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