Journal of Multidisciplinary Healthcare

Dovepress
open access to scientific and medical research

Open Access Full Text Article

REVIEW

Nutritional Status and Dietary Behaviors of Children with Intellectual or Developmental Disabilities in Saudi Arabia: A Systematic Review

Nora A AlFaris[1], Naseem M Alshwaiyat[2], Jozaa Z ALTamimi[1], Reham I Alagal[3], Saleh M AlSalehi[4], Raed I Al Zarah[5], Razan F Alfaiz[5], Ameera I Alhariqi[5], Dalal F Alshamri[6], Noura A AlSouan[6], Lujain A AlMousa[3]

[1]Department of Physical Sports Sciences, College of Sports Sciences & Physical Activity, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia; [2]Department of Nutrition and Food Technology, Faculty of Agriculture, Jordan University of Science and Technology, Irbid, Jordan; [3]Department of Health Sciences, College of Health and Rehabilitation Sciences, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia; [4]Child Development Center, King Abdullah Bin Abdulaziz University Hospital (KAAUH), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia; [5]Department of Pediatrics, King Abdullah bin Abdulaziz University Hospital (KAAUH), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia; [6]Department of Clinical Nutrition, King Abdullah Bin Abdulaziz University Hospital (KAAUH), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia

Correspondence: Lujain A AlMousa, Email laalmousa@pnu.edu.sa

Abstract: Children with intellectual or developmental disabilities are susceptible to malnutrition. This systematic review was conducted to assess the nutritional status and dietary behaviors of children with intellectual or developmental disabilities in Saudi Arabia. The target population was children from Saudi Arabia aged 18 years or younger and diagnosed with intellectual or developmental disabilities. Appropriate research studies that were published from inception up to December 2023 were obtained and reviewed. The outcomes of interest, including anthropometric data, laboratory data, dietary intake data, and dietary behaviors data, were collected and organized in relevant tables. The methodological quality and bias risk for the involved studies were evaluated. Out of 286 screened articles, 31 research articles were selected. The review results show that the rates of overweight and obesity were significantly higher among children with intellectual or developmental disabilities compared to typically developing children. The laboratory data revealed that they were more likely to have nutritional deficiencies. Low intake of energy, protein, and several micronutrients is frequently reported among them. Moreover, they are anticipated to have unhealthy dietary behavior. In conclusion, the findings suggested that children with intellectual or developmental disabilities were at higher risk of malnutrition including deploying obesity and nutritional deficiencies. Healthy and balanced nutrition that considers dietary requirements and food preferences is critical to maintaining the optimal development of these children. This review could invite researchers and policy-makers in Saudi Arabia to put more effort into integrating individuals with disability into the healthcare system and community. Further research is required to determine the types of intervention measures that can be taken to reduce the risk of malnutrition. Additional action is needed to monitor the implementation of national policies and programs that target this part of society.

Keywords: nutritional status, dietary behaviors, intellectual or developmental disabilities, children, Saudi Arabia

Introduction

Worldwide, more than 290 million children are disabled.[1] A disability could contribute to the development of malnutrition through several pathways.[2] Malnutrition and disability interplay in various manners. Disability-associated feeding difficulties, nutritional inadequate absorption, and social isolation are a few forms in which disability might raise the likelihood of malnutrition.[3] In comparison to children without disabilities, those with disabilities had a three-fold increased risk of malnutrition.[4] Furthermore, children with disability are more likely to experience detrimental consequences from malnutrition, including higher mortality rates.[5]

Received: 10 April 2024
Accepted: 27 June 2024
Published: 12 July 2024

The risk of malnutrition can be increased among disabled children due to several factors, such as long-term restrictive diets, the existence of medical comorbidities, hyperactivity, unhealthy feeding patterns, and family dietary behaviors.[6] Undernutrition can have a substantial negative influence on the health status and quality of these children.[7] Moreover, children with disabilities may be more susceptible to becoming overweight or obese, which can be linked to side effects from psychiatric medications, sleep issues, the home environment, challenges with motor skills, physical inactivity, sedentary lifestyle, diet selection, and a craving for high-energy foods.[8] On the other hand, they are at higher risk of nutritional deficiencies such as deficiency of several vitamins and minerals, which could negatively affect their growth and development.[9]

Prenatal and neonatal diet quality could be the root cause of many childhood disabilities by impacting epigenetic inheritance.[10] Increasing rates of disability are associated with the neonatal diet and the prenatal consumption of ultra-processed foods and nutritional deficits.[10] The processes used in the production of many food ingredients result in the widespread presence of heavy metal residues in the food system. Children who consume food loaded with heavy metal residues could build up lead and mercury in their blood and have signs of disabilities such as autism.[11] Furthermore, exposure to heavy metal residues during pregnancy may affect a child's gene function and cause intellectual or developmental impairments.[12] If families do not improve their diets, disability prevalence will continue to rise.[13]

In Saudi Arabia, the disability prevalence in 2016 was estimated at 3.3% of the population (about 0.7 million out of 20 million), which is lower than the global disability rate (15%).[14] Moreover, the disability rate among Saudi children aged 19 years or younger was 2.7% (about 0.2 million out of 7.8 million).[14] The general healthcare system and the disability care services in Saudi Arabia have been progressively developed in terms of facilities and professional staff during the last few decades.[15] The governmental and private sectors are being promoted to invest more in consumer access to healthcare.[15] Healthcare facilities are establishing human rights committees to oversee the rights of individuals with disabilities.[16] Scientific research on disability has steadily increased in Saudi Arabia.[17] However, many challenges are faced in Saudi Arabia regarding the public health and disability sector. To effectively integrate individuals with disabilities into the community, a more efficient healthcare system that provides equitable treatment, patient rights insurance, and financial support for families with limited resources is required.[15] Furthermore, governmental bodies should spend additional funds on disability management. Hospitals and healthcare facilities should upgrade their infrastructure and qualified staff to deliver high-quality healthcare for disabled patients.[18,19] It is important to monitor the implementation of national policies and programs that are designed to integrate disabled patients with the public health system and community.[15]

The current study aims to review the research findings related to the nutritional status and dietary behaviors of children with intellectual or developmental disabilities (IDD) in Saudi Arabia. This systematic review is noteworthy because it offers a thorough summary of the data that is currently available regarding the nutritional status and dietary behaviors of children with IDD in Saudi Arabia. In addition, methodological issues and research gaps were emphasized, which can aid in boosting the quality of subsequent studies from Saudi Arabia in this field. The current study is founded on the following assumptions. First, a limited number of studies examined the nutritional status and dietary behaviors of children with IDD in Saudi Arabia. Second, these studies commonly assessed only specific aspects of nutritional status and dietary behaviors. Third, the outcomes of these studies were highly variable.

Methods

In the current review, IDD are disorders that typically manifest from birth and have an adverse effect on an individual's physical, intellectual, and/or emotional development pathway. The IDD cases included in this review are autism spectrum disorder (ASD), Down syndrome (DS), attention deficit hyperactivity disorder (ADHD), and cerebral palsy (CP). Throughout the review, the PRISMA guidelines were adhered to.[20] The study protocol was registered on the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY). The registration number is INPLASY202420055.

Research Questions Identifying

The current study was carried out to find answers to several questions. First, what are the findings that can be collected from available literature related to nutritional status among children with IDD from Saudi Arabia? Second, what are the findings of available literature related to dietary behaviors among children with IDD from Saudi Arabia? Finally, what are the research gaps and methodological issues that can be emphasized in the available literature to help improve future research?

Literature Search Strategy

The literature search was handled by two authors to locate appropriate research articles that had been published up to December 2023 in Web of Science, Scopus, PubMed, and Google Scholar databases. Used keywords were grouped into four types of terms: target population terms (children, child, adolescents, teens, teenagers, youth, boys, girls, and toddlers), IDD terms (intellectual disabilities, developmental disabilities, intellectual disability, developmental disability, Down syndrome, attention deficit hyperactivity disorder, ADHD, autism spectrum disorders, ASD, autism, autistic, and cerebral palsy), nutritional status and dietary behavior terms (nutritional status, nutrition, malnutrition, weight, body mass index, BMI, diet, dietary behaviors, food, feeding behavior, eating, and meals), and geographic location terms (Saudi Arabia, Saudi, Kingdom of Saudi Arabia, KSA, Riyadh, Jeddah, Mecca, Medina, and Dammam). The Boolean operator (OR) was used between the search keywords within each type of terms, while the Boolean operator (AND) was used between different types of terms.

Study Selection

Based on predetermined inclusion criteria, appropriate research articles were chosen. The inclusion criteria include 1) research articles issued in English in peer-reviewed journals, 2) The target population was children aged 18 years or younger, of both genders, 3) the children should be diagnosed with one of IDD, including ASD, DS, ADHD, and CP, 4) the study objectives include assessing nutritional status or dietary behaviors of children with IDD, and 5) the study should be conducted in Saudi Arabia. Assessing nutritional status could be seen as an anthropometric assessment, such as measuring height, weight, circumferences, or body mass index, laboratory assessment, such as measuring serum proteins, metabolites, electrolytes or vitamins, or dietary assessment, such as evaluating macronutrients and micronutrients intake. Assessing dietary behaviors could be seen as evaluating behaviors related to food such as daily meals and snacks frequency, mealtime behaviors, and feeding difficulties. The selection of appropriate studies was done in two stages. First, two separate authors evaluated the titles and abstracts of the gathered papers to determine their relevance based on the inclusion criteria. Second, the same two authors gathered and reviewed the complete texts of selected articles in the first stage to confirm their relevance for this systematic review. A third author compared the data gathered by each author after each phase, discussing and fine-tuning any discrepancies. The final list of appropriate studies was established.

Data Collection

The relevant data were gathered from the chosen research articles. The collected data include general characteristics of selected studies such as type of recruited cases, sample sizes, study design, objectives, and location. Then, the outcomes of interest, including anthropometric data, laboratory data, dietary intake data, or dietary behaviors data, were collected. Data collected from the included studies were organized in relevant tables.

Quality Assessment

The methodological quality and bias risk were evaluated by two authors. When there were discrepancies, a third author was consulted to settle any disputes. The Quality Criteria Checklist of the Academy of Nutrition and Dietetics was employed.[21] The reviewers evaluated each study based on ten criteria, which included research question, selection, study groups comparable, withdrawals, blinding, intervention, outcomes, statistical analysis, conclusions supported by results, and funding or sponsorship.[21] Following a review of the Methods section of each study, an overall rating was assigned using the Quality Criteria Checklist. If five or more items—including items 2, 3, 6, and 7—are answered "Yes", the study

is rated positively, and there is less chance of bias. A neutral rating is given if five or more items are marked as "Yes", but the responses to questions 2, 3, 6, or 7 fail to indicate that the study is particularly strong. If the response to six or more items is "No", the rating is considered negative.[21]

Results

Study Description

Out of 286 screened articles, 31 papers were selected (see Figure 1). The characteristics of selected articles are presented in Table 1. All articles were issued between 2003 and 2023. Most of them were targeted subjects diagnosed with ASD (n = 18), followed by DS (n = 7), CP (n = 3), and ADHD (n = 1), and two studies included subjects diagnosed with ASD, DS, and CP. The majority of the studies had observational study designs, either cross-sectional (n = 12) or case–control (n = 8). However, the study design for nine studies was not reported, although it can be implied that these studies were observational. One study was with a prospective design, while another study was with a retrospective design. Most studies were conducted in the city of Riyadh (n = 18), followed by Taif (n = 3), Madinah (n = 2), Makkah (n = 1), and

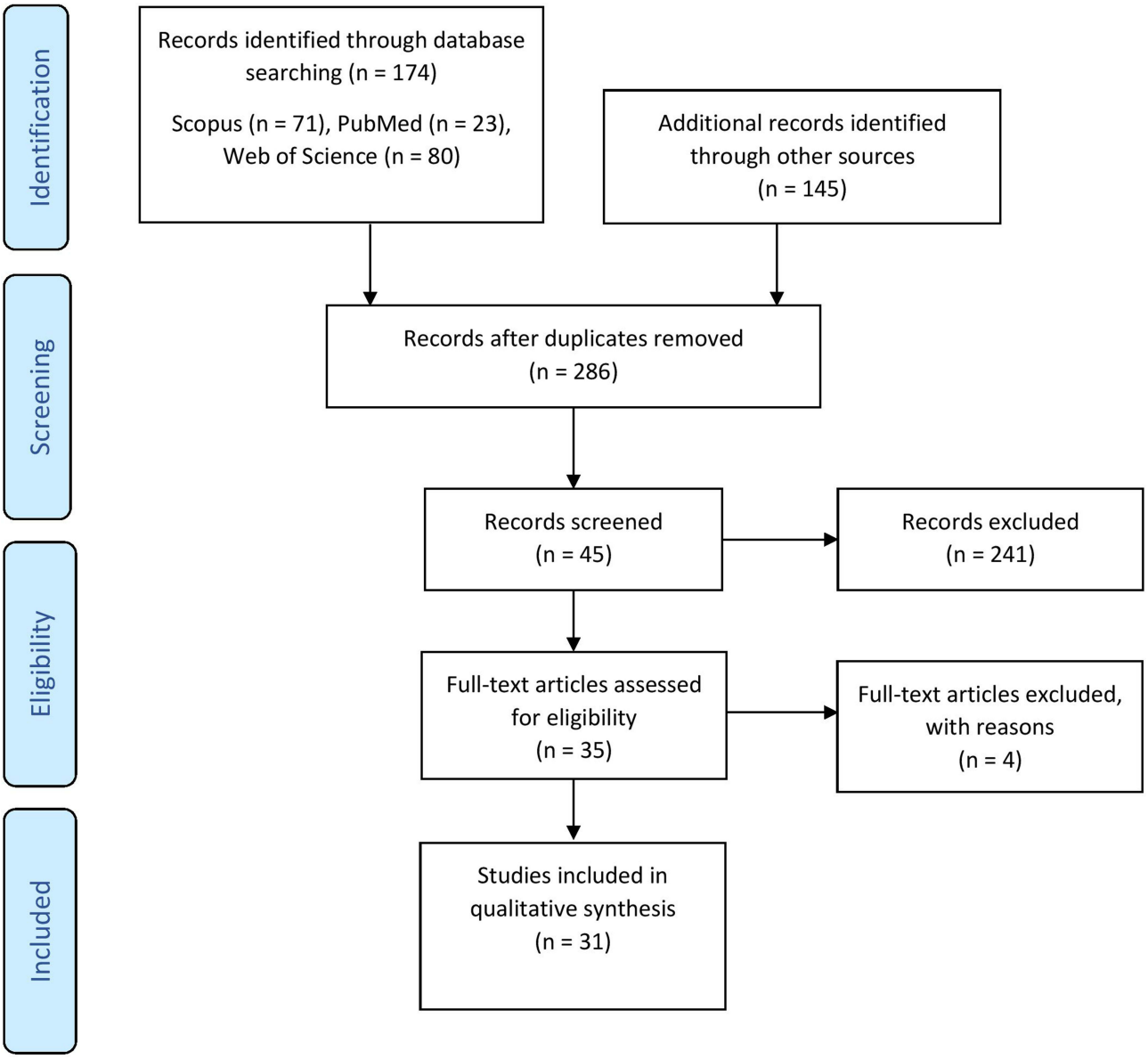

Figure 1 Flowchart illustrating the selection process for studies included in the systematic review.

Table 1 Characteristics of Selected Studies Included in the Systematic Review (n = 31)

No.	Studies (Authors, Year)	Type of Cases*	Study Design	Study Objectives	Study Location	Data Collection Period	Sample Size	Age (Years)	Cases Recruitment	Control Recruitment
1	Al Husain, 2003a[22]	DS	Cross-sectional study	Assess the prevalence of overweight/obesity and establish reference BMI percentile curves for children with DS	Riyadh	January to December 2001	Cases: 785 (M/F: 393/392) Control: 989 (M/F: 591/470)	0–5	Genetic and the General Pediatric Clinics at King Khalid University Hospital, Riyadh	NR
2	Al Husain, 2003b[23]	DS	Cross-sectional study	Construct growth charts for Saudi children under 5 years of age with DS	Riyadh	January to December 2001	Cases: 785 (M/F: 393/392) Control: 989 (M/F: 591/470)	0–5	Genetic and the General Pediatric Clinics at King Khalid University Hospital, Riyadh	NR
3	Alsulaimani et al, 2014[24]	ASD	Case-control study	Determine possible risk factors for autism	Taif	June 2011 to May 2013	Cases: 60 (M/F: 46/14) Control: 120 (M/F: 92/28)	1.6–8	Mental Health Clinic integrated in Pediatric Clinic, Prince Mansour Military Hospital, Taif	Outpatient Clinics, Prince Mansour Military Hospital, Taif
4	Alhusaini et al, 2018[25]	DS	Cross-sectional study	Compare physical activity levels between children with DS and typically developing children	Riyadh	NR	Cases: 37 (M) Control: 41 (M)	8–12	Al-Nahda School for Down Syndrome and Down Syndrome Charitable Association, Riyadh	Two regular schools, Riyadh
5	Allam et al, 2020[26]	DS	Cross-sectional study	Compare the walking capacity of children with DS to typically developing children	Riyadh	NR	Cases: 37 (M) Control: 41 (M)	8–12	Al-Nahda School for Down Syndrome and Down Syndrome Charitable Association, Riyadh	Two regular schools, Riyadh
6	Mohamed et al, 2013[27]	DS	NR	Investigate dietary practice and physical activity among children with DS	Riyadh	February to May 2011	Cases: 108 (M/F: NR) Control: 113 (M/F: NR)	5–12	Al-Nahda School for Down Syndrome and Down Syndrome Charitable Association, Riyadh	Healthy, age-matched siblings
7	Bindayel, 2021[28]	DS	Cross-sectional study	Determine the prevalence of overweight and obesity in children and adolescents with DS	Riyadh	NR	Cases: 48 (M/F: 22/26) Control: 27 (M/F: 12/15)	3–18 3–12 (children) 13–18 (adolescents)	The Voice of Down Syndrome Society (SAUT) and Down Syndrome Charitable Association (DSCA), Riyadh	Healthy, age-matched siblings
8	Samarkandy et al, 2012[29]	DS	Case-control study	Assess nutritional status and prevalence of obesity among children with DS	Riyadh	February to May 2011	Cases: 108 (M/F: 62/46) Control: 113 (M/F: 60/53)	5–12	Al-Nahda School for Down Syndrome and Down Syndrome Charitable Association, Riyadh	Healthy, age-matched siblings
9	Alahmari et al, 2022[30]	ASD	Case-control study	Compare the nutritional status of children with ASD to typically developing children	NR	November 2020 to March 2021	Cases: 70 (M/F: NR) Control: 85 (M/F: NR)	7–12	Autism centers (location: NR)	One elementary school (location: NR)
10	Hammouda et al, 2018[31]	ASD	Case-control study	Identify nutritional risk factors that predispose to autism	Madinah	February to April 2014	Cases: 30 (M/F: NR) Control: 36 (M/F: NR)	2–10	Pediatric Psychiatry Outpatient Clinic and Autism Day Care Center, Al-Amal Psychiatric Hospital, Madinah	Taibah University and Nabaa AL-Maref Nursery for the young age group, Madinah

(*Continued*)

https://doi.org/10.2147/JMDH.S473107 DovePress

Table 1 (Continued).

No.	Studies (Authors, Year)	Type of Cases*	Study Design	Study Objectives	Study Location	Data Collection Period	Sample Size	Age (Years)	Cases Recruitment	Control Recruitment
11	Ashour et al, 2018[32]	ASD, DS, CP	Cross-sectional study	Investigate the association between dental caries and obesity	Makkah	October to December 2016	ASD: 41 (F) DS: 52 (F) CP: 17 (F)	6–17	Nineteen special care schools, Makkah	NA
12	Al-Blowi et al, 2020[33]	CP	Retrospective cohort study	Evaluate the nutritional status of children with CP	Madinah	January 2012 to December 2016	Cases: 119 (M/F: 56/63)	5.9 ± 3.9 (mean ± SD)	Maternity and Children's Hospital, Madinah	NA
13	Kasnawi & Jambi, 2020[34]	ASD	Cross-sectional study	Investigate the association of Food Selectivity domains with nutritional adequacy in autistic children	Two cities in the western region	September to December 2014	Cases: 32 (M/F: 28/4)	6–12	Six autism centres in two cities in the western region	NA
14	Mohamed et al, 2021[35]	ASD, DS, CP, ID	Cross-sectional study	Assess the association between dental caries and obesity	Taif	September 2018 to March 2019	ASD: 107 (M/F: NR) DS: 70 (M/F: NR) CP: 43 (M/F: NR) ID: 123 (M/F: NR)	6–12	Twenty-five regular schools, Taif (only children with special needs were selected)	NA
15	Almuneef et al, 2019[36]	CP	Cross-sectional study	Assess the nutritional status of children with CP	Riyadh	January to August 2015	Cases: 74 (M/F: 44/30)	1–12	Cerebral Palsy Clinic, Sultan Bin Abdulaziz Humanitarian City (SBAHC), Riyadh	NA
16	Elshorbagy et al, 2018[37]	ADHD	Case-control study	Evaluate serum vitamin D levels in children diagnosed with ADHD	Taif	December 2015 to January 2017	Cases: 50 (M/F: 28/22) Control: 40 (M/F: 21/19)	7–14	Pediatric Neuropsychiatric Outpatient Clinic, Al Hada and Taif Military Hospitals, Taif	Primary health care centers, Taif
17	El-Ansary et al, 2018[38]	ASD	Cross-sectional study	Determine the relationship between vitamin D levels and selected biomarkers	Riyadh	NR	Cases: 28 (M) Control: 27 (M)	3–12	Autism Research and Treatment Center, Faculty of Medicine, King Saud University, Riyadh	Well Baby Clinic at King Khalid University Hospital, Riyadh
18	Mostafa & AL-Ayadhi, 2012[39]	ASD	Cross-sectional study	Investigate the relationship between serum vitamin D levels and anti-myelin-associated glycoprotein auto-antibodies	Riyadh	NR	Cases: 50 (M/F: 39/11) Control: 30 (M/F: 24/6)	5–12	Autism Research and Treatment Center, Faculty of Medicine, King Saud University, Riyadh	Well Baby Clinic at King Khalid University Hospital, Riyadh
19	Al-Gadani et al, 2009[40]	ASD	NR	Measure oxidative stress/ antioxidant status in autistic children	NR	NR	Cases: 30 (M/F: 22/8) Control: 30 (M/F: 20/10)	3–15	NR	NR
20	Azhari, 2023[41]	ASD	Prospective study	Assess vitamin D levels in ASD children and the effects of vitamin D supplementation	NR	January to July 2022	Cases: 11 (M/F: 9/2)	4–12	Will Be Center for Special Needs and The Leading Academy for Autism, (location: NR)	NA
21	El-Ansary et al, 2011a[42]	ASD	NR	Compare plasma fatty acid profiles of autistic children with typically developing children	Riyadh	NR	Cases: 26 (M/F: NR) Control: 26 (M/F: NR)	4–12 (Cases) 4–11 (Control)	Autism Research and Treatment Center, Faculty of Medicine, King Saud University, Riyadh	Well Baby Clinic at King Khalid University Hospital, Riyadh

22	El-Ansary et al, 2010[43]	ASD	NR	Investigate the role of selected ions related to energy metabolism in deterioration accompanied ASD	NR	NR	Cases: 30 (M/F: 22/8) Control: 30 (M/F: 20/10)	3–15	NR	NR
23	El-Ansary et al, 2011c[44]	ASD	NR	Investigate the relationship between concentrations of selected ions and proinflammatory and proapoptotic biomarkers	Riyadh	NR	Cases: 25 (M) Control: 16 (M)	4–12 (Cases) 4–11 (Control)	Autism Research and Treatment Center, Faculty of Medicine, King Saud University, Riyadh	Well Baby Clinic at King Khalid University Hospital, Riyadh
24	El-Ansary, 2017[45]	ASD	NR	Assess the relative abundance of lead, mercury, and selenium in red blood cells (RBCs)	Riyadh	NR	Cases: 35 (M) Control: 30 (M)	3-12	Autism Research and Treatment Center, Faculty of Medicine, King Saud University, Riyadh	Well Baby Clinic at King Khalid University Hospital, Riyadh
25	Mostafa & AL-Ayadhi, 2015[46]	ASD	Case-control study	Investigate plasma levels of PUFAs and serum carnitine in relation to GI manifestations	Riyadh	NR	Cases: 100 (M/F: 78/22) Control: 100 (M/F: 78/22)	3–10	Autism Research and Treatment Center, Faculty of Medicine, King Saud University, Riyadh	Well Baby Clinic at King Khalid University Hospital, Riyadh
26	El-Ansary et al, 2011b[47]	ASD	NR	Compare plasma relative concentrations of essential fatty acids of autistic children with typically developing children	Riyadh	NR	Cases: 25 (M/F: NR) Control: 16 (M/F: NR)	4–12 (Cases) 4–11 (Control)	Autism Research and Treatment Center, Faculty of Medicine, King Saud University, Riyadh	Well Baby Clinic at King Khalid University Hospital, Riyadh
27	AlOmar et al, 2021[48]	ASD	Case-control study	Study the role of a vitamin D deficient diet in the development of ASD	Arar & Dammam	NR	Cases: 100 (M/F: 76/24) Control: 100 (M/F: 53/47)	3–10	Child psychiatry clinic of Al Amal Mental health complex, Arar; Shumua Al Amal Centre for Special Education and Rehabilitation; Shamah Autism Centre and Prince Sultan Rehabilitation Complex, Dammam	Department of Paediatrics, Arar Maternity and Child Health Centre, Arar; Baraam AlSharqiyah School, Dammam
28	Bin Ammar & Almuhaini, 2022[49]	ASD	Case-control study	Evaluate the dietary habits of autistic children	Hail	March to April 2022	Cases: 80 (M/F: 54/26)	4–12	Tawasol Medical Centres for Autism and Hdka Medical Centre for Autism, Hail	NA
29	Bin Eid et al, 2022[50]	ASD	NR	Assess sleep in both children with ASD and typically developing children	Riyadh	NR	Cases: 81 (M/F: 67/14) Control: 78 (M/F: 36/41)	5–12	One large special care school and two ASD centres, Riyadh	Regular schools, Riyadh
30	Murshid, 2014[51]	ASD	Cross-sectional study	Assess the diet, oral hygiene and dental health of autistic children	Riyadh	May 2012	Cases: 344 (M/F: 261/83)	3–14	Three autistic rehabilitation centers, Riyadh	NA
31	Al-Hammad, 2015[52]	CP	NR	Determine dietary practices of children with CP	Riyadh	NR	Cases: 157 (M/F: 90/67)	2–10	Disabled Children's Association Center (DCAC), Riyadh	NA

Notes: *ASD: Autism Spectrum Disorder; DS: Down Syndrome; CP: Cerebral Palsy; ADHD: Attention Deficit Hyperactivity Disorder; ID: Intellectual Disability; NA: Not Applicable; NR: Not Reported; M: Male; F: Female.

https://doi.org/10.2147/JMDH.S473107

Hail (n = 1), and two studies were recruited subjects from two different cities for each study. However, the study locations for four studies were not reported. Twenty-two out of 31 included studies recruited typically developing children as a control for comparison, in addition to recruitment of children with IDD (cases). The sample size varies considerably among different included articles. There was a range of 11 to 785 participants in the case group and 16 to 989 participants in the control group.

Risk of Bias Assessment

Out of 31 papers, 15 articles had a positive rating, indicating a high-quality study and a lower risk of bias (Table 2). Furthermore, 16 studies had a neutral rating, demonstrating a study of moderate quality and risk of bias. Interestingly, no

Table 2 Risk of Assessment Bias for Selected Studies Included in the Systematic Review (n = 31)

No.	Studies (Authors, Year)	Q1*	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Rating
1	Al Husain, 2003a[22]	Y	U	Y	Y	NA	Y	Y	Y	N	N	Neutral
2	Al Husain, 2003b[23]	Y	Y	Y	Y	NA	Y	Y	Y	U	N	Positive
3	Alsulaimani et al, 2014[24]	Y	Y	Y	N	NA	Y	Y	Y	Y	N	Positive
4	Alhusaini et al, 2018[25]	Y	N	Y	Y	NA	Y	Y	Y	Y	Y	Neutral
5	Allam et al, 2020[26]	Y	N	Y	Y	NA	Y	Y	U	Y	Y	Neutral
6	Mohamed et al, 2013[27]	Y	Y	Y	N	NA	Y	Y	Y	Y	N	Positive
7	Bindayel, 2021[28]	Y	Y	Y	Y	NA	Y	Y	Y	Y	Y	Positive
8	Samarkandy et al, 2012[29]	Y	Y	Y	N	NA	Y	Y	Y	Y	N	Positive
9	Alahmari et al, 2022[30]	Y	N	Y	N	NA	Y	Y	Y	Y	Y	Neutral
10	Hammouda et al, 2018[31]	Y	U	Y	N	NA	Y	Y	Y	Y	N	Neutral
11	Ashour et al, 2018[32]	Y	Y	N	N	NA	Y	Y	Y	Y	N	Neutral
12	Al-Blowi et al, 2020[33]	Y	Y	N	N	NA	Y	Y	Y	Y	N	Neutral
13	Kasnawi & Jambi, 2020[34]	Y	Y	N	N	NA	Y	Y	Y	Y	N	Neutral
14	Mohamed et al, 2021[35]	Y	Y	N	N	NA	Y	Y	Y	Y	Y	Neutral
15	Almuneef et al, 2019[36]	Y	Y	N	Y	NA	Y	Y	Y	Y	Y	Neutral
16	Elshorbagy et al, 2018[37]	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Positive
17	El-Ansary et al, 2018[38]	Y	Y	Y	U	NA	Y	Y	Y	Y	Y	Positive
18	Mostafa & AL-Ayadhi, 2012[39]	Y	Y	Y	N	NA	Y	Y	Y	Y	Y	Positive
19	Al-Gadani et al, 2009[40]	Y	U	Y	N	NA	Y	Y	Y	N	N	Neutral
20	Azhari, 2023[41]	Y	Y	N	N	NA	Y	Y	Y	Y	Y	Neutral
21	El-Ansary et al, 2011a[42]	Y	Y	Y	N	NA	Y	Y	Y	U	Y	Positive
22	El-Ansary et al, 2010[43]	Y	Y	Y	N	NA	Y	Y	Y	N	Y	Positive
23	El-Ansary et al, 2011c[44]	Y	Y	Y	N	NA	Y	Y	Y	N	Y	Positive
24	El-Ansary, 2017[45]	Y	Y	Y	N	NA	Y	Y	Y	Y	Y	Positive

(*Continued*)

Table 2 (Continued).

No.	Studies (Authors, Year)	Q1*	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Rating
25	Mostafa & AL-Ayadhi, 2015[46]	Y	Y	Y	N	NA	Y	Y	Y	Y	Y	Positive
26	El-Ansary et al, 2011b[47]	Y	Y	Y	N	NA	Y	Y	Y	U	Y	Positive
27	AlOmar et al, 2021[48]	Y	Y	Y	N	NA	U	N	Y	N	Y	Neutral
28	Bin Ammar & Almuhaini, 2022[49]	Y	Y	N	N	NA	N	Y	Y	U	Y	Neutral
29	Bin Eid et al, 2022[50]	Y	Y	Y	Y	NA	Y	Y	Y	U	Y	Positive
30	Murshid, 2014[51]	Y	Y	N	Y	NA	Y	Y	Y	Y	N	Neutral
31	Al-Hammad, 2015[52]	Y	Y	N	N	NA	Y	Y	Y	Y	Y	Neutral

Notes: *Q: Question; Y: Yes; N: No; NA: Not Applicable; U: Unclear.

studies had been given a negative rating. Clear research questions were observed in all studies. Most studies were found to be free from selection bias (n = 25), and bias due to the study's funding or sponsorship (n = 19), and had comparable study groups (n = 22), description of intervention/exposure in detail (n = 29), clear outcomes, valid and reliable measurements (n = 30), appropriate statistical analysis (n = 30), and conclusions that supported by Results (n = 21). However, a few studies were included a clear description of study withdrawal handling (n = 9), and only one study included blinding that was used to prevent the introduction of bias as most included selected studies had observational designs.

Systematic Review Findings

Anthropometric Data

Anthropometric data are shown in Table 3. Out of 31 selected articles, 15 studies involved anthropometric data. Collected anthropometric data includes height, weight, BMI, BMI categories, and others. Seven different studies reported data on each of the following measurements: height, weight, and BMI. In an attempt to develop growth charts for children with DS aged one month to five years, height, weight and BMI were reported based on gender for six age intervals.[22,23] For boys with DS, the BMI means were significantly lower than the control for age intervals 0–0.5 years, and 0.5–1 years, and significantly higher than the control for age intervals 3–4 years, and 4–5 years. For girls with DS, the BMI means were significantly lower than the control for age intervals 0–0.5 years, 0.5–1 years, and 1–2 years, and significantly higher than the control for age intervals 3–4 years, and 4–5 years.[22,23] Differences in height and weight were statistically not significant (P = 0.812) between autistic children and control.[24] Although children with DS were found to be significantly shorter than the control (P = 0.003), no significant differences in weight, or BMI between cases and control were observed.[25,26] A similar result was observed among children with DS stratified based on gender compared with control regarding height and weight.[27] However, boys and girls with DS significantly had greater BMI than control.[27] Although adolescents with DS were significantly shorter (P = 0.009) and had greater BMI (P = 0.029) than control, no significant difference in height, weight, or BMI between children with DS and control was reported.[28] Finally, the mean BMI for DS children was significantly higher than control.[29]

The rates of overweight and obesity were included in nine studies. Two studies reported a greater prevalence of overweight and obesity in DS children compared with control.[25,29] Another study observed that the rate of obesity was greater in children and adolescents with DS compared with control.[28] The rate of obesity was found to be greater in autistic children compared with control in two reports.[30,31] Finally, four articles reported overweight and obesity rates in children with ASD, DS, and/or CP without comparing results with control.[32–35] Other reported anthropometric indicators

Table 3 Anthropometric Assessment Reported in Selected Studies Included in the Systematic Review (n = 15)

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Height (cm) mean ± SD	Weight (kg) mean ± SD	BMI (kg/m2) mean ± SD	BMI Categories n (%)	Others
1	Al Husain, 2003a[22]	DS, M (n = 393)	0–0.5 0.5–1 1–2 2–3 3–4 4–5			15.0 ± 2.2 16.6 ± 2.3 16.7 ± 2.7 16.3 ± 1.6 16.4 ± 1.6 17.1 ± 2.9		
		Control, M (n = 591)	0–0.5 0.5–1 1–2 2–3 3–4 4–5			16.4 ± 2.3 17.5 ± 1.8 17.1 ± 1.8 16.4 ± 3.0 15.1 ± 1.6 15.0 ± 1.3		
		P value	0–0.5 0.5–1 1–2 2–3 3–4 4–5			0.0002 0.0106 0.2344 0.7989 0.0001 0.0001		
		DS, F (n = 392)	0–0.5 0.5–1 1–2 2–3 3–4 4–5			13.6 ± 2.2 15.7 ± 1.9 15.9 ± 2.0 15.8 ± 2.0 16.0 ± 1.5 16.5 ± 2.3		
		Control, F (n = 470)	0–0.5 0.5–1 1–2 2–3 3–4 4–5			16.4 ± 1.9 17.5 ± 1.9 17.1 ± 2.6 15.5 ± 1.7 14.9 ± 1.4 14.8 ± 1.8		
		P value	0–0.5 0.5–1 1–2 2–3 3–4 4–5			0.0001 0.0001 0.0003 0.3714 0.0001 0.0001		

2	Al Husain, 2003b[23]	DS, M (n = 393)	 0–0.5 0.5–1 1–2 2–3 3–4 4–5	 56.4 ± 6.3 66.1 ± 2.9 74.99 ± 5.9 84.2 ± 5.4 88.1 ± 8.3 95.8 ± 10.9	 4.9 ± 1.74 7.3 ± 1.4 9.5 ± 2.1 11.63 ± 1.9 13.0 ± 1.7 15.95 ± 3.3			Head circumference (cm) 38.02 ± 3.5 41.9±2.3 43.7 ± 2.1 45.6 ± 2.5 46.9 ± 1.99 48.2 ± 2.4
		DS, F (n = 392)	 0–0.5 0.5–1 1–2 2–3 3–4 4–5	 55.9 ± 5.3 65.23 ± 3.6 73.5 ± 6.2 81.75 ± 3.9 89.0 ± 4.9 96.5 ± 6.96	 4.35 ± 1.4 6.7 ± 1.2 8.6 ± 1.7 10.6 ± 1.7 12.7 ± 1.99 15.5 ± 3.6			Head circumference (cm) 36.73 ± 2.64 40.99 ± 1.7 43.4 ± 2.1 44.9 ± 1.97 46.3 ± 2.3 48.3 ± 2.5
3	Alsulaimani et al, 2014[24]	ASD (n = 60)	1.6–8, 3.1 ± 1.3	95 ± 10	15 ± 5			
		Control (n = 120)	1.6–8, 3.1 ± 1.3	96 ± 10	14 ± 4			
		P value		0.812	0.531			
4	Alhusaini et al, 2018[25]	DS (n = 37)	8–12, 10.22 ± 1.31	127.41 ± 15.50	42.10 ± 16.28	24.43 ± 7.82	UWT: 0 (0.0%) NWT: 11 (29.7%) OWT: 13 (35.1%) Obese: 13 (35.1%)	
		Control (n = 41)	8–12, 10.53 ± 1.71	138.02±14.49	41.94 ± 21.26	21.23 ± 4.50	UWT: 0 (0.0%) NWT: 26 (63.4%) OWT: 8 (19.5%) Obese: 7 (17.1%)	
		P value	0.28	0.003	0.97	0.23	NR	
5	Allam et al, 2020[26]	DS (n = 37)	8–12, 10.22 ± 1.31	127.4 ± 15.49		24.42 ± 7.81		
		Control (n = 41)	8–12, 10.52 ± 1.17	138.02 ± 14.49		21.23 ± 4.5		
		P value	0.282	0.003		0.028		
6	Mohamed et al, 2013[27]	DS, M (n = NR)	5–12, 8.2 ± 1.7	108 ± 9.9	22.2 ± 7.7	19.1 ± 4.1		

(*Continued*)

https://doi.org/10.2147/JMDH.S473107

Table 3 (Continued).

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Height (cm) mean ± SD	Weight (kg) mean ± SD	BMI (kg/m2) mean ± SD	BMI Categories n (%)	Others
		Control, M (n = NR)	5–12, 8.9 ± 1.4	124 ±12.9	26.1 ± 7.8	16.9 ± 3.4		
		P value	0.115	0.001	0.054	0.013		
		DS, F (n = NR)	5–12, 7.9 ± 1.5	105.75 ± 8.3	20.4 ± 6.3	18.5 ± 3.1		
		Control, F (n = NR)	5–12, 8.1 ± 1.6	115.1 ± 10.1	21.5 ± 4.9	16.3 ± 1.9		
		P value	0.523	0.001	0.921	0.039		
7	Bindayel, 2021[28]	DS, Children (n = 28)	3–12, 7 ± 2	114.8 ± 11.3	26.3 ± 10.0	19.3 ± 4.0	UWT: 1 (4%) NWT: 8 (29%) OWT: 6 (21%) Obese: 13 (46%)	Lean Body Mass (kg): 10.5 ± 5.7 Fat Mass (kg): 22.3 ± 8.3 Body Fat (%): 38.89 ± 13.8 Ideal Body Fat (%): 15.88 ± 1.4
		Control, Children (n = 17)	3–12, 8 ± 3	116.6 ± 27.0‡	27.6 ± 10.6	19.7 ± 3.5‡	UWT: 0 (0%) NWT: 4 (33%)‡ OWT: 4 (33%) Obese: 4 (33%)	
		P value	0.167	0.841	0.676	0.783	0.775	
		DS, Adolescents (n = 20)	13–18, 15 ± 2	145.0 ± 8.3	59.02 ± 13.0	27.9 ± 5.5	UWT: 0 (0%) NWT: 5 (25%) OWT: 4 (20%) Obese: 11 (55%)	Lean Body Mass (kg): 14.4 ± 5.1 Fat Mass (kg): 34.7 ± 6.6 Body Fat (%): 35.30 ± 11.6 Ideal Body Fat (%): 20.05 ± 5.8
		Control, Adolescents (n = 10)	13–18, 17 ± 3	161.1 ± 22.0	55.8 ± 9.2	22.6 ± 5.8	UWT: 2 (20%) NWT: 4 (40%) OWT: 3 (30%) Obese: 1 (10%)	
		P value	0.188	0.009	0.494	0.029	0.038	
8	Samarkandy et al, 2012[29]	DS (n = 108)	5–12			17.8 ± 3.6	UWT: 0.0 (0.0%) NWT: 61 (56.5%) OWT: 22 (20.4%) Obese: 25 (23.1%)	Triceps Skinfold Thickness (mm): 9.1 ± 3.2 Excess Subcutaneous Fat (%): 9.3%
		Control (n = 113)	5–12			15.1 ± 2.7	UWT: 0.0 (0.0%) NWT: 99 (87.6%) OWT: 8 (7.1%) Obese: 6 (5.3%)	Triceps Skinfold Thickness (mm): 8.6 ± 2.6 Excess Subcutaneous Fat (%): 2.7%

		P value				0.03	<0.0001	Triceps Skinfold Thickness (mm): <0.001 Excess Subcutaneous Fat (%): 0.036
9	Alahmari et al, 2022[30]	ASD (n = 70)	7–12, 8.5 ± NR				UWT/NWT: 39 (55%) OWT/Obese: 31 (45%)	
		Control (n = 85)	7–12, 8.0 ± NR				UWT/NWT: 65 (77%) OWT/Obese: 20 (23%)	
		P value					NR	
10	Hammouda et al, 2018[31]	ASD (n = 30)	2–10, 4.9 ± 1.7				UWT: 7 (23.3%) NWT: 19 (63.3%) OWT: 0 (0.0%) Obese: 4 (13.3%)	
		Control (n = 36)	2–10, 4.9 ± 1.7				UWT: 3 (8.3%) NWT: 31 (86.1%) OWT: 0 (0.0%) Obese: 2 (5.6%)	
		P value	0.884				0.098	
11	Ashour et al, 2018[32]	ASD (n = 41)	6–17				UWT: 2 (4.8%) NWT: 23 (56.1%) OWT: 7 (17.1%) Obese: 9 (21.9%)	
		DS (n = 52)	6–17				UWT: 3 (5.7%) NWT: 24 (46.1%) OWT: 13 (25%) Obese: 12 (23.07%)	
		CP (n = 17)	6–17				UWT: 2 (11.7%) NWT: 9 (52.9%) OWT: 3 (17.6%) Obese: 3 (17.6%)	
12	Al-Blowi et al, 2020[33]	CP (n = 119)	5.9 ± 3.9				UWT: 101 (84.9%) NWT: 15 (12.6%) OWT: 3 (2.5%) Obese: 0 (0.0%)	
13	Kasnawi & Jambi, 2020[34]	ASD (n = 32)	6–12, 8.0 ± 2.3			15.9 ± 3.2	UWT: 9 (28.1%) NWT: 20 (62.5%) OWT: 1 (3.1%) Obese: 2 (6.2%)	

(*Continued*)

https://doi.org/10.2147/JMDH.S473107

Table 3 (Continued).

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Height (cm) mean ± SD	Weight (kg) mean ± SD	BMI (kg/m2) mean ± SD	BMI Categories n (%)	Others
14	Mohamed et al, 2021[35]	ASD (n = 107)	6–12				UWT: 5 (4.7%) NWT: 49 (45.8%) OWT: 15 (14%) Obese: 38 (35.5%)	
		DS (n = 70)	6–12				UWT: 2 (2.9%) NWT: 42 (60%) OWT: 15 (21.4%) Obese: 11 (15.7%)	
		CP (n = 43)	6–12				UWT: 3 (7%) NWT: 22 (51.2%) OWT: 3 (7%) Obese: 15 (34.8%)	
		ID (n = 123)	6–12				UWT: 7 (5.7%) NWT: 59 (47.9%) OWT: 32 (26.1%) Obese: 25 (20.3%)	
		P value					NR	
15	Almuneef et al, 2019[36]	CP (n = 74)	1–12, 5.6 ± 2.7					Weight-for-age-z-score (WAZ): −1.73 ± 1.02 Underweight (%):28.4% Height-for-age-z-score (HAZ): −1.30 ± 1.06 Stunting (%): 33.8% Weight-for-height-z-score (WHZ): −2.17 ± 1.30 Wasting (%): 25% BMI-for-age-z-score (BAZ): −1.68 ± 1.36 Thinness (%): 50% Malnutrition (%): 55.4%

Notes: *ASD: Autism Spectrum Disorder; DS: Down Syndrome; CP: Cerebral Palsy; ID: Intellectual Disability; NR: Not Reported; M: Male; F: Female; UWT: Underweight; NWT: Normal weight; OWT: Overweight. ‡Height information was not available for 5 healthy siblings, therefore, BMI and BMI-for-age for siblings are calculated for n=12.

include triceps skinfold thickness,[29] body fatness,[28,29] head circumference,[22,23] and z-scores for weight-for-height and weight-, height-, and BMI-for-age.[36]

Laboratory Data

Laboratory data are presented in Table 4. Out of 31 selected studies, 12 studies involved laboratory data. Collected laboratory data include serum levels of selected vitamins, minerals, and fatty acids, and specific hematological indices. Five studies reported data on serum concentrations of vitamins D, C, and E. In comparison with control, one study found that serum level of vitamin D was significantly lower among ADHD children,[37] while another two studies found that serum level of vitamin D was significantly lower among autistic children.[38,39] In another study, the serum level of vitamin E, but not vitamin C, was significantly lower in autistic children than in the control.[40] Furthermore, two studies reported the rate of vitamin D deficiency.[41,42]

Three studies reported data on serum levels of selected minerals among autistic children. These studies observed that autistic children had significantly lower serum concentrations of calcium and selenium, significantly higher serum concentrations of potassium, lead, and mercury than control, and/or no significant differences in serum concentrations of magnesium.[43–45]

Two studies reported data on serum levels of selected fatty acids among autistic children,[42,46] while serum fatty acid ratios were included in two studies.[46,47] One study observed that ASD children had significantly lower serum concentrations of several fatty acids such as a-linolenic, docosahexaenoic, and linoleic acids, significantly higher serum concentrations of certain fatty acids such as hexanoic, and stearidonic acids than control, and/or no significant differences in serum level of eicosapentaenoic acid.[42] Finally, hematological indices were reported in one study as the percentage of abnormal values of hemoglobin, hematocrit, and RBC counts.[36]

Dietary Intake Data

Results on dietary intake are presented in Table 5. Out of 31 selected studies, only four studies involved dietary intake data. One of these studies recruited only autistic children with no typically developing children as a control for comparison.[34] Collected dietary intake data include daily intake of energy, macronutrients, and micronutrients. Three studies reported data on energy intake. Even though differences were not significant, two studies found that energy intake was lower among children with DS and ASD, respectively, compared with control.[29,31] Contrarily, the third article observed that energy intake was significantly greater in autistic children than that reported for control.[30]

One study reported a significantly lower intake of protein, fat, vitamin A, riboflavin, sodium, potassium, and calcium among children with DS than that reported for control, and no significant difference in dietary intake of carbohydrates, fiber, carotene, vitamin C, thiamin, phosphorus, and iron.[29] Another study reported a significantly greater intake of vitamin C, and potassium, and a significantly lower intake of folic acid, vitamin B12, sodium, calcium, iron, magnesium, and selenium in autistic children compared with control, and no significant difference in dietary intake of vitamin A, thiamin, riboflavin, vitamin B6, phosphorus, and zinc.[30] A third study observed a significantly lower intake of omega-3 fatty acids and iron among autistic children compared to the control, and no significant differences in dietary intake of carbohydrates, protein, fat, vitamin D, folic acid, vitamin B12, and calcium.[31]

Dietary Behaviors Data

Dietary behaviors data are presented in Table 6. Out of 31 selected studies, ten studies involved dietary behaviors data.[27,28,31,34,36,48–52] Collected dietary behaviors data include daily rates of meal intake, healthy food intake, unhealthy food intake, mealtime behavior, and feeding difficulties. Five studies reported data on meal intake, including the frequency of daily consumption of regular meals, main meals including breakfast, lunch and dinner, and snacks. Six studies reported data on healthy food intake, including the frequency of daily consumption of dairy products milk, cheese, red meat, chicken, seafood, fish, tuna, liver, eggs, vegetables, fruits, fresh fruit juices, legumes, pasta, cereal, bread, rice, macaroni, butter, olive oil, water, and beverages. Similarly, six studies reported data on unhealthy food intake, including the frequency of daily consumption of fast food, junk foods, desserts, sweets, soft drinks, sweetened juice, and processed meat. Finally, only three studies reported data about mealtime behavior such as crying or screaming at mealtime, preferring sweet food, and eating meals with the family, while only two studies reported data about feeding

Table 4 Laboratory Results Reported in the Selected Studies That Included in the Systematic Review (n = 12)

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Serum Vitamins mean ± SD /median (IQR)	Vitamin D Status n (%)	Serum Minerals (mmol/L) mean ± SD	Serum Fatty Acid (mmol/L) mean ± SD /median (IQR)	Serum Fatty Acid ratios	Hematological indices
1	Almuneef et al, 2019[36]	CP (n = 74)	1–12, 5.6 ± 2.7						Anemia/ Hemoglobin abnormal range % (57%); Hematocrit abnormal range % (34%); RBC abnormal range % (30%)
2	Elshorbagy et al, 2018[37]	ADHD (n = 50)	7–14, 9.31 ± 2.60	Calcitriol (ng/mL): 7.23 ± 8.98					
		Control (n = 40)	6–13, 8.80 ± 3.72	Calcitriol (ng/mL): 31.47 ± 14.42					
		P value	0.4	0.0009					
3	El-Ansary et al, 2018[38]	ASD (n = 28)	3–12, 7.0 ± 2.34	Calcidiol (ng/mL): 95.63 ± 26.63					
		Control (n = 27)	3–12, 7.2 ± 2.14	Calcidiol (ng/mL): 140.43 ± 17.68					
		P value		0.001					
4	Mostafa & AL-Ayadhi, 2012 ‡[39]	ASD (n = 50)	5–12, 8.24 ± 2.37	Vitamin D (ng/mL): 18.5[14]	Deficiency: 40% Insufficiency: 48% Sufficiency: 12%				
		Control (n = 30)	5–12, 8.63± 2.65	Vitamin D (ng/mL): 33[11]	Deficiency: 0% Insufficiency: 20%, Sufficiency: 80%				
		P value		< 0.001					
5	Al-Gadani et al, 2009[40]	ASD (n = 30)	3–15	Vitamin E (mg/dL): 0.64 ± 0.39 Vitamin C (mg/dL): 6.88 ± 2.16					
		Control (n = 30)	3–15	Vitamin E (mg/dL): 1.86 ± 0.47 Vitamin C (mg/dL): 7.70 ± 1.97					

		P value		Vitamin E: < 0.05 Vitamin C: > 0.05					
6	Azhari, 2023 ‡‡[41]	ASD (n = 11)	4–12	Vitamin D (nmol/L): 29.43 ± 7.82	Severe Deficiency: 36% Deficiency: 46% Insufficiency: 0% Sufficiency: 18%				
7	El-Ansary et al, 2011a[42]	ASD (n = 26)	4–12				Acetic acid: 0.972 ± 0.247 Valeric acid: 0.510 ± 0.229 Hexanoic acid: 1.442 ± 0.349 Stearidonic acid: 0.455 ± 0.120 Propionic acid: 0.874 ± 0.249 Butyric acid: 0.587 ± 0.267 Caprylic acid: 1.109 ± 0.281 Decanoic acid: 0.759 ± 0.182 Lauric acid: 0.808 ± 0.160 Palmitic acid: 1.631 ± 0.372 Stearic acid: 0.687 ± 0.281 Arachidic acid: 0.425 ± 0.222 a-Linolenic acid: 0.299 ± 0.067 Eicosapentaenoic acid: 0.284 ± 0.145 Docosahexaenoic acid: 0.380 ± 0.097 Linoleic acid: 0.220 ± 0.255 g-Linolenic acid: 0.162 ± 0.101 Arachidonic acid: 0.120 ± 0.040 Oleic acid: 0.225 ± 0.064 Elaidic acid: 0.122 ± 0.099		

(*Continued*)

https://doi.org/10.2147/JMDH.S473107

Table 4 (Continued).

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Serum Vitamins mean ± SD /median (IQR)	Vitamin D Status n (%)	Serum Minerals (mmol/L) mean ± SD	Serum Fatty Acid (mmol/L) mean ± SD /median (IQR)	Serum Fatty Acid ratios	Hematological indices
		Control (n = 26)	4–11				Acetic acid: 0.558 ± 0.082 Valeric acid: 0.100 ± 0.015 Hexanoic acid: 0.597 ± 0.478 Stearidonic acid: 0.363 ± 0.122 Propionic acid: 1.674 ± 0.441 Butyric acid: 0.738 ± 0.211 Caprylic acid: 2.250 ± 0.481 Decanoic acid: 1.954 ± 0.750 Lauric acid: 1.903 ± 0.574 Palmitic acid: 1.905 ± 0.537 Stearic acid: 1.219 ± 0.315 Arachidic acid: 0.673 ± 0.174 a-Linolenic acid: 0.354 ± 0.119 Eicosapentaenoic acid: 0.328 ± 0.112 Docosahexaenoic acid: 0.754 ± 0.340 Linoleic acid: 0.359 ± 0.162 g-Linolenic acid: 0.716 ± 0.323 Arachidonic acid: 0.574 ± 0.202 Oleic acid: 1.212 ± 0.518 Elaidic acid: 0.234 ± 0.080		
		P value					Acetic acid: 0.0001 Valeric acid: 0.0001 Hexanoic acid: 0.0001 Stearidonic acid: 0.009 Propionic acid: 0.0001 Butyric acid: 0.028 Caprylic acid: 0.0001 Decanoic acid: 0.0001 Lauric acid: 0.0001 Palmitic acid: 0.037 Stearic acid: 0.0001 Arachidic acid: 0.0001 a-Linolenic acid: 0.045 Eicosapentaenoic acid: 0.245 Docosahexaenoic acid: 0.0001 Linoleic acid: 0.023 g-Linolenic acid: 0.0001 Arachidonic acid: 0.0001 Oleic acid: 0.0001 Elaidic acid: 0.0001		

https://doi.org/10.2147/JMDH.S473107 DovePress

8	El-Ansary et al, 2010[43]	ASD (n = 30)	3–15			Calcium: 4.84 ± 1.25 Potassium: 8.55 ± 5.76 Sodium: 105.76 ± 17.75 Magnesium: 2.04 ± 0.49 Lead: 0.09 ± 0.04			
		Control (n = 30)	3–15			Calcium: 11.67 ± 2.04 Potassium: 4.99 ± 2.12 Sodium: 118.11 ± 23.77 Magnesium: 1.83 ± 0.34 Lead: 0.03 ± 0.02			
		P value				Calcium: < 0.05 Potassium: < 0.05 Sodium: > 0.05 Magnesium: > 0.05 Lead: < 0.05			
9	El-Ansary et al, 2011c[44]	ASD (n = 25)	4–12			Calcium: 4.42 ± 0.87 Potassium: 10.95 ± 5.26 Sodium: 105.06 ± 17.43 Magnesium: 1.97 ± 0.43			
		Control (n = 16)	4–11			Calcium: 12.29 ± 1.53 Potassium: 4.76 ± 2.04 Sodium: 120.92 ± 21.94 Magnesium: 1.86 ± 0.35			
		P value				Calcium: < 0.05 Potassium: < 0.05 Sodium: 0.036 Magnesium: 0.411			
10	El-Ansary, 2017[45]	ASD (n = 35)	3–12, 7.0 ± 2.34			Lead (μg/dL): 6.04 ± 1.11 Selenium (μg/L): 111.9 ± 15.1 Mercury (μg/L): 3.66 ± 1.13			
		Control (n = 30)	3–12, 7.2 ± 2.14			Lead (μg/dL): 3.89 ± 0.88 Selenium (μg/L): 194.6 ± 26.7 Mercury (μg/L): 2.71 ± 0.57			
						Lead (μg/dL): < 0.001 Selenium (μg/L): < 0.001 Mercury (μg/L): < 0.001			
11	Mostafa & AL-Ayadhi, 2015[46]	ASD (n = 100)	3–10, 6.22 ± 2.1				Docosahexaenoic acid (ω3) (μg/mL): 0.18 (1.2) Linolenic acid (μg/mL): 1.6 (1.3) Arachidonic acid (ω6) (μg/mL): 1.7 (1.8) Linoleic acid (μg/mL): 1.3 (2.6)	ω6/ω3: 3 (2.4)	

(*Continued*)

Table 4 (Continued).

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Serum Vitamins mean ± SD /median (IQR)	Vitamin D Status n (%)	Serum Minerals (mmol/L) mean ± SD	Serum Fatty Acid (mmol/L) mean ± SD /median (IQR)	Serum Fatty Acid ratios	Hematological indices
		Control (n = 100)	3–10, 5.96 ± 2				Docosahexaenoic acid (ω3) (μg/mL): 3.1 (0.8) Linolenic acid (μg/mL): 3.3 (2.6) Arachidonic acid (ω6) (μg/mL): 4.2 (3.4) Linoleic acid (μg/mL): 3.2 (1.5)	ω6/ω3: 1.8 (1.4)	
		P value					Docosahexaenoic acid (ω3) (μg/mL): < 0.001 Linolenic acid (μg/mL): < 0.01 Arachidonic acid (ω6) (μg/mL): < 0.01 linoleic acid (μg/mL): < 0.05	ω6/ω3: < 0.01	
12	El-Ansary et al 2011b ‡‡‡[47]	ASD (n = 25)	4–12					LA/AA ratio: 1.08 ± 0.90 ALA/DHA ratio: 0.84 ± 0.19 AA/DHA ratio: 0.33 ± 0.14 EPA/DHA ratio: 0.61 ± 0.19 EPA/AA ratio: 0.96 ± 0.20	
		Control (n = 16)	4–11					LA/AA ratio: 0.62 ± 0.16 ALA/DHA ratio: 0.59 ± 0.36 AA/DHA ratio: 0.81 ± 0.17 EPA/DHA ratio: 0.56 ± 0.39 EPA/AA ratio: 0.66 ± 0.37	
		P value						LA/AA ratio: 0.034 ALA/DHA ratio: 0.004 AA/DHA ratio: 0.0001 EPA/DHA ratio: 0.576 EPA/AA ratio: 0.0001	

Notes: * ASD: Autism Spectrum Disorder; CP: Cerebral Palsy; ADHD: Attention Deficit Hyperactivity Disorder. ‡ Vitamin D Status (deficiency: <10 ng/mL, insufficiency: 10 to 30 ng/mL, sufficiency: >30 ng/mL). ‡‡ Vitamin D Status (severe deficient: <24 nmol/L, deficient: 25–49 nmol/L, insufficient: 50–79 nmol/L, sufficient: >80 nmol/L). ‡‡‡ Linoleic acid/arachidonic acid (LA/AA) ratio; a-linolenic acid/docosahexaenoic acid (ALA/DHA) ratio; arachidonic acid/docosahexaenoic acid (AA/DHA) ratio; Eicosapentaenoic acid/docosahexaenoic acid (EPA/DHA) ratio; Eicosapentaenoic acid/arachidonic acid (EPA/AA) ratio.

Table 5 Dietary Intake Results Reported in the Selected Studies Included in the Systematic Review (n = 4)

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Energy (kcal/day)	Carbohydrates (g/day)	Protein (g/day)	Fat (g/day)	Fiber (g/day)	Omega-3 Fat (g/day)	Vitamin A (ug/day)	Carotene (ug/day)	Vitamin D (ug/day)	Vitamin E (mg/day)	Vitamin C (mg/day)	Thiamin (mg/day)
1	Samarkandy et al, 2012[29]	DS (n = 108)	5–12	1692 ± 442	246.5 ± 68.2	55 ± 14	53.4 ± 14.8	11.65 ± 4.7		543.5 ± 225.4	894.5 ± 328			50.2 ± 32.4	0.7 ± 0.35
		Control (n = 113)	5–12	1826 ± 562	245.5 ± 88	65.6 ± 23	64.7 ± 29	12.45 ± 5.7		719 ± 387	841.5 ± 415			56 ± 28	0.8 ± 0.3
		P value		0.21	0.84	<0.001	0.031	0.57		0.024	0.73			0.72	0.71
2	Alahmari et al, 2022[30]	ASD (n = 70)	7–12, 8.5 ± NR	1522 ± 269						160 mg/d				22.2	0.27
		Control (n = 85)	7–12, 8.0 ± NR	1311 ± 132						0 mg/d				0	0
		P value		0.01						≥0.05				<0.05	≥0.05
3	Hammouda et al, 2018[31]	ASD (n = 30)	2–10, 4.9 ± 1.7	1330 ± 541	199 ± 87	38 ± 20	46 ± 24		0.029 ± 0.036			1.31 ± 1.91			
		Control (n = 36)	2–10, 4.9 ± 1.7	1576 ± 463	234 ± 67	48 ± 25	54 ± 21		0.268 ± 0.498			1.60 ± 1.60			
		P value	0.884	0.051	0.076	0.091	0.159		0.011			0.515			
4	Kasnawi & Jambi, 2020[34]	ASD (n = 32)	6–12, 8.0 ± 2.3		209 ± 89.03	49.64 ± 20.73		12.81 ± 7.92		2.30 µg/d ± 127.14		2.12 µg/d ± 1.90	4.08 mg/d ± 2.27	85.4 mg/d ± 64.01	

(*Continued*)

https://doi.org/10.2147/JMDH.S473107

Table 5 (Continued).

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Riboflavin (mg/day)	Vitamin B6 (mg/day)	Folic acid (mg/day)	Vitamin B12 (mg/day)	Sodium (mg/day)	Potassium (mg/day)	Calcium (mg/day)	Phosphorus (mg/day)	Iron (mg/day)	Magnesium (mg/day)	Selenium (mg/day)	Zinc (mg/day)
1	Samarkandy et al, 2012[29]	DS (n = 108)	5–12	1.5 ± 0.74				1880 ± 675	1704 ± 535	515 ± 297	911 ± 327.5	25 ± 3			
		Control (n = 113)	5–12	1.8 ± 0.85				2331 ± 767	1964 ± 751	626 ± 277.3	1029 ± 277.4	33 ± 4			
		P value		0.032				<0.001	0.038	0.017	0.21	0.34			
2	Alahmari et al, 2022[30]	ASD (n = 70)	7–12, 8.5 ± NR	0	0	169	0.38	1444	1454	466	468	8	84	7	4
		Control (n = 85)	7–12, 8.0 ± NR	0	0	270	0.83	2071	1320	820	463	14	150	8	4
		P value		≥0.05	≥0.05	<0.05	<0.05	<0.05	<0.05	<0.05	≥0.05	<0.05	<0.05	<0.05	≥0.05
3	Hammouda et al, 2018[31]	ASD (n = 30)	2–10, 4.9 ± 1.7			173 ± 128 μg/day	0.45 ± 2.27 μg/day			538 ± 332		6.66 ± 4.00			
		Control (n = 36)	2–10, 4.9 ± 1.7			203 ± 97.9 μg/day	0.55 ± 1.9 μg/day			331 ± 560		10.23 ± 6.01			
		P value	0.884			0.44	0.365			0.797		0.007			
4	Kasnawi & Jambi, 2020[34]	ASD (n = 32)	6–12, 8.0 ± 2.3			1.77 μg/d ± 83.67	1.75 μg/d ± 1.24			533 mg/d ± 365.67		8.57 mg/d ± 3.98			3.79 mg/d ± 1.86

Notes: *ASD: Autism Spectrum Disorder; DS: Down Syndrome; NR: Not Reported.

Table 6 Types of Collected Data Related to Dietary Behavior Included in the Systematic Review (n = 10)

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Meals Intake	Healthy Foods Intake	Unhealthy Foods Intake	Mealtime Behavior	Feeding Difficulties
1	Mohamed et al, 2013[27]	DS	5–12		Meat Chicken Fish Egg Whole milk Low-fat/skimmed milk Cheese Rice/macaroni Fresh vegetables Fresh fruits	Fast food	Difficulties in using utensils Food rejection Eating meals with the family	Vomiting after meals Chewing/swallowing difficulties
2	Bindayel, 2021[28]	DS	3–18	Breakfast Lunch Dinner	Dairy Products Seafood Red Meat Fruits Vegetables/salad Rice Caffeinated beverages	Fast food Dessert/Sweets Carbonated beverages		
3	Hammouda et al, 2018[31]	ASD	2–10		Milk Dairy products Eggs Fresh fruits Cooked vegetables Fresh vegetables Tuna Other fish types Liver Meat Include (chicken) Butter Olive oil	Fast food Sweets Sweetened Juice Soft drinks Processed meat		
4	Kasnawi & Jambi, 2020[34]	ASD	6–12		Milk & cheese Fat & sauces Fruit Legumes & pasta Meat & eggs Vegetables Cereal, bread and rice Beverages	Snacks & sweets		
5	Almuneef et al, 2019[36]	CP	1–12					Feeding problems Appetite of child

(*Continued*)

https://doi.org/10.2147/JMDH.S473107 DovePress

Table 6 (Continued).

No.	Studies (First Author, Year)	Type of Cases*	Age (years) range, mean ± SD	Meals Intake	Healthy Foods Intake	Unhealthy Foods Intake	Mealtime Behavior	Feeding Difficulties
6	AlOmar et al, 2021[48]	ASD	3–10	Regular meals	Milk intake Fish and egg intake Fruits intake			
7	Bin Ammar & Almuhaini, 2022[49]	ASD	4–12				Cries or screams at mealtimes Turns his/her face or body away from food Expels food that he/she has eaten Remains seated at the table until the meal is finished Aggressive during mealtimes Displays self-injurious behavior during mealtimes Closes mouth tightly when food is presented Is disruptive during mealtimes Is flexible about mealtime routines Is willing to try new foods Prefers the same food for each meal Prefers crunchy foods Accepts or prefers a variety of foods Prefers to have food served in a particular way Prefers food prepared in a certain way (Fried and greasy) Prefers only sweet foods Dislikes certain foods and will not eat them Refuses to eat foods that require a lot of chewing	
8	Bin Eid et al, 2022[50]	ASD	5–12	No. snacks/day No. meals/day				
9	Murshid, 2014[51]	ASD	3–14	Snacks per day		Sweet food per day Soft drinks per day	Prefers sweet food	
10	Al-Hammad, 2015[52]	CP	2–10	Frequency of main meals	Meats Vegetables Fruits Bottled Water Tap Water Fresh Fruit Juice Cheese	Puddings Packed Juices Soft Drinks Flavored Fizzy Drinks Biscuits Potato Chips Chocolates		

Notes: * ASD: Autism Spectrum Disorder; DS: Down Syndrome; CP: Cerebral Palsy.

difficulties like vomiting after meals, ability to chew and swallow food and appetite of the child. Generally, data exhibit that children with IDD are anticipated to have unhealthy dietary behavior compared with control.

Discussion

This review is the first one to target the nutritional status and dietary behaviors of children with IDD in Saudi Arabia. Data on the nutritional status and dietary behaviors of children with IDD from this country are still limited and inconsistent, despite the observed rise in the rates of IDD in children in Saudi Arabia and the crucial role of nutritional status in the management of these types of disability. The results of this review showed that the quantity of the selected articles is generally low. Additionally, there was an extensive amount of disparity between the objectives and findings of different studies, which made it difficult to draw comprehensive conclusions. This could be explained by the impact of using various indicators to assess the nutritional status and dietary behaviors outcomes of children with IDD in these studies.

The results of anthropometric measurements show that the rates of overweight and obesity were significantly greater among children with IDD compared to control, despite that inconsistent results were shown in weight and BMI means of children with IDD compared to control. Although different studies used different cut-off points to determine obesity rates based on the BMI-for-age growth charts at the 95th or 97th percentile, many studies revealed that children with IDD were less expected to maintain normal body weight and were at higher risk of either gaining weight and developing obesity or losing weight and becoming underweight.[53] Consequences of neurodevelopmental disorders such as greater levels of growth hormone may contribute to the greater prevalence of obesity seen in children with IDD compared to control.[54] However, environmental factors such as unhealthy eating patterns and physical inactivity are still significant players in the development of obesity among these children.[55]

The laboratory data revealed that children with IDD were more likely to have nutritional deficiencies compared with control. This could be related to restrictive diets and meal skipping usually observed among children with IDD.[56] Despite the limited number of studies, results confirm significantly lower levels of serum vitamin D among children with IDD. Vitamin D deficiency in these children could be related to inadequate sun exposure and limited outdoor daytime activities.[57] Furthermore, there is a high correlation between vitamin D deficiency and the severity of disability, indicating the importance of continuous monitoring of this nutrient among children with IDD.[58,59] Interestingly, variations in serum profile of fatty acids were reported among autistic children compared with control. These findings could be referred to variations in types of consumed dietary fats including saturated fats and omega-3 fats intake.[60,61]

The results of a few studies that reported dietary intake data provide inconsistent results about intake of energy, macronutrients, and micronutrients in children with IDD compared with control. However, low intake of energy, protein, and several micronutrients is frequently reported among children with IDD.[62,63] This could be related to restrictive and selective diets usually observed among those children.[56,64] The identified variations in mealtime practices and food choices can potentially have an impact on nutritional status. Food intake might be restricted as a result of selective eating and food rejection, which might compromise the diet's sufficiency in vital vitamins, minerals, and essential fatty acids.[65]

Although there is a growing interest in scientific research regarding the prevalence of the nutritional status and dietary behaviors of children with IDD, the current evidence is still limited and modest.[55,66–70] A scoping review was conducted to identify evidence on the prevalence of nutritional status in children with DS, CP, and ASD.[66] Their results revealed that children with CP were at risk of being underweight, while children with DS and ASD were at risk of being overweight or obese.[66] The rate of overweight and obesity in children with DS ranged from 33.5% to 43.5%. The rate of underweight in children with CP ranged from 22.2% to 78.2%.[66] A systematic review that investigated the nutritional status and feeding behavior of autistic children in the Middle East North Africa found that both overweight and underweight, feeding behavior problems, and nutritional deficiencies such as iron, calcium, vitamin B12, folate, and vitamin D were common.[55] Contrarily, another systematic review investigated the anthropometric measurements and nutritional assessment in individuals with autism and reported inconsistent results.[67] While some reports have found that autistic children are at risk of being overweight or obese, other studies have suggested that autistic children are at risk of having lower BMI.[67] Moreover, they reported contradictory results regarding the adequacy of dietary intake of autistic children.[67] A recent systematic review that was carried out to assess the rate of malnutrition among children with CP found that the prevalence of malnutrition was 40% and certain nutritional deficiencies such as hypocalcemia and reduced serum

concentrations of zinc, copper, and vitamin D were commonly reported.[68] Another systematic review was conducted to evaluate the nutritional interventions in children and adolescents with CP and reported that children and adolescents with CP have worse nutritional status than control.[69] Finally, a recent systematic review studied the clinical implications of adequate nutrition in children and adolescents with ADHD. They reported that the daily intake of calories and nutrients in those treated with methylphenidate is commonly lower than control.[70]

This review had a few limitations. The search strategy was narrowed to research papers that were written in English in reliable databases to ensure including good-quality reports. Unfortunately, most of the relevant research articles that were published in Arabic languages were of low quality. The language restrictions we did would strengthen the credibility of this review, even if it would impact the availability of relevant studies. The second limitation was the scarcity of available research studies that assess the nutritional status and dietary behaviors of children with IDD in Saudi Arabia. The potential impact of nutritional status on the health outcomes of children with IDD is an emerging field of research in Saudi Arabia.[17] This review could invite researchers and academicians in Saudi Arabia to put more effort into this important research area. Furthermore, a high disparity in measured outcomes in the included studies was noted. However, the present systematic review is the first one that was conducted to examine the obtainable data from research articles carried out to evaluate the nutritional status and dietary behaviors of children with IDD in Saudi Arabia. The analysis of the quality of included studies in this review showed that the quality of the selected articles is generally moderate (neutral rating) to high (positive rating). Interestingly, no studies had been given a negative rating which indicates a low-quality research article. This could support the credibility and the overall conclusions of this review. The results of this study will advance our understanding of the nutritional status and dietary behaviors of children with IDD in Saudi Arabia.

Research evidence provided in this review indicates that children with IDD are highly susceptible to malnutrition, which could impact their health and development. Further research is required to determine the types of intervention measures that can be taken to reduce the detrimental effect of malnutrition on the health and development of children with IDD. Adopting a healthy diet and minimizing unhealthy dietary behaviors are currently important approaches used to lower the risk of malnutrition among children with IDD. More studies are needed to determine the impact of various dietary behaviors on the health quality and nutritional status of these children. Furthermore, the mechanisms by which specific micronutrients impact the nutritional status of children with IDD are poorly understood. Further research is required to determine the effect of different micronutrients on the nutritional status of children with IDD using longitudinal designs or controlled interventions.

Conclusion

Results of the current study indicate that children with IDD are considered at higher risk for malnutrition. Therefore, healthy and balanced nutrition that considers dietary requirements and food preferences is critical to maintain optimal development of these children. Continuous monitoring of the nutritional status of children with IDD is recommended and helpful in planning timely and appropriate nutritional intervention when necessary. Moreover, improving family diets is a key factor in reducing the number of disabled children in the future. Converting to a healthy diet and reducing the consumption of ultra-processed foods is a crucial approach used to decrease serum heavy metals and enhance behaviors and learning among children with IDD. With IDD prevalence rising at worrying rates at the population level, it is evident that more work needs to be done at the health policy level to enhance the health quality and nutritional status of children with IDD. Prominently, advancements should be made in the health care system by establishing health and nutrition screening and education programs oriented toward this in-need group of the community and their families. The introduction of policies that aid in monitoring the nutritional status and dietary behaviors of children with IDD will help to improve their health and development. Future studies with robust and appropriate methods are needed to assess various aspects of the nutritional status and dietary behaviors of children with IDD in Saudi Arabia.

Acknowledgments

The authors extend their appreciation to the King Salman Center for Disability Research for funding this work through Research Group no KSRG-2023-325.

Funding

This research was funded by the King Salman Center for Disability Research through Research Group no KSRG-2023-325.

Disclosure

The authors declare that they have no conflicts of interest.

References

1. Olusanya BO, Wright SM, Nair MKC, et al. Global burden of childhood epilepsy, intellectual disability, and sensory impairments. *Pediatrics*. 2020;146:e20192623. doi:10.1542/peds.2019-2623
2. Kerac M, Postels DG, Mallewa M, et al. The interaction of malnutrition and neurologic disability in Africa. *Semin Pediatr Neurol*. 2014;21:42–49. doi:10.1016/j.spen.2014.01.003
3. Groce NE, Kerac M, Farkas A, et al. Inclusive nutrition for children and adults with disabilities. *Lancet Glob Health*. 2013;1:e180–1. doi:10.1016/S2214-109X(13)70056-1
4. Hume-Nixon M, Kuper H. The association between malnutrition and childhood disability in low- and middle- income countries: systematic review and meta-analysis of observational studies. *Trop Med Int Health*. 2018;23:1158–1175. doi:10.1111/tmi.13139
5. Lelijveld N, Groce N, Patel S, et al. Long-term outcomes for children with disability and severe acute malnutrition in Malawi. *BMJ Glob Health*;2020. 5:e002613. doi:10.1136/bmjgh-2020-002613
6. Klein A, Uyehara M, Cunningham A, Olomi M, Cashin K, Kirk CM. Nutritional care for children with feeding difficulties and disabilities: a scoping review. *PLOS Global Public Health*. 2023;3(3):e0001130. doi:10.1371/journal.pgph.0001130
7. Engl M, Binns P, Trehan I, et al. Children living with disabilities are neglected in severe malnutrition protocols: a guideline review. *Arch Dis childhood*. 2022;107(7):637–643. doi:10.1136/archdischild-2021-323303
8. Hashim NHR, Harith S, Bakar RS, Sahran NF. Prevalence and Risk Factors Associated with Malnutrition among Children with Learning Disabilities: a Scoping Review. *Malaysian J Nutr*. 2017;23(1).
9. AlDarwish N, AlSaab A, AlQusair D, AlWahsh I, Sebastian T, AlGindan Y. Dietary pattern, physical activity and body composition of Children with and without Down Syndrome–A case control study. *J Intellect Disabil*. 2023;17446295231219618. doi:10.1177/17446295231219618
10. Dufault RJ, Crider RA, Deth RC, et al. Higher rates of autism and attention deficit/hyperactivity disorder in American children: are food quality issues impacting epigenetic inheritance? *World J Clin Ped*. 2023;12(2):25. doi:10.5409/wjcp.v12.i2.25
11. Alabdali A, Al-Ayadhi L, El-Ansary A. A key role for an impaired detoxification mechanism in the etiology and severity of autism spectrum disorders. *Behai Brain Fun*. 2014;10:1–11. doi:10.1186/1744-9081-10-14
12. Vaiserman A, Lushchak O. DNA methylation changes induced by prenatal toxic metal exposure: an overview of epidemiological evidence. *Environ Epigenet*. 2021;7(1):dvab007. doi:10.1093/eep/dvab007
13. Dufault RJ, Adler KM, Carpenter DO, Gilbert SG, Crider RA. Nutritional epigenetics education improves diet and attitude of parents of children with autism or attention deficit/hyperactivity disorder. *World J Psych*. 2024;14(1):159. doi:10.5498/wjp.v14.i1.159
14. Bindawas SM, Vennu V. The national and regional prevalence rates of disability, type, of disability and severity in Saudi Arabia—Analysis of 2016 demographic survey data. *Int J Environ Res Public Health*. 2018;15(3):419. doi:10.3390/ijerph15030419
15. Malik S, Shrahili M, Khan SU. the transformation to reduce the disability prevalence rates in Saudi Arabia: A Theoretical Analysis. *J Disab Res*. 2024;3(3):20240024. doi:10.57197/JDR-2024-0024
16. Alsalem MA. Towards new disability paradigms: generating equality in Saudi Arabian policy in light of the Convention on the Rights of Persons with Disabilities. *Intl J Disab Develop Edu*. 2023;70(7):1410–1424. doi:10.1080/1034912X.2021.1980864
17. Alghadier M, Albesher RA, Basoudan R. Bibliometric Analysis of Scientific Research on Children's Disability in Saudi Arabia. *J Disab Res*. 2024;3(6):20240068. doi:10.57197/JDR-2024-0068
18. Yousef L, Almatroodi N, AlAngari D, AlShehri R, Alshammari S. Disability inclusion assessment in primary healthcare centers in Eastern Saudi Arabia: a way forward. *J Med Life*. 2023;16(12):1813. doi:10.25122/jml-2023-0385
19. Woodman A, Jaoua N, Al-Jamea LH, et al. Attitudes of health care providers in relation to disability. *Saudi Arabia Ibnosina J Med Biomed Scie*. 2024. doi:10.1055/s-0044-1787109
20. Moher D, Liberati A, Tetzlaff J, Altman DG, Group PRISMA. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Internal Med*. 2009;151(4):264–269. doi:10.7326/0003-4819-151-4-200908180-00135
21. Academy of Nutrition and Dietetics. *Evidence Analysis Manual: Steps in the Academy Evidence Analysis Process*. Chicago, IL, USA: Academy of Nutrition and Dietetics; 2016:8–91.
22. Al Husain M. Body mass index for Saudi children with Down's syndrome. *Acta Paediatrica*. 2003;92(12):1482–1485. doi:10.1111/j.1651-2227.2003.tb00836.x
23. Al Husain M. Growth charts for children with Down's syndrome in Saudi Arabia: birth to 5 years. *Int J Clin Pract*. 2003;57(3):170–174. doi:10.1111/j.1742-1241.2003.tb10457.x
24. Alsulaimani AA, Helmy FF, Abdel Wahab MM. Risk factors of autism: a Saudia Study. International. *J Science Res*. 2014;3(10):1200–1210.
25. Alhusaini AA, Al-Walah MA, Melam GR, Buragadda S. Pedometer-determined physical activity levels of healthy children and children with Down's syndrome. *Somatosens Mot Res*. 2018;34(4):219–225. doi:10.1080/08990220.2017.1415880
26. Allam HH, Al-Walah MA, Elsayyad LK. Walking capacity in boys with Down's syndrome in Saudi Arabia. International. *J Therap Rehabil*. 2020;27(2):1–9. doi:10.1177/1060028018759471
27. Mohamed BA, Alhamdan AA, Samarkandy MM. Dietary practice and physical activity in children with Down syndrome and their siblings in Saudi Arabia. *Canadian J Clin Nutrit*. 2013;1(1):35–46. doi:10.14206/canad.j.clin.nutr.2013.01.05
28. Bindayel IA. Relationship between Down syndrome (DS) and obesity in children and adolescents and its relation to dietary and lifestyle factors. *Prog Nutr*. 2021;23(4):e2021180. doi:10.23751/pn.v23i4.10715
29. Samarkandy MM, Mohamed BA, Al-Hamdan AA. Nutritional assessment and obesity in Down syndrome children and their siblings in Saudi Arabia. *Saudi Med J*. 2012;33(11):1216–1221.
30. Alahmari S, Alatawi R, Albalawi R, Albalawi R, Alamri E. Nutritional status among children with autism spectrum disorders in Saudi Arabia. *Medi Sci*. 2022;26(119):e1960. doi:10.54905/disssi/v26i119/ms40e1960

31. Hammouda SAI, Al Areefy AAE, Al-Thbiany A, et al. Assessment of nutritional risk factors predisposing to autism among Saudi children. *Nutrafoods*. 17:27–32. doi:10.17470/NF-017-1003-1
32. Ashour NA, Ashour AA, Basha S. Association between body mass index and dental caries among special care female children in Makkah City. *Ann Saudi Med*. 2018;38(1):28–35. doi:10.5144/0256-4947.2017.31.12.1515
33. Al-Blowi AA, Al-Mutairi RA, Ghabbany RM, et al. The prevalence of malnutrition and the nutritional status in children with cerebral palsy and its causes in Madinah Maternity and Children Hospital. *Curr Pediatr Res*. 2020;24(7):273–280.
34. Kasnawi FA, Jambi HA. The Effect of Food Selectivity on Nutritional Adequacy for Autistic Children in Western Region, Saudi Arabia. *J Med Pharmaceutical Scienc*. 2020;4(3):77–87. doi:10.26389/AJSRP.S200720
35. Mohamed RN, Basha S, Al-Thomali Y, AlZahrani FS, Ashour AA, Almutair NE. Association between dental caries and obesity among children with special health care needs. *Oral Health Prev Dent*. 2021;19:101–106. doi:10.1080/08990220.2017.1415880
36. Almuneef AR, Almajwal A, Alam I, et al. Malnutrition is common in children with cerebral palsy in Saudi Arabia–a cross-sectional clinical observational study. *BMC Neurol*. 2019;19(317). doi:10.1186/s12883-019-1553-6
37. Elshorbagy HH, Barseem NF, Abdelghani WE, et al. Impact of vitamin D supplementation on attention-deficit hyperactivity disorder in children. *Ann Pharmacoth*. 2018;52(7):623–631. doi:10.1177/1060028018759471
38. El-Ansary A, Cannell JJ, Bjørklund G, et al. In the search for reliable biomarkers for the early diagnosis of autism spectrum disorder: the role of vitamin D. *Metab Brain Dis*. 2018;33:917–931. doi:10.1007/s11011-018-0199-1
39. Mostafa GA, Al-Ayadhi LY. Reduced serum concentrations of 25-hydroxy vitamin D in children with autism: relation to autoimmunity. *J Neuroinflammation*. 2012;9:201. doi:10.1186/1742-2094-9-201
40. Al-Gadani Y, El-Ansary A, Attas O, Al-Ayadhi L. Metabolic biomarkers related to oxidative stress and antioxidant status in Saudi autistic children. *Clin Biochem*. 2009;42(10–11):1032–1040. doi:10.1016/j.clinbiochem.2009.03.011
41. Azhari SA. 25-hydroxyvitamin D level in autism spectrum disorders and the efficacy of vitamin D supplementation in Saudi Autistic children. *J Pharm Res Int*. 2023;35(10):40–47. doi:10.9734/JPRI/2023/v35i107353
42. El-Ansary AK, Ben Bacha AG, Al-Ayahdi LY. Plasma fatty acids as diagnostic markers in autistic patients from Saudi Arabia. *Lipids Health Dis*. 10:62. doi:10.1186/1476-511X-10-62
43. El-Ansary A, Al-Daihan S, Al-Dbass A, Al-Ayadhi L. Measurement of selected ions related to oxidative stress and energy metabolism in Saudi autistic children. *Clin Biochem*. 43(1–2):63–70. doi:10.1016/j.clinbiochem.2009.09.008
44. El-Ansary AK, Ben Bacha AG, Al-Ayadhi LY. Proinflammatory and proapoptotic markers in relation to mono and di-cations in plasma of autistic patients from Saudi Arabia. *J Neuroinflammation*. 8:142. doi:10.1186/1742-2094-8-142
45. El-Ansary A, Bjørklund G, Tinkov AA, Skalny AV, Al Dera H. Relationship between selenium, lead, and mercury in red blood cells of Saudi autistic children. Metabolic Brain. *Disease*. 2017;32(4):1073–1080.
46. Mostafa GA, Al-Ayadhi LY. Reduced levels of plasma polyunsaturated fatty acids and serum carnitine in autistic children: relation to gastrointestinal manifestations. *Behai Brain Fun*. 2015;11:4. doi:10.1186/s12993-014-0048-2
47. El-Ansary AK, Ben Bacha AG, Al-Ayadhi LY. Impaired plasma phospholipids and relative amounts of essential polyunsaturated fatty acids in autistic patients from Saudi Arabia. *Lipids Health Dis*. 10:63. doi:10.1186/1476-511X-10-63
48. AlOmar RS, Oommen A, Aljofi HE. Vitamin D deficient diet and autism. *Kuwait Med J*. 2021;53(2):179–183.
49. Bin Ammar AA, Almuhaini SS. Autism children dietary habits in Hail, Saudi Arabia: a parents' survey. *Med Sci*. 2022;26:ms489e2563. doi:10.54905/disssi/v26i129/ms489e2563
50. Bin Eid WB, Lim M, Halstead E, Esposito G, Dimitriou D. A cross-cultural comparison of sleep patterns between typically developing children and children with ASD living in Saudi Arabia and the United Kingdom. *Res Devel Disab*. 2022;128:104290. doi:10.1016/j.ridd.2022.104290
51. Murshid EZ. Diet, oral hygiene practices and dental health in autistic children in Riyadh Saudi Arabia. *Oral Health Dent Manag*. 2014;13(1):91–96.
52. Al-Hammad NS. Dietary practices in Saudi cerebral palsy children. *Pakistan j Med Scien*. 2015;31(4):860–864. doi:10.12669/pjms.314.7812
53. Li Y-J, Xie X-N, Lei X, Li Y-M, Lei X. Global Prevalence of Obesity, Overweight and Underweight in Children, Adolescents and Adults with Autism Spectrum Disorder, Attention-Deficit Hyperactivity Disorder: A Systematic Review and Meta-Analysis. *Obesity Rev*. 21(12):e13123. doi:10.1111/obr.13123
54. Must A, Phillips SM, Curtin C, et al. Comparison of Sedentary Behaviors between Children with Autism Spectrum Disorders and Typically Developing Children. *Autism*. 2014;18:376–384. doi:10.1177/1362361313479039
55. Kittana M, Ahmadani A, Williams KE, Attlee A. Nutritional Status and Feeding Behavior of Children with Autism Spectrum Disorder in the Middle East and North Africa Region: a Systematic Review. *Nutrients*. 2023;15(3):711. doi:10.3390/nu15030711
56. Marí-Bauset S, Zazpe I, Marí-Sanchis A, Llopis-González A, Suárez-Varela MM. Anthropometric Measurements and Nutritional Assessment in Autism Spectrum Disorders: a Systematic Review. *Res Autism Spectr Disord*. 2015;9:130–143. doi:10.1016/j.rasd.2014.08.012
57. Bener A, Khattab AO, Al-Dabbagh MM. Is High Prevalence of Vitamin D Deficiency Evidence for Autism Disorder?: in a Highly Endogamous Population. *J Pediatr Neurosci*. 2014;9:227–233. doi:10.4103/1817-1745.147574
58. Kittana M, Ahmadani A, Stojanovska L, Attlee A. The Role of Vitamin D Supplementation in Children with Autism Spectrum Disorder: A Narrative Review. *Nutrients*. 2021;14:26. doi:10.3390/nu14010026
59. Mengoni SE, Smith B, Wythe H, Rogers SL. Experiences of feeding young children with Down syndrome: parents' and health professionals. *Pers Int J Develop Disabi*. 2023;1–9.
60. Al-Farsi YM, Waly MI, Deth RC, et al. Impact of Nutrition on Serum Levels of Docosahexaenoic Acid among Omani Children with Autism. *Nutrition*. 2013;29:1142–1146. doi:10.1016/j.nut.2013.03.009
61. Meguid NA, Anwar M, Bjørklund G, et al. Dietary adequacy of Egyptian children with autism spectrum disorder compared to healthy developing children. *Metab Brain Dis*. 2017;32:607–615. doi:10.1007/s11011-016-9948-1
62. Esteban-Figuerola P, Canals J, Fernández-Cao JC, Arija Val V. Differences in Food Consumption and Nutritional Intake between Children with Autism Spectrum Disorders and Typically Developing Children: a Meta-Analysis. *Autism*. 2019;23:1079–1095. doi:10.1177/1362361318794179
63. Hielscher L, Irvine K, Ludlow AK, Rogers S, Mengoni SE. A Scoping Review of the Complementary Feeding Practices and Early Eating Experiences of Children With Down Syndrome. *J Pediatric Psychol*. 2023;48(11):914–930.. doi:10.1093/jpepsy/jsad060
64. de Souza Silva E, Castro K, Valle SC, Dos Santos Vaz J. Dietary Assessment Methods Applied in Clinical and Epidemiological Studies in Children and Adolescents with Autism Spectrum Disorder: a Systematic Review. Review. *J Autism Devel Disord*. 2023;1–14.

65. Monteiro MA, Dos Santos AAA, Gomes LMM, Rito RVVF. Autism Spectrum Disorder: a Systematic Review about Nutritional Interventions. *Rev Paul Pediatr*. 2020;38:e2018262. doi:10.1590/1984-0462/2020/38/2018262
66. Nor NSM, Aziz NSA, Cheong SM, Ambak R, Omar MA. Nutritional status of children with autism spectrum disorders, Cerebral Palsy and Down Syndrome. *Scop Rev Open Access J ScienceTech*. 2015;3. doi:10.11131/2015/101174
67. Mari-Bauset S, Zazpe I, Mari-Sanchis A, Llopis-Gonzalez A, Suárez-Varela MM. Anthropometric measurements and nutritional assessment in autism spectrum disorders: a systematic review. *Res Autism Spectrum Disord*. 2015;(9):130–143.
68. Da Silva DCG, da Cunha MDSB, de Oliveira Santana A, Dos Santos Alves AM, Santos MP. Malnutrition and nutritional deficiencies in children with cerebral palsy: a systematic review and meta-analysis. *Public Health*. 2022;205:192–201. doi:10.1016/j.puhe.2022.01.024
69. Silva DCGD, Cunha MDSBD, Santana ADO, Alves AMDS, Santos MP. Nutritional interventions in children and adolescents with cerebral palsy: systematic review. *Rev Paulista Pediatria*. 2023;42:e2022107. doi:10.1590/1984-0462/2024/42/2022107
70. Rocha MS, de Aquino LL, de Oliveira Gonçalves G, et al. Major clinical implications of adequate nutrition in children and adolescents with attention-deficit/hyperactivity disorder: a concise systematic review. *Inter J Nutrology*. 2024;17(2). doi:10.54448/ijn24205