

Review Article

Nutritional Status of Children with Autism Spectrum Disorders, Cerebral Palsy and Down Syndrome: A Scoping Review

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Abstract. *Introduction:* Autism Spectrum Disorders (ASD), Down Syndrome (DS) and Cerebral Palsy (CP) are the most common disabilities among children. Nutritional status assessment is important as these children are at risk of underweight, overweight or obesity. Therefore, the objectives of this review were to identify evidence on the prevalence of nutritional status of children with DS, CP and ASD, and to determine tools and indicators to measure the nutritional status of these children. *Methods:* This scoping review was conducted using a framework suggested by Arksey and O'Maley. A comprehensive search was performed to identify published and unpublished works, reviews, grey literature and reports. Inclusion criteria for the search were articles in English published from 1990 to 2014 and related to children with ASD, DS and CP. Titles, abstract, and keywords for eligibility were examined independently by the researchers. *Results:* A total of 305,268 titles were extracted from electronic databases and other resources. Based on the inclusion criteria, 21 articles were selected for review. The prevalence of overweight or obese children with DS ranged from 33.5% to 43.5%. The prevalence of underweight children with CP was 22.2% to 78.2%. Children with ASD at a younger age were more likely to be overweight or obese compared with normal developing children. The common nutritional indicators used were z-scores for weight-for-age, height-for-age, body mass index-for-age, and head circumference-for-age. *Conclusions:* Overall, there is emerging evidence on the nutritional status of children with ASD, DS and CP although this is still very limited in developing countries including Malaysia. The evidence shows that children with CP were at risk of being underweight, while children with DS and ASD were at risk of being overweight or obese.

Keywords: Nutritional status; children; autism spectrum disorders; cerebral palsy; down syndrome

1. Introduction

Disability is defined as “difficulties in three areas of human functioning, which include i) impairments, ii) activity limitations, and iii) participation restrictions” [1]. Disability is a complex condition because it varies according to age, gender,

socioeconomic status, cultural background, geographical area and health condition [2]. The degree of disability for any individual with disability also depends upon the relationship between various environmental factors [3]. Indeed, children with disabilities and their families may require a variety of services whereby the economic and social cost can be

substantial [4]. According to the United Nations Children's Fund (UNICEF), it was estimated that the number of children with disabilities under 18 years old was approximately 150 million [5]. This included children with Autism Spectrum Disorders (ASD), Cerebral Palsy (CP), Down syndrome (DS), Learning Disabilities and other types of disabilities.

Nutritional status is an important indicator of the overall health status and wellbeing of children with disability. It portrays the physical growth of children and whether they are at risk of being underweight, overweight or obese. The impact of poor nutritional status and poor growth among children with disability may eventually lead to poor motor function, bone health, social participation and healthcare utilisation [6]. For example, the consequences of overweight and obesity problems in children with DS are the increased risk of developing adult obesity and non-communicable diseases such as diabetes and hypertension [7]. Malnutrition among children with CP can lead to poor growth and nutrient deficiencies such as iron and vitamin deficiency [8]. However, evidence on the nutritional status of children with DS, CP, and ASD is still limited and little is known on the overall prevalence of the nutritional status of these children, including the methods, tools and indicators to assess this. Various tools may be required to assess the nutritional status of children with disability due to the disparities in their health conditions, growth and development stage. Good knowledge and understanding are required among health care professionals in order to monitor the health status of these children, so that further treatment or intervention could be planned for this group.

Therefore, the present review will explore evidence on the nutritional status among children with disability, particularly among children with DS, CP, and ASD. It is hoped that these findings will support future research on the nutritional status for children with disability and the future planning of health interventions/programmes for this population.

2. Methods

The design of the present study was scoping review. Scoping review aims "to map rapidly the key concepts underpinning a research area and the main sources and types of evidence available especially when an area is complex or has not been reviewed comprehensively before" [9]. Scoping review seeks to provide wide coverage of available literature depending on the purpose of the review. For the purpose of this topic, the scoping review was performed to; i) determine the extent and nature of research on the nutritional status of children ASD, CP, and DS; ii) describe the details of the evidence in terms of the prevalence of nutritional status, methods and tools used to determine nutritional status particularly for children with ASD, CP, and DS. In this review, nutritional status is defined as obesity, underweight, stunting and wasting.

The 5 stages of the scoping review framework by Arskey and O'Maley [9] include 'identifying the research

questions', 'identifying relevant studies', 'study selection', 'charting the data' and 'collating, summarising and reporting the results'. Consultation with programme managers and stakeholders from the Family Health Division, Ministry of Health Malaysia and health professionals (medical doctors, dietitians and paediatricians) at government hospitals were also conducted to enhance the review work undertaken by the research team members. The study was registered under the National Medical Research Registry Malaysia (NMRR) and the protocol was approved by the Medical Research and Ethics Committee (MREC) Malaysia (ID: NMRR -1495-19402).

2.1. Identifying the research questions. The review questions were: i) what is the prevalence or rate of nutritional status of children with ASD, CP, and DS aged 18 years and below? And, ii) what are the tools, indicators and measurements used to assess nutritional status of children with ASD, CP, and DS?

2.2. Identifying relevant studies. The purpose of performing the scoping review was to conduct a comprehensive search to identify primary studies (published and unpublished work), reviews, grey literature and annual reports. The research team members adopted a strategy for searching the evidence using different sources which included electronic databases of Medline Embase/Ovid, Pubmed, Highwire Press, Scopus, and Google Scholar, relevant research websites such as Disability Clearing House, World Health Organizations (WHO), and Welfare Department of Malaysia. The searches also involved hand-searching of relevant peer reviewed journals (Asia Pacific Public Health Journal, Journal of Developmental Disabilities, Journal of Autism and Developmental Disorders (JADD), Child: Care, Health and Development, Paediatrics, Research in Developmental Disorders, Human Nutrition and Dietetics, Malaysian Journal of Nutrition and Malaysian Medical Journal), bibliographic search of reference lists in books, reports, summaries, newsletters, and references from selected articles or bulletins from the World Health Organizations, Ministry of Health Malaysia, Ministry of Education Malaysia, Statistics department and Welfare Department of Malaysia.

The researchers decided to set the coverage of the review based on the time span and language of the articles. Inclusion criteria for the search were articles in English from 1990 to 2014 and related to children with ASD, CP, and DS who were below 18 years old. The commencement date of 1990 was chosen in order to cover a wide range of evidence and it was felt that the evidence on the nutritional status of children with disability was limited especially in Asian countries including Malaysia. Titles, abstract, keywords for eligibility were examined independently by the researchers. All types of studies were included in the search strategy. Foreign language articles were excluded due to the cost and time that would be required to translate these documents. Key terms used in the search of articles were shown in

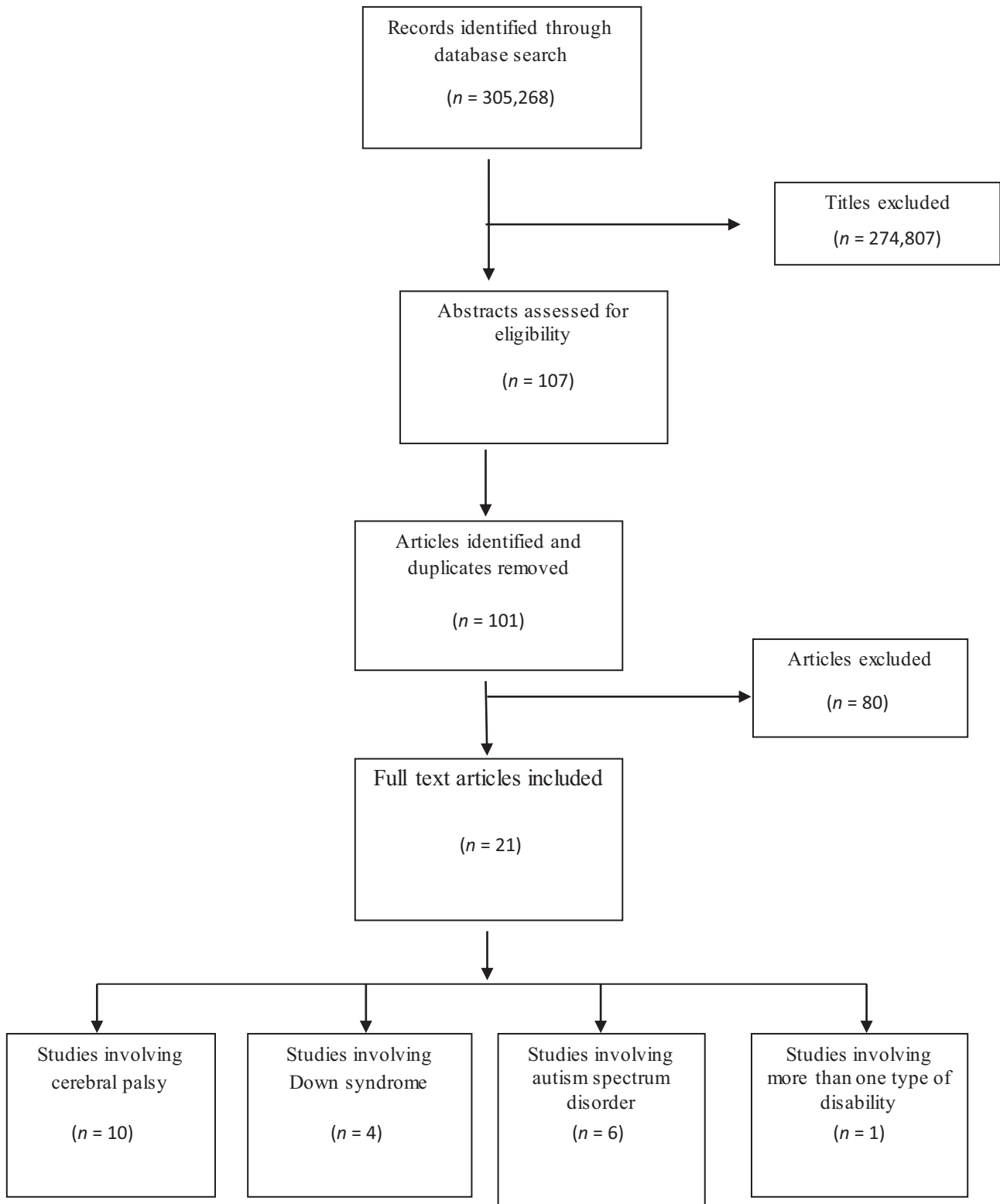


Figure 1: Flow chart of scoping review (based on framework by Arskey and O’Malley 2005).

Table 1: Key terms in the scoping review.

Key search terms	
Nutritional Status AND Children AND Cerebral Palsy	Obesity OR Overweight OR Underweight AND Children AND Cerebral Palsy
Nutritional Status AND Children AND Down Syndrome	Obesity OR Overweight OR Underweight AND Children AND Down Syndrome
Nutritional Status AND Children AND Autism Spectrum Disorders OR Autism OR Asperger Syndrome	Obesity OR Overweight OR Underweight AND Children AND Autism Spectrum Disorders OR Autism OR Asperger Syndrome
Growth OR Nutritional Status AND Children AND Cerebral Palsy OR Down Syndrome OR Autism Spectrum Disorders	Nutritional status AND Children AND Disability OR Cerebral Palsy OR Down Syndrome OR Autism Spectrum Disorders

Table 1. Endnote software and Microsoft Excel programmes were used to manage the records via searching, keeping track of articles, checking the duplication of records and sorting reference lists. The researchers then compiled these records and made a summary.

2.3. Study selection. The study selection was based on the objectives of the study. The review only focused on documents related to the nutritional status of children with ASD, CP, and DS. The search strategy identified a large number of studies which were not relevant in answering the specific objectives. Thus, the researchers eliminated irrelevant articles based on the inclusion and exclusion criteria and those articles that did not answer the research questions. Four research team members screened the titles and retrieved the relevant abstracts. Abstracts that did not capture fully the scope of the study were excluded. Based on the eligible abstracts, copies of full articles were retrieved. The full articles were then checked by the researchers as to whether they appeared to answer the research question of the study. Selected full articles were then read by the researchers in order to select the final full articles for the review.

2.4. Charting the data. General and specific information about the studies were charted which include author(s), year of publication, objectives or aims of the study, country or study location, study population, sample characteristics, design, sample size including comparison group (if any), instruments and indicators used in the study and findings that were relevant to the objectives of the review.

2.5. Collating, summarising, and reporting the results. The characteristics of the results from the selected articles from various countries were described based on the design, types and outcomes of each study. The findings of the review were presented in two ways. First, tables of evidence on the nutritional status of children with Down, Syndrome, Cerebral Palsy and ASD were presented. Second, a summary table of the measurements, instruments and indicators were used to describe the various approaches or methods used to measure nutritional status. This included: types, categories of measurements, indicators, and availability of tools for measuring weight, height, length, and head circumference.

Limitations of several studies and research gaps were also identified in order to make useful recommendations to the stakeholders and programme managers.

3. Results

A total of 305,268 titles were extracted from selected electronic databases and other resources. As shown in Figure 1, 107 abstracts were included after the initial screening process and the rest were excluded as they were irrelevant with regards to the types of disability, non-English articles, and duplicates. Only 21 studies met the inclusion criteria. Among these 21 articles included in the review, 10 articles were studies among children with CP, 4 among children with DS, 6 among children with ASD and 1 study among children with more than one type of disability. Countries of origin of the studies included developed and developing countries such as Mexico, United Kingdom, United States of America, Saudi Arabia, Argentina, Netherland and Malaysia. The majority of studies were cross-sectional (19 studies, 90%) and some studies used retrospective data. Only 2 out of 21 studies (10%) were prospective longitudinal studies. Sample size of the studies ranged from 50–400 children with CP, DS, and ASD aged from birth until 18 years old. The study population was recruited from various sources which included clinical settings (hospital and specialist clinics) and community settings (rehabilitation centres, universities, public schools, nurseries and households).

3.1. Nutritional status among children with CP, DS, and ASD. Overall, the majority of studies found that children with CP were at risk of being underweight, while children with DS and ASD tend to be at risk of being overweight or obese [Table 2].

3.2. Down syndrome. Several studies have shown that children with DS were shorter than the standard references of typically developing children, but they had comparable weights. The prevalence of at-risk-for- overweight or overweight or obesity among children with DS aged between 3 to 18 years old ranged from 33.5% to 43.5% [10–14].

Table 2: Prevalence of the nutritional status of children with DS, CP, and ASD.

No.	Study	Type of Disability	Purpose	Participants Characteristics (Diagnosis and Age)	Sample Size and Comparison Group	Tools/ Methods/ Indicators	Rate and Prevalence of Nutritional Status
1.	Samaarkandy et al. (2012)	Down syndrome	To assess the nutritional status and prevalence of obesity among children with Down syndrome (DS).	Age: 5–12 years old Pre-pubertal children with clinically and cytogenetically proven DS. Country: Saudi Arabia	Sample size DS: 108 Control group: healthy siblings closest in age to the DS children ($n = 113$)	Anthropometric: Body weight, height, Triceps skinfold thickness (TSFT). BMI: Classified as overweight: ≥ 85 th percentile - ≤ 95 th percentile. Obesity: ≥ 95 th percentile. Dietary Assessment: 3 days dietary records. Validated FFQ: Interviewed parents.	Prevalence of: • Normal: 62 (56.5%). • Overweight: 22 (20.4%) • Obesity: 24 (23.1%) - The mean height-for-age was significantly lower in children with DS (11.4 ± 14.7) compared to siblings (39.8 ± 18.8). There was no significant difference in mean weight-for-age between DS cases (38.7 ± 27.8) and siblings (41.7 ± 28.2) - DS children higher BMI 17.8 ± 3.6 and triceps skin fold thickness (TSFT) 9.1 ± 3.2 compared with their siblings, BMI 15.1 ± 2.7 , TSFT 8.6 ± 2.6
2.	Helma et al. (2012)	Down syndrome	To establish growth references for weight and to assess the prevalence rates of being overweight and obese in a nationwide sample of Dutch children with Down syndrome.	Dutch children with Down Syndrome and attending hospital-based out-patient clinics between July 2009 - Feb 2010 Country: Netherland 4 Health Categories: - Healthy - severe CHD, - hypothyroidism - other disorder	Sample size: 1596 *Source of data: Growth Data From 25 Dutch Regional Specialised DS Centre	Methods: Weight and BMI. LMS method Indicators: Weight-for-age SD scores (overweight and obesity).	Prevalence of: Overweight in DS Boys: 25.5%, Girls: 32.0% Obese in DS. Boys: 4.2%, Girls: 5.1% *Healthy children 13.3% boys and 14.9% girls (Comparison was done using Data from Fourth Dutch Growth Study 1997 and Dutch Growth Study 2009) - From the age of 4, >25% of healthy children with DS are overweight. Mean Birth weight: Boys: 3.1kg, Girls: 3.0kg Prevalence rates of being overweight among children with DS vary between children within the various health categories.
3.	Lopes et al. (2013)	Cerebral Palsy	To assess the food intake pattern and the nutritional status of children with cerebral palsy.	Children With cerebral palsy in following forms: hemiplegia, diplegia, tetraplegia. Age: 2–12.8 years old Country: Brazil	Sample size: 90 children (52 males, 38 females) Children and adolescents treated in rehabilitation centres for Physical and Mental Disabilities.	Methods: Weight, height, age data Dietary: 24-hrs recall and Food Frequency Questionnaire(FFQ) Tools: Diet-pro software version 5.5i, bone caliper Indicators: Z-score of BMI for age, Z- score Height-for-Age (H/A) and Weight-for-Age (W/A).	Prevalence of CP with: Hemiplegia: 54% Tetraplegia: 43% Diplegia: 3% Z-score of CP children with: • Diplegia: -2.40 for H/A • Tetraplegia: $-2(-1.88)$ for W/A And H/A: -2.14 Significantly lower than the group with hemiplegia.

Table 2: Continued.

No.	Study	Type of Disability	Purpose	Participants Characteristics (Diagnosis and Age)	Sample Size and Comparison Group	Tools/ Methods/ Indicators	Rate and Prevalence of Nutritional Status
4.	Vega-Sanchez et al. (2012)	Cerebral Palsy (CP), Spina Bifida(SP) Muscular Dystrophy (MD), Down syndrome DS)	To describe the weight based nutritional diagnosis of children and adolescents with neuromotor disabilities who attended a private rehabilitation centre in Mexico City.	Neuromotor Disabilities, Cerebral Palsy, Spina Bifida, Muscular Dystrophy, Down Syndrome. Classification based on 10th revision of the International Classification of Disease (ICD-10) Country: Mexico	Sample size: 410 Data from clinical records at the Teleton Centre for children Rehabilitation Mexico City	Method: - Sex, Age, Disability Diagnosis, Height or length, and weight. - All measurements were standardized according to the Habicht method - Nutritional diagnosis based on the National Center for Health Statistics (NCHS) growth charts. - Indicators: Weight-for-age, weight-for-height/length, length-for-age, and body mass index (BMI)- for age	Weight based nutritional diagnosis: DS (<i>n</i> : 21) Low weight /Under nutrition: 14% Overweight/Obese: 19% CP (<i>n</i> : 210) Low weight /Under nutrition: 49% Overweight/Obese: 16% Spina Bifida (<i>n</i> : 66): Overweight/Obese: 56% Muscular Dystrophy (<i>n</i> : 24) Low weight /Under nutrition: 33% Overweight/Obese: 19%
5.	Westborn et al. (2010)	Cerebral Palsy	To study the development of weight, height, and body mass index (BMI) during five years after Selective Dorsal Rhizotomy.	Only Children with definite cerebral palsy according to common definitions were selected.	Sample size: 56 children with cerebral palsy spastic diplegia.	Methods: Height recumbent length for children without standing ability weight, BMI. Tools: Stadiometer measuring tape, gym map, hospitalbalance, sit balance, Swedish Growth Charts. Gross Motor Function Classification System (GMFCS). Indicators: Z-sores for age and gender.	Prevalence of: ● Thinness: 6 (11%) ● Obese: 2 (4%) - 5 or 6 children with thinness before SDR operations were within typical limit (+ 2SD) five years later. - 2 children with preoperative BMI > 2.0 SD were still obese after five years. 6 of the 8 children had acquired obesity after five years, 3 had BMI > 2.5 SD and preoperative BMI z-scores of -0.05, 1.90, and 2.61. Overall, children with thinness decreased, number with overweight and obesity increased.
6.	Hurvitz et al. (2008)	Cerebral Palsy	To investigate the prevalence of being overweight in a clinic-based population of children with cerebral palsy.	Children with CP seen in clinic during a 3 month period. Age: 2-18 years old. Country: United States of America	Sample size: 137 Identified based on gross motor function classification scale (GMFCS).	Methods: Weight and height record. Indicators: Percentile.	Overall prevalence of: ● Being overweight: 18.2% ● At Risk of being Overweight: 10.9% - Prevalence of being overweight among CP Children: ● Ambulatory(Level I&II): 22.7% ● Non-ambulatory (Level IV&V): 9.6%. - Being underweight was prevalent among females compared to males in non-ambulatory children (40%).

Table 2: Continued.

No.	Study	Type of Disability	Purpose	Participants Characteristics (Diagnosis and Age)	Sample Size and Comparison Group	Tools/ Methods/ Indicators	Rate and Prevalence of Nutritional Status
7.	Rosulescu E. et al. (2009)	Cerebral Palsy	To evaluate the growth, physical development and nutrition status for a sample of cerebral palsied children with spastic, dyskinetic and ataxia type.	Children diagnosed with CP that have received by their type of disorder and associated impairments, various complex therapeutic programs at the Centre of neuromotor rehabilitation for the severe disabled child from Craiova and at the Training Centre for health care, prophylactic and rehabilitation services of Faculty of Physical Education – Kenotherapy Country: Craiova, Rome	Sample size: 81 divided into 3 Groups: Spastic dyskinetic, ataxic.	Methods: Height (H) or recumbent length (L), weight (W). Tools: • Stadiometer, • Infant beam weight scale, • Digital weight scale. Indicators: • Children under 2 years: Percentiles of Weight for recumbent Length (WL) • Children over 2 years: BMI	Prevalence of: Children over 2 years old: • Overweight: 4 (5.5%) • Altered nutritional status: 7 (10%) Average Z-score for children: • Under 2 years old: -0.5 ± 1.2 . (Using weight for length) • Children over 2 years old: -0.1 ± 1.4 . Using BMI for age)
8.	Hung et al. (2003)	Cerebral Palsy	To investigate the nutritional status of children with spastic cerebral palsy. To identify the risk factors of under nutrition.	Children with spastic cerebral palsy were selected from a rehabilitation clinic. Age: 5 months to 10 years old. Country: Taiwan	Sample size: 75 children, (47 boys, 28 girls).	Methods: Weight and length. Tools: Beam balance: Weight. Supine-length measuring board & stationary inflexible. Measuring tape: Length. Indicators: - Weight-for-age (NHA of Taiwan) - Length-for-age (NHA of Taiwan) - Weight-for-length (NCHS US).	Prevalence of: • Under nutrition: 41.3% • Over nutrition: 4% -46.7% fell below the 10th percentile of weight-for-age reference data. -36% were fell below the 10th percentile of length-of-age reference data.
9.	Memari A. et al. (2012)	Autism Spectrum Disorder	To survey weight status of children and adolescents with autism spectrum disorder in Iranian pupils and to investigate the associated factors.	Children and adolescents attending 5 autism specific schools in Tehran in 2010. Age: 7–14 years old Country: Iran	Sample size: 113	Methods: BMI Indicators: BMI Categories	Prevalence of: • Normal: 50.4% • Underweight: 8.7% • Overweight: 13.3% • Obese: 11.5%

Table 2: Continued.

No.	Study	Type of Disability	Purpose	Participants Characteristics (Diagnosis and Age)	Sample Size and Comparison Group	Tools/Methods/ Indicators	Rate and Prevalence of Nutritional Status
10.	Curtin et al. (2010)	Autism Spectrum Disorder	To estimate the prevalence of obesity in children and adolescents with autism.	Children with self-reported doctor diagnosis of autism from parents in the 2003-2004 National Survey of Children's Health. Age: 3-17 years old. Country: United States of America	Sample size: 454	Methods: Self-report height and weight by parents. BMI. Indicator: BMI Percentile.	Prevalence of obesity of children: <ul style="list-style-type: none"> • Autism: 30.4% • Without Autism: 23.6%
11.	Curtin et al. (2005)	Autism spectrum disorder	To determine the prevalence of being overweight among a clinical population of children diagnosed with attention deficit hyperactivity and autism spectrum disorders.	Age: 3-18 years old Chart of children aged 3-18 years old seen between 1992 and 2003 at a tertiary care clinic. Country: United States of America	Sample size: 140	Methods: Reviewed patient records to obtain information on age, race, gender, height, weight. Tools: Chart Indicator: BMI Z-scores.	Prevalence of: <ul style="list-style-type: none"> • At-risk-for-overweight: 35.7% • Overweight: 19%
12.	Evans et al. (2012)	Autism Spectrum Disorder	To determine dietary patterns and association between dietary patterns and body mass index among children with autism spectrum disorder.	Children with autism spectrum disorder without other diseases or disorders and do not take any medications which would affect their appetite. Age: 3-11 years old. Country: United States of America	Sample size: 53 with autism spectrum disorder and 58 normally developing children.	Methods: BMI Tools: SECA portable scale and stadiometer. Indicators: BMI z-scores	Prevalence of: <ul style="list-style-type: none"> • Underweight: 2% • Overweight: 26% • Obese: 17%. - BMI z-score 0.52 (0.83)
13.	Hyman et al. (2012)	Autism	To compare nutrient intake from food consumed by children with and without ASD and to examine nutrient deficiency and excess.	Children aged 2-11 years old from 5 participating Autism Treatment Networks (ATN) Country: North America.	Sample size: 367	Methods: Height, weight, BMI. Indicator: BMI percentile	Prevalence of: <ul style="list-style-type: none"> • Underweight: 7% • Healthy weight: 63% • Overweight: 16% • Obese: 14%

Table 3: Summary of measurements, instruments, and indicators used to determine the nutritional status of children with disability aged 0 to 18 years.

Measurements	Instruments	Indicators
Weight (kg)	<ul style="list-style-type: none"> • Beam balance scale • ADE M50610 scale • Health o Meter MDC100KD-01 scale • Seca 954 chair scale • TANITA digital weighing scale • Infant beam weight scale 	<ul style="list-style-type: none"> • Growth curve for weight • Weight-for-age
Height (cm)	<ul style="list-style-type: none"> • Stadiometer, • Vertical mounted scale 	Growth curve for height, height- for-age
Length Segmental length Knee height Supine length/ Recumbent length Upper arm length (cm)	<ul style="list-style-type: none"> • ADE MZ10021 glass fibre metric tape • Measuring tape gym map • Length measuring board • Supine-length measuring board • Stationary inflexible measuring tape * Bone caliper for knee height estimation (Stevenson formula) 	<ul style="list-style-type: none"> • Weight-for- length • Length-for-age
Head circumference (cm)	<ul style="list-style-type: none"> • Steel flexible measuring tape 	<ul style="list-style-type: none"> • Head circumference- for-age
BMI (kg/m ²)	<ul style="list-style-type: none"> • Formula calculation 	<ul style="list-style-type: none"> • Growth curve for • BMI BMI-for-age
Mid-arm circumference (cm)	<ul style="list-style-type: none"> • Non-stretch measuring tape 	<ul style="list-style-type: none"> • Z-score for age
Triceps or subscapular skinfold thickness (mm)	<ul style="list-style-type: none"> • Holton skinfold calliper • Harpenden skinfold calliper 	<ul style="list-style-type: none"> • Subcutaneous fat (%)

3.3. Cerebral palsy. Several studies reported that the prevalence of underweight or undernutrition for children with CP aged 2 to 20 years old were within the range of 22.2% to 78.2% [15–19]. At the same time, the prevalence of being overweight or obese among this group of children ranged from 4.0% to 29.1%. A large proportion of children with CP had poor nutritional status. These studies also revealed that ambulatory children showed a higher prevalence of being overweight compared to non-ambulatory children [15–19].

3.4. Autism spectrum disorders. According to the 7 studies investigating the nutritional status of children with ASD [Table 2], children at a younger age were more likely to be overweight or obese as compared to the general population [20–26].

A narrative review was then conducted to summarise the instruments, measurements and indicators to determine the nutritional status of children with disability. Overall, the most common anthropometric measurements used for children with CP, DS, and ASD were body weight, body height or length, body mass index, and head circumference (Table 3). The most commonly used nutritional indicators were Weight-for-Age, Height-for-Age, Body Mass Index-for-Age, Head Circumference-for-Age and subcutaneous fat percentage. The majority of the studies used z-scores to interpret the nutritional status of children. Growth curves were also applied. There were variety of tools utilised to conduct the anthropometric assessments which included weighing scale, sit balance scale, bone caliper for knee height estimation,

spine- length measuring board, stadiometer, measuring tape and skinfold calipers.

4. Discussion

Based on the evidence in this review, there is emerging literature reporting the nutritional status of children with DS, CP, and ASD over the past 15 years. Several important aspects of the nutritional status among these children have been identified:

Firstly, children with DS, CP, and ASD have underweight, overweight and obesity problems and these were regularly reported by the published studies. However, the rates and prevalence varied between studies. There are several reasons for these inconsistent findings including the differences in the study design, sample size, recruitment procedures, choice of comparison groups or data and methods used to assess nutritional status. Secondly, it appears that the instruments and techniques of measurement used to measure weight, height and length of children with disability were also varied depending on the child's development and health condition. For example, Lopes et al [19] used estimates of weight and height for children with CP because it is rather difficult to measure the physical condition of a CP child, especially among those with hemiplegia and tetraplegia. In their study the parents were weighed using light clothing and then they were weighed with their child on the lap. Children with DS also grow in a different way and their growth is characterised by an earlier onset of growth spurt and reduced

linear velocity. Therefore, DS children have shorter stature than the general population [11–14]. Common indicators used to assess the nutritional status of children with DS were weight-for-age percentile, height-for-age percentile and BMI-for-age percentile. Subcutaneous fat estimate was also used to determine the nutritional status of children with DS. The measurement of the Triceps Skinfold Thickness (TSFT) was performed using the skinfold calipers [11]. Thirdly, findings from this scoping review have demonstrated that children with CP were at risk of being underweight, while children with DS and ASD were at risk of being overweight or obese. Malnutrition is common among children with CP and their nutritional status must be monitored regularly by health professionals [19]. Past studies have also shown that feeding difficulties is likely to become a determining factor in the nutritional status of children with DS, CP, and ASD. Feeding difficulties were associated with poor health and nutritional status [19, 26]. Lopes et al [19] reported that children with CP especially those who were tetraplegic had a higher prevalence of difficulties in swallowing and chewing. Children with ASD also have various feeding problems including constipation, diarrhoea and abdominal pain which affect the nutritional status of these children [20–26]. Therefore, early identification of feeding difficulties and other related symptoms should be conducted by health professionals in order to monitor their nutritional status and to plan for proper dietary intervention.

Finally, this scoping review also found that there was no clear evidence on the nutritional status of children with DS, CP, and ASD in developing countries including Malaysia. Only one study in Malaysia by Zainah et al. [18] was identified. The study only compared the linear growth and nutritional parameters of a group of Malaysian children with cerebral palsy (CP) against a group of controls. The limitation of this study was that the data was collected from selected resources. The overall prevalence of nutritional status of children with CP, DS, and ASD in developing studies is not reported in this study. Therefore, future researches need to be conducted in developing countries in order to address the prevalence of underweight, overweight and obesity among these children. Collaborative research efforts between the Ministry of Health, universities and other government agencies is one of the strategies that need to be implemented to provide evidence on the nutritional status of children with disability. Trained professionals are also needed to conduct these studies and interventions for this group. For example in Malaysia, trained professionals and health experts to conduct the anthropometric measurements for children with disability and research in this area are also limited.

In conclusion, there is emerging evidence on the nutritional status of children with ASD, DS, and CP, although this is still very limited in developing countries including Malaysia. Findings of this scoping review demonstrated that children with CP were at risk of being underweight, while children with DS and ASD were at risk of being overweight or

obese. It is hoped that these findings will support the planning of future researches and health interventions/programmes for this population.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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