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ORIGINAL PAPER

Correlates of Feeding Difficulties Among Children with Autism Spectrum Disorder: A Systematic Review

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Abstract

Feeding difficulties related to selective intake, or eating a limited variety of foods, are very common in children with autism spectrum disorder (ASD). A systematic search of PubMed, Embase, PsycInfo, and CINAHL identified 29 studies that evaluated eight correlates: age, ASD symptoms and severity, cognitive and adaptive skills, sensory processing and perception, challenging behavior, weight status, gastrointestinal symptoms, and parenting stress. Feeding difficulties related to selective intake are consistently correlated with impaired sensory processing and perception and tend to be positively associated with rigidity and challenging behavior. These feeding difficulties tend to persist with advancing age. Other correlates demonstrated inconsistent findings. A significant limitation of research reviewed is variability in terminology, definitions, and measurement of feeding difficulties.

Keywords Autism spectrum disorder · Feeding difficulty · Food selectivity · Selective eating

Introduction

Children with autism spectrum disorder (ASD) have a fivefold increase in the odds of having a feeding difficulty compared to typically developing children (Sharp et al., 2013a). Feeding difficulty is an umbrella term that has been used to refer to a wide array of problems related to dietary intake and eating behaviors. Kerzner et al. (2015) classified feeding difficulties into three categories: limited appetite, selective intake, and fear of feeding. Children with selective intake eat a limited variety of foods. Kerzner et al. (2015) further classified selective intake into neophobia (i.e., rejection of foods that are new), mild selectivity (or "picky eating"), severe selectivity (as in ASD), and organic (e.g., related to developmental delay) to describe that selective intake can range from mild to severe and may be primarily behavioral or organic in origin.

In the literature on children with ASD, feeding difficulties related to selective intake have been called food selectivity, selective eating, food fussiness, picky eating, food neophobia, food refusal, food aversion, and atypical eating, among others. This paper will focus on feeding difficulties related to selective intake among children with ASD that will hereafter be referred to as feeding difficulties, except where studies indicate use of a specific term.

Feeding difficulties are very common among children with ASD. A recent paper found that the median prevalence was 62% (range: 30–84%) among children with ASD (Mayes & Zickgraf, 2019). Prevalence estimates range widely due to variability in assessment methods.

Children with ASD have deficits in social interaction and social communication as well as restricted, repetitive patterns of behavior, interests, or activity (American Psychiatric Association, 2013) that may contribute to the development of feeding difficulties. For example, inflexibility or insistence on sameness may manifest as the child eating the same foods daily, while hyperreactivity to sensory input may result in food aversions. Deficits in communication can impact the child's ability to verbally convey hunger, fullness, likes, and dislikes. Further, social deficits may impair the child's ability to copy the early feeding behaviors that parents model

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and reduce engagement in family mealtimes. However, not all children with ASD display feeding difficulties. Therefore, it is important to determine the cognitive, behavioral, physiological, and familial factors that are associated with feeding difficulties. This will help to develop effective treatment approaches.

A potential consequence of feeding difficulties is reduced diet quality. Children, with and without ASD, who have a limited food repertoire are at risk for nutrient deficiencies (Bandini et al., 2010). There is evidence that children with ASD consume fewer fruits and vegetables and have a lower intake of calcium and protein compared to their typically developing peers (Sharp et al., 2013a). However, when compared to daily recommended intakes, protein intake among children with ASD was two to three times higher than recommended and fruit and vegetable intake was adequate (Esteban-Figuerola et al., 2019). Children with ASD have been found to have lower intake than recommended for calcium and vitamin D (Esteban-Figuerola et al., 2019). In some children with ASD, feeding difficulties may lead to overconsumption of certain foods. For example, Evans et al. (2012) found that children with ASD overconsumed juice, sweetened non-dairy beverages, and snack foods compared to typically developing children.

A child's risk for specific nutrient deficiencies will be related to their individual pattern of intake and this risk may be mitigated by consumption of processed foods that are fortified with vitamins and minerals and the use of dietary supplements. Nonetheless, there are instances where children with ASD exhibit extremely selective diets and cases of specific nutrient deficiencies have been reported. These include: scurvy from vitamin C deficiency (Sharp et al., 2020), xerophthalmia from vitamin A deficiency (Duignan et al., 2015), optic neuropathy from vitamin B12 deficiency (Pineles et al., 2010), and pellagra from niacin deficiency (Zaenglein et al., 2020).

Five previous reviews on feeding difficulites in children with ASD provide an overview of the scope of the problem (Cermak et al., 2010; Kral et al., 2013; Ledford & Gast, 2006; Mari-Bauset et al., 2014; Sharp et al., 2013a). Collectively, these reviews include literature spanning from 1970 to 2013 and establish that children with ASD experience more feeding difficulites and are at higher risk for reduced diet quality compared to typically developing children.

Additionally, Cermak et al. (2010) examined sensory sensitivities (i.e., over responsivity to sensory stimuli in the environment) as a correlate of food selectivity and presented evidence that sensory sensitivities, especially to food texture, may contribute to food selectivity. Since 2013, there has been substantial growth in the literature on feeding difficulites as well as changes to the diagnostic criteria for ASD. No reviews to our knowledge have systematically described the correlates of feeding difficulties in children with ASD.

The purpose of this systematic review is to examine the correlates of feeding difficulties among children with ASD. Specifically, this review aims to (a) identify correlates of feeding difficulties that have been empirically studied and (b) describe the relationship between the correlates and feeding difficulties.

Methods

Search Strategy

A search strategy was developed in consultation with a research librarian. First, four databases were selected: PubMed, Embase, PsycInfo, and CINAHL. Second, search terms were defined (Table 1). This included controlled vocabulary (e.g., MeSH or Emtree terms) and keywords for each concept (i.e., autism and feeding difficulties). Multiple terms and broad vocabulary were used to capture the diverse ways that feeding difficulties are described in the literature. The pediatric search filter validated by Leclercq et al. (2013) was used. Finally, results were restricted to English language and publication dates from January 2013 through June 2020.

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were defined a priori. Inclusion criteria were published, peer reviewed studies that used quantitative methodologies to evaluate one or more correlates (e.g., age) of feeding difficulties. The population included children ages 2–18 with a diagnosis of ASD. A diagnosis of ASD was defined as meeting diagnostic criteria according to the Diagnostic and Statistical Manual of Mental Disorders, fourth or fifth editions (DSM-IV, DSM-IV-TR, DSM-5). Studies of children with comorbid diagnoses that impact eating, such as Prader Willi or anorexia nervosa, were excluded. Studies were excluded if they (a) did not specify the type of feeding difficulties (b) included feeding difficulties not related to selective intake (e.g., pica, dysphagia), (c) did not separate out the ASD group from a control group in analysis, (d) assessed effects of dietary interventions (e.g., gluten/casein free, ketogenic), or (e) examined only nutrient intake.

Study Selection

The PRISMA flow diagram (Fig. 1) details the article selection process. The database search yielded 3235 unique articles. The titles and abstracts were screened, resulting in 205 articles that were assessed for eligibility. Of these, 172 articles did not meet inclusion criteria. The most common reasons for exclusion were case study methodology (n = 72) and feeding difficulties not related to selective intake (n = 41).

Table 1 Search terms: controlled vocabulary and keywords

	PubMed (MeSH terms)	Embase (Emtree)	PsycInfo (Thesaurus terms)	CINAHL (CINAHL headings)	Keywords (for all searches)
Autism	Autism spectrum disorder	Autism	Autism spectrum disorders	Autistic disorder	Autism OR Autistic OR Asperger OR ASD
Feeding difficulties	Eating; feeding and eating disorders; feeding behavior; diet, healthy; meals;	Eating; feeding; feeding behavior; feeding disorder; eating disorder; dietary intake; meal	Eating behavior; feeding disorder; eating disorder; mealtimes	Eating behavior; feeding and eating disorders of childhood; eating disorders; diet; meals	"eating behav*" OR "feeding behav*" OR "food selectivity" OR mealtime OR "meal time" OR "food refusal" OR picky OR pickiness OR "fussy eaters" OR "food fussiness" OR "food neophobia" OR "disordered eating" OR "selective eating" OR "feeding disorders" OR "eating disorders" OR "food preference" OR meals OR mealtimes OR "dietary intake" OR diet OR eating OR feeding

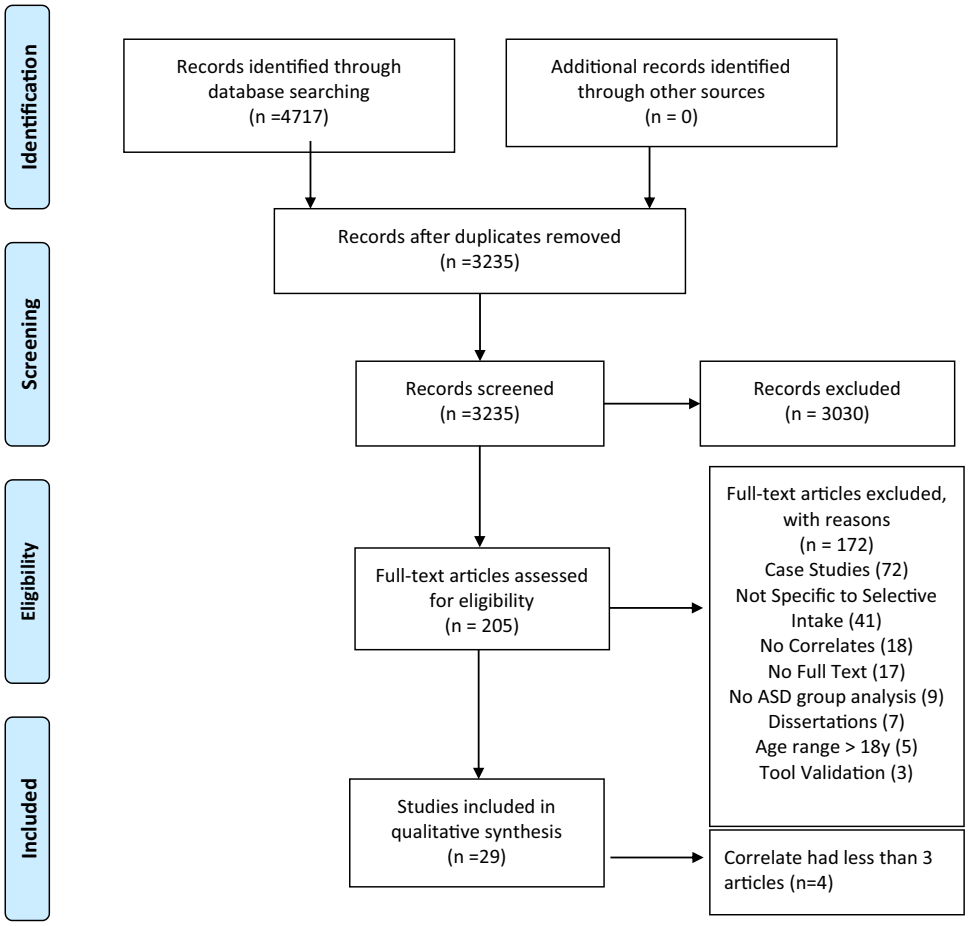

Fig. 1 PRISMA diagram

A total of 11 correlates were identified in the remaining 33 articles. To allow for synthesis of results for each correlate, if a correlate was evaluated by less than three articles, it was also excluded. This resulted in the exclusion of four articles: two on gut microbiota (Berding & Donovan, 2018; Tomova et al., 2020), one on dental health (Leiva-Garcia et al., 2019) and one on the TARS2R38 genotype (Riccio et al., 2018). Therefore, 29 studies were analyzed. Manually screening the references of these articles did not identify any additional literature.

Following article selection, the following data were extracted: country, study design, sample size, participant characteristics (e.g., age, race, sex), definition and measurement of feeding difficulty, definition and measurement of correlate(s), and statistical analysis of the relationship. The methodological quality of each study was evaluated using tools from the *National Heart, Lung, and Blood Institute* and quality ratings (good, fair, or poor) were assigned. The table of evidence (Table 2) summarizes study characteristics and quality ratings.

Results

Study Characteristics

Of the 29 studies, there were 20 cross-sectional studies, three chart reviews, three secondary data analyses, two follow-up studies, and one case–control study. Two of the secondary data analyses and one of the follow-up studies used data from the Children's Activity and Meal Patterns Study (CHAMPS) (Bandini et al., 2017; Chistol et al., 2018; Curtin et al., 2015). Each study evaluated different correlates, so all three were retained in this review. Studies were conducted in the United States (15), Israel (4), Australia (2), Ireland (2), Switzerland (2), Italy (2), United Kingdom (1), and India (1).

All studies used convenience sampling. Participants were recruited from medical centers, schools, parent groups, or organizations that provide services to families. Sample sizes ranged from 18 to 1224 children with a mean of 190. After removing outliers, defined as any point beyond 1.5 interquartile ranges above the third quartile or below the first quartile, the mean sample size was 82. The diagnosis of ASD was provided by parental report in 18 studies, with nine of these studies confirming the diagnosis with either a screening test (e.g., Social Communication Questionnaire) or the Autism Diagnostic Observation Schedule-ADOS (Lord et al., 2012a, 2012b). In nine studies a clinician provided the diagnosis as a part of the study and in two studies ICD-9 (International Classification of Diseases, Ninth Revision) codes were used to identify patients with ASD. Eleven studies included control groups of typically developing children or children with other developmental disabilities. In six studies all participants had ASD, so children without feeding difficulties were considered the control group.

Study Quality

The overall quality of the literature on the correlates of feeding difficulties was fair. Specifically, 12 studies were rated as good, 14 as fair, and three as poor. The most frequent source of potential bias was lack of measurement or adjustment for the impact of potential confounding variables (e.g., race/ethnicity, medication use) that could influence the variable under study. Seventeen studies did not report race/ethnicity. Another frequent source of bias was the use of unvalidated measures of feeding difficulties or correlates.

Measurement of Feeding Difficulties

Several different terms were used to refer to feeding difficulties related to selective intake. Food selectivity was the most common term and was used in 12 studies. Food selectivity has been operationally defined as including three domains (food refusal, limited food repertoire, and high frequency single food intake) that are assessed using measures of dietary intake (Bandini et al., 2010). However, only four studies used this precise definition (Bandini et al., 2017; Chistol et al., 2018; Curtin et al., 2015; Postorino et al., 2015). Other terms used by studies in this review were feeding/eating problems (4), selective eating (2), food neophobia (2), feeding difficulties (2), mealtime behaviors/problems (2), food fussiness (1), eating disturbance behavior (1), child eating behavior (1), feeding challenges (1), and problem eating behaviors (1).

A variety of methods were used to assess feeding difficulties through the measurement of eating behaviors and/or dietary intake. The majority of studies (n = 26) used parent report measures only, while three studies combined parent report measures with a mealtime observation. Parent report measures included: the Brief Autism Mealtime Behavior Inventory—BAMBI (Lukens & Linscheid, 2008) in seven studies, a Food Frequency Questionnaire—FFQ in six studies, a single question in six studies, the Child Food Neophobia Scale (Pliner, 1994) in three studies, a diet log in three studies, the Children's Eating Behavior Questionnaire (Wardle et al., 2001) in two studies, the Screening Tool of Feeding Problems for Children—STEP-CHILD (Seiverling et al., 2011) in two studies, a clinical interview with parents in two studies, the Food Preferences Inventory in one study, the Aut-Eat questionnaire (Vissoker et al., 2019) in one study, and the Swedish Eating Assessment for ASDs (Karlsson et al., 2013) in one study.

Table 2 Table of evidence

Author (year) country study design	Participant characteristics					Feeding difficulties measurement	Correlates	Quality rating
	Age, years [range mean (sd)]	N	Sex (% male)	Race	ASD diagnosis	Terminology: measurement tool		
Aponte and Romanczyk (2016) USA Cross-sectional	3.5–12.5 6.9	38	84	NR	Parent report	Feeding problems (food selectivity and behavioral refusal): FFQ; BAMBI; mealtime observation	ASD severity and symptoms	Good
Bandini et al. (2017) USA Follow up to a cross-sectional Study (CHAMPS study)	Baseline 6.8 (2.3) Follow up 13.2 (2.5)	18	89	NR	Parent report; confirmed with ADI-R	Food selectivity: FFQ; 3-day food record	Age Weight status	Fair
Beighley et al. (2013) USA Cross-sectional	2–18 8.36 (3.59)	525 (127 autistic, 82 PDD-NOS, 60 asperger's, 107 Atypical, 149 typical)	69.9	79.2% White	Clinician diagnosis per DSM-IV	Food selectivity: ASD-CC—single item "will eat only certain food" rated as 0 (not a problem), 1 (mild), or 2 (severe)	Age	Fair
Bitsika and Sharpley (2018) Australia Cross-sectional	6–14 9.7 (2.4)	50	0	NR	Clinician diagnosis per DSM-5 and ADOS-2	Eating disturbance behavior: Swedish eating assessment for ASDs (SWEAA)	Cognitive skills	Good
Chistol et al. (2018) USA Secondary data analysis (CHAMPS study)	3–11 ASD: 6.6 (2.1) TYP: 6.7 (2.4)	111 (53 ASD, 58 TYP)	ASD: 83 TYP: 76	ASD: 83% White TYP: 76% White	Parent report; confirmed with ADI-R	Food selectivity: FFQ; 3-day food record	Sensory processing	Good
Curtin et al. (2015) USA Secondary data analysis (CHAMPS study)	3–11 ASD: 6.6 (2.1) TYP: 6.7 (2.4)	111 (53 ASD, 58 TYP)	ASD: 83 TYP: 78	ASD: 91% White TYP: 81% White	Parent report; confirmed with ADI-R	Food selectivity: FFQ	Parenting stress	Good
Gray et al. (2018) USA Cross-sectional	2–17 8.1	41	73	39% White; 34% Hispanic	Parent report	Feeding difficulties: unnamed instrument	Age	Poor

Table 2 (continued)

Author (year) country study design	Participant characteristics					Feeding difficulties measurement	Correlates	Quality rating
	Age, years [range mean (sd)]	N	Sex (% male)	Race	ASD diagnosis	Terminology: measurement tool		
Kral et al. (2015) USA Cross-sectional	4–6 ASD: 5 (0.9) TYP: 5.2 (0.7)	55 (25 ASD, 30 TYP)	ASD: 72, TYP: 47	ASD: 60% White, 24% Black TYP: 7% White, 83% Black	Parent report and elevated score on SCQ	Child eating behaviors: Child Food Neophobia Scale; Child Eating Behavior Questionnaire	Sensory processing	Fair
Lane et al. (2014) Australia Cross-sectional	3.4–9.4 6.7	30	80	NR	Parent report	Problem eating behaviors: BAMBI	Sensory processing	Fair
Leader et al. (2020b) Ireland Cross-sectional	8.36 (4.13)	136	72	NR	Parent report	Feeding problems: STEP-CHILD	Sensory processing Behavior GI symptoms	Fair
Leader et al. (2020a) Ireland Cross-sectional	3–17 8 (3.8)	120	77.5	NR	Parent report	Feeding problems: STEP-CHILD	Adaptive skills Sensory processing Behavior GI symptoms	Fair
Luisier et al. (2015) Switzerland Cross-sectional	6–13 ASD: 9.58 (0.83) TYP: 9.97 (0.80)	20 (10 ASD, 10 TYP)	100	NR	Parent report	Food neophobia: French adapted Food Neophobia Scale	Sensory perception	Good
Luisier et al. (2019) Switzerland Cross-sectional	5.1–15.2 ASD: 10.4 (2.4) TYP: 10.6 (2.4)	22 (11 ASD, 11 TYP)	ASD: 100 TYP: 63.6	NR	Parent report; confirmed by ADOS	Food neophobia: French adapted Food Neophobia Scale	Sensory perception	Good
Padmanabhan and Shroff (2020) India Cross-sectional	3–11 7.09 (2.55)	146	80.8	NR	Parent report	Feeding difficulties: 24-h diet recall	Sensory processing	Fair
Patton et al. (2020) USA Cross-sectional	2–8 5.42 (1.88)	73	77	64% White	Parent report	Mealtime problems: BAMBI; Dyadic Interaction Nomenclature for Eating	ASD severity	Fair
Pham et al. (2020) USA Chart review	2–18	592	NR for full sample	NR for full sample	ICD-9 code in chart	Food selectivity or sensitivity: CARS-2 items or note in chart	Weight status ASD severity	Fair

Table 2 (continued)

Author (year) country study design	Participant characteristics					Feeding difficulties measurement	Correlates	Quality rating
	Age, years [range mean (sd)]	N	Sex (% male)	Race	ASD diagnosis	Terminology: measurement tool		
Postorino et al. (2015) Italy Cross-sectional	3–12 7.16 (2.05)	158 (79 with FS, 79 without FS)	86	100% White	Clinician diagnosis per DSM-IV	Food selectivity: FFQ	GI symptoms Weight status ASD severity and symptoms Cognitive skills Adaptive skills Behavior Parental stress	Good
Prosperi et al. (2017) Italy Cross-sectional	1–6 3.6 (1.2)	163	84	NR	Clinician diagnosis per DSM-IV or DSM-5; confirmed by ADOS	Food selectivity: CBCL item—answered "very or often true" to the item "doesn't eat well" and specified food selectivity in comment	Behavior GI symptoms ASD severity and symptoms Cognitive skills	Fair
Sharp et al. (2013a, 2013b) USA Cross-sectional	3–8 yeas 5.7 (1.4)	30	76.7	NR	Parent report; confirmed by social responsiveness scale	Feeding problems: food preferences inventory; BAMBI; mealtime observation	Weight status ASD severity	Fair
Sharp et al. (2018) USA Chart review	2–17 5.09	70	80	61.4% White	ICD-9 code in chart	Food selectivity: multimethod assessment by registered dietician nutritionist	Age Weight status	Fair
Shmaya et al. (2017) Israel Case–control	ASD: 4.5 (0.9) Siblings: 6.4 (2.7) TYP: 4.3 (0.97)	91 (ASD: 50; siblings: 12; TYP: 29)	ASD: 80.4 Sibs: 71.4 TYP: 75.9	NR	Clinician diagnosis including CARS and ADOS; All participants screened using ASQ	Mealtime behaviors: BAMBI	Sensory processing	Good
Smith et al. (2020) UK Cross-sectional	6–17 ASD: 10.8 (3.6), Tourette's: 10.2 (2.6) ADHD: 10.8 (3.6) TYP: 9.7 (2.4)	98 (27 ASD, 27 Tourette's, 17 ADHD, 27 TYP)	59.3	NR	Parent report and elevated score on autism spectrum screening questionnaire	Food fussiness: Child Eating Behavior Questionnaire	Age Weight status ASD Severity Sensory processing	Good

Table 2 (continued)

Author (year) country study design	Participant characteristics					Feeding difficulties measurement	Correlates	Quality rating
	Age, years [range mean (sd)]	N	Sex (% male)	Race	ASD diagnosis	Terminology: measurement tool		
Suarez et al. (2014) USA Follow up to a cross-sectional study	Baseline: 3–9 6.6 Follow up: 4–11 8.3	52	88	96% White	Parent report	Food selectivity: single question—select how many foods the child accepts as a part of his regular diet: less than 5, 6–10, 11–20, 21–30, 30+ FS categories: acceptance of less than 10 foods (severe), 10–20 foods (moderate), 21 or more foods (typical)	Age Sensory processing ASD symptoms	Poor
Tanner et al. (2015) USA Cross-sectional	4–10 years FS: 6.6 (1.9) No FS: 7 (2)	35 (17 FS, 18 No FS)	FS: 88.2 No FS: 94.4	FS: 76.5% White No FS: 50% White	Parent report and elevated score on SCQ	Selective eating: FFQ; BAMBI-C	Weight status Sensory processing Behavior ASD symptoms	Fair
Thullen and Bonsall (2017) USA Cross-sectional	4–13 9.5 (2.5)	112	81.3	92.9%	Clinician diagnosis including ADOS	Feeding challenges: BAMBI	Parenting stress	Fair
Vissoker et al. (2018) Israel Chart review	1.6–11 3.9 (1.4)	68	86.8	NR	Clinician diagnosis as per DSM-IV	Food selectivity: parent report of over-selectivity, aversions to specific textures, colors, smells and temperatures, rigidity with respect to brands of food, restricted intake to certain food groups	GI symptoms	Poor
Vissoker et al. (2019) Israel Cross-sectional	3–7 ASD: 2.4 (1.4) TYP: 4.2 (1.37)	200 (105 ASD, 95 TYP)	100	NR	Clinician diagnosis as per DSM-5	Eating problems and patterns: AUT-EAT Questionnaire	Age	Good

Table 2 (continued)

Author (year) country study design	Participant characteristics					Feeding difficulties measurement	Correlates	Quality rating
	Age, years [range mean (sd)]	N	Sex (% male)	Race	ASD diagnosis	Terminology: measurement tool		
Zachor and Ben-Itzchak (2016) Israel Cross-sectional	1–12 years 4.2 (2.5)	1224	85.2	NR	Clinician diagnosis as per DSM-IV or DSM-5 and ADOS and ADI-R	Food selectivity: categorized parental responses as: 0 = eats normally or has a few specific foods that he won't eat 1 = has more restrictions (will only eat certain food groups), fairly limited options 2 = very limited options and/or will not eat certain textures or certain colors (defined as FS)	ASD severity Adaptive skills Cognitive skills	Good
Zickgraf et al. (2020) USA Secondary data analysis	ASD: 4–17 8.65 (3.04), anxiety/OC: 5–17 11.85 (3.48), TYP: 5–17 10.62 (3.96), college: 18–22 19.93 (2.27)	1137 ASD: 185, anxiety/OC: 179, TYP: 263, college: 510	ASD: 72, anxiety/OC: 58.1, TYP: 47.5, college: 29	NR	Parent report and elevated score on autism quotient-10	Selective eating, picky eating: children's eating behavior questionnaire	Sensory processing ASD symptoms	Good

ADOS autism diagnostic observation schedule, *ADI-R* autism diagnostic interview-revised, *ASD-CC* autism spectrum disorder-comorbidity for children, *ASQ* autism screening questionnaire, *BAMBI* brief autism mealtime behavior inventory, *BAMBI-C* brief assessment of mealtime behavior in children, *CARS* childhood autism rating scale, *CBCL* child behavior checklist, *DSM* diagnostic and statistical manual of mental disorders, *FFQ* food frequency questionnaire, *FS* food selectivity, *ICD* International Classification of Diseases, *NR* not reported, *PDD-NOS* pervasive developmental disorder—not otherwise specified, *SCQ* social communication questionnaire, *STEP-CHILD* screening tool of feeding problems for children, *TYP* typically developing control group

For studies that used dietary intake to operationalize feeding difficulties, there was variability in how much acceptance or refusal constituted feeding difficulties. For example, Curtin et al. (2015) defined "high food selectivity" as refusing greater than 33% of foods offered over the course of a year, whereas Tanner et al. (2015) defined selective eating as consuming fewer than 50 foods in the past year. This variability renders cross-study comparison or integration of data very challenging if not impossible.

Correlates of Feeding Difficulties

The eight correlates of feeding difficulties identified were: (a) age, (b) ASD symptoms and severity, (c) cognitive and adaptive skills, (d) sensory processing and perception, (e) challenging behavior, (f) weight status, (g) gastrointestinal (GI) symptoms, and (h) parenting stress. All correlates were characteristics of the child with the exception of parenting stress. The associations between correlates and feeding difficulties are summarized in Table 3.

Age

Seven studies examined the correlation between age and feeding difficulties. Three studies reported a negative association (Bandini et al., 2017; Beighley et al., 2013; Gray et al., 2018), one study reported a positive association (Vissoker et al., 2019) and three studies reported no association between age and feeding difficulties (Sharp et al., 2018; Smith et al., 2020; Suarez et al., 2014).

Five studies used cross-sectional data. Beighley et al. (2013) found that food selectivity, defined as "will eat only certain food", decreased with increasing age, up to 18 years old. Gray et al. (2018) compared eating behaviors among children with ASD across early childhood (2–6 years), mid-childhood (7–11 years), and adolescence (12–17 years) and found that parents reported that picky eating decreased and eating a variety of foods increased from early childhood to adolescence. However, across all three age groups, children displayed specific food preferences, avoided certain foods, and resisted trying new foods with high prevalence. In contrast, Vissoker et al. (2019) found a significant positive correlation between age and food selectivity, measured by a subscale on the Aut-Eat Questionnaire. This was supported by a significant negative correlation between age and the number of foods regularly consumed. Further, the researchers report that the positive relationship between age and food selectivity appeared to be driven by increased ritualistic behavior that was more common in older children. This study only included children up to 7 years old, thus limiting the ability to draw conclusions about the trajectory of feeding difficulties across childhood.

Two studies examined the persistence of feeding difficulties over time by conducting follow-up assessments approximately 2 years (Suarez et al., 2014) and 6 years (Bandini et al., 2017) later. Both studies had attrition rates of greater than 60%, posing a significant threat to study validity. Suarez et al. (2014) reported that there were no significant differences in food selectivity over time, with 60.1% of the sample having the same level of food selectivity, defined as the number of foods accepted, at follow up as they did at baseline. In contrast, Bandini et al. (2017) found that food refusal (number of foods refused out of those offered) declined with age. There was no significant change in food repertoire over the 6 year period, which is consistent with the definition of food selectivity used by Suarez et al. (2014). The impact of treatment or nutritional counseling was considered only by Suarez et al. (2014). Two participants had received treatment for severe feeding difficulties and only one participant improved from severely to moderately selective.

As a whole, these seven studies suggest that feeding difficulties are a persistent problem throughout childhood and adolescence, although some aspects of the feeding difficulties do improve with advancing age.

ASD Symptoms and Severity

In studies that evaluated the association between ASD severity and feeding difficulties, one study reported a positive association (Pham et al., 2020) and three reported no association (Prosperi et al., 2017; Sharp et al., 2013b; Smith et al., 2020). In three studies, the relationship varied by how feeding difficulties or ASD severity were assessed (Patton et al., 2020; Postorino et al., 2015; Zachor & Ben-Itzchak, 2016).

Pham et al. (2020) reported that the prevalence of food selectivity increased as ASD severity increased from mild to moderate to severe. ASD severity was assessed by the total score on the Childhood Autism Rating Scale—2nd Edition (CARS-2), a clinician-completed assessment based on parental report. Food selectivity in this study was determined by either select items on the CARS-2 or another note in the medical chart. This association may be biased by the fact that the measure of feeding difficulties is a component of the CARS-2 total score. Also using the CARS-2, Patton et al. (2020) reported no associations between ASD severity and feeding difficulties, measured by the BAMBI. However, in the mealtime observation part of this study, children with more severe ASD were less likely to take a bite of an unfamiliar food.

Zachor and Ben-Itzchak (2016) and Postorino et al. (2015) found that the correlation between feeding difficulties and ASD severity differed by assessment method. Zachor and Ben-Itzchak (2016) reported that food selectivity was positively correlated with ASD severity when

Table 3 Correlates of feeding difficulties

Correlate	Positive association	Negative association	No association
Age	Vissoker et al. (2019)	Bandini et al. (2017) (Food refusal only), Beighley et al. (2013) and Gray et al. (2018)	Sharp et al. (2018), Smith et al. (2020) and Suarez et al. (2014)
ASD severity	Pham et al. (2020), Postorino et al. (2015) (Social responsiveness scale), Patton et al. (2020) (Clinician observed FS), and Zachor and Ben-Itzchak (2016) (ADI-R only)		Patton et al. (2020) (Parent report of FS), Postorino et al. (2015) (ADOS and ADI-R), Prosperi et al. (2017), Sharp et al. (2013b) and Smith et al. (2020)
ASD symptoms: social	Postorino et al. (2015)		
ASD symptoms: repetitive and restrictive behaviors	Prosperi et al. (2017), Suarez et al. (2014), and Zickgraf et al. (2020)	Tanner et al. (2015) (Compulsive behavior scale only)	Aponte and Romanczyk (2016), and Tanner et al. (2015)
Cognitive skills		Bitsika and Sharpley (2018), and Postorino et al. (2015) (Leiter international performance test-revised)	Postorino et al. (2015) (Griffiths mental developmental scale-extend revised), Prosperi et al. (2017), and Zachor and Ben-Itzchak (2016)
Adaptive skills		Zachor and Ben-Itzchak (2016)	Leader et al. (2020a), and Postorino et al. (2015)
Sensory processing: total problems	Leader et al. (2020a, 2020b), Padmanabhan and Shroff (2020), and Suarez et al. (2014)		
Sensory processing: oral sensory sensitivity or taste/smell sensitivity	Chistol et al. (2018), Kral et al. (2015), Lane et al. (2014), Shmaya et al. (2017), Smith et al. (2020), Tanner et al. (2015), and Zickgraf et al. (2020) (Not smell sensitivity)		
Sensory perception impairments	Luisier et al. (2015, 2019)		
Challenging behavior	Leader et al. (2020b), Postorino et al. (2015), and Prosperi et al. (2017)		Tanner et al. (2015)
Weight status	Pham et al. (2020)		Bandini et al. (2017), Postorino et al. (2015), Sharp et al. (2013b, 2018), Smith et al. (2020) and Tanner et al. (2015)
GI symptoms	Leader et al. (2020b) and Prosperi et al. (2017)		Leader et al. (2020a), Postorino et al. (2015) and Vissoker et al. (2018)
Parenting stress	Postorino et al. (2015)		Curtin et al. (2015) and Thullen and Bonsall (2017)

assessed by parental report using the Autism Diagnostic Interview- Revised, ADI-R (Lord et al., 1994), but not when it was assessed by clinician observation using the Autism Diagnostic Observation Scale-Calibrated Severity Scale, ADOS-CSS (Gotham et al., 2009). Postorino et al. (2015) found that children with food selectivity had more severe symptoms when assessed by the Social Responsiveness Scale-SRS (Constantino, 2012), a parent report measure, but not on the ADOS-CSS or the ADI-R. Prosperi et al. (2017) also found no association when using the ADOS-CSS. Finally, Sharp et al. (2013) found no association between ASD severity assessed by the SRS and feeding difficulties that were assessed by the BAMBI, the Food Preferences Inventory, and a mealtime observation.

Two studies used screening tools: the Social Communication Questionnaire-SCQ (Rutter et al., 2003) and

the Autism Spectrum Screening Questionnaire—ASSQ (Ehlers et al., 1999). Postorino et al. (2015) reported that children with food selectivity scored higher on the SCQ while Smith et al. (2020) reported that the ASSQ total score was not correlated with food fussiness on the Children's Eating Behavior Questionaire (CEBQ). The positive correlation between social impairment and feeding difficulties warrants further evaluation, as this was not evaluated by any other studies.

Findings related to the association between feeding difficulties and restricted, repetitive behaviors (RRB) were mixed. RRB are a core feature of ASD and include behaviors such as stereotyped or repetitive motor movements (e.g., hand flapping), repetitive use of objects (e.g., lining up toys), insistence on sameness, rituals, and highly specific interests or preoccupations (American Psychiatric Association, 2013). In the diagnostic criteria for ASD, hyper or hyporeactivity to sensory input is also considered a RRB, but is considered separately in this paper.

Using the Repetitive Behaviors Scale—Revised—RBS-R (Lam & Aman, 2007), Suarez et al. (2014) and Prosperi et al. (2017) found that children with food selectivity had more severe RRB. However, Suarez et al. (2014) found that RRB was no longer a significant predictor of food selectivity once sensory hyperreactivity was accounted for in their statistical models. Tanner et al. (2015) reported that children with selective eating had higher scores only on a single item about repetitive behavior during mealtime. Children without selective eating had more compulsive behaviors and did not differ from children with selective eating in ritualistic/sameness behaviors or on the total RBS-R score. A methodological difference is that Tanner et al. (2015) derived feeding difficulties from the FFQ, while Suarez et al. (2014) and Prosperi et al. (2017) relied on questionnaires.

Other tools for assessing RRB included the Pervasive Developmental Disorder Behavior Inventory (Cohen & Sudhalter, 2005) and the Flexibility Scale-Revised (Strang et al., 2017). Importantly, these measures focus on ritualistic behavior and rigidity, while the RBS-R also includes motor stereotypies, self-injury, and compulsive behavior. Aponte and Romanczyk (2016) reported that the Ritualism domain of the Pervasive Developmental Disorder Behavior Inventory did not relate to the limited variety subscale of the BAMBI or to the percentage of foods accepted during the mealtime observation. Zickgraf et al. (2020) used the Flexibility Scale-Revised and found that rigidity was significantly positively correlated with selective eating.

The research conducted to date suggests that, with comorbid feeding difficulties, parents may perceive their child's ASD to be more severe. When clinician assessment is used to determine ASD severity, there tends to be no relationship with feeding difficulties. RRB tend to be positively associated with feeding difficulties. No conclusions can be drawn about the relationship between social symptoms and feeding difficulties at this time.

Sensory Processing and Perception

Eleven studies examined sensory processing and feeding difficulties. Sensory processing refers to the interaction between the responsiveness of one's nervous system to sensory input and self-regulation strategies (Dunn, 1997). All studies found that impaired sensory processing was positively correlated with feeding difficulties.

Six studies (Lane et al., 2014; Leader et al., 2020a, 2020b; Padmanabhan & Shroff, 2020; Smith et al., 2020; Tanner et al., 2015) used the Short Sensory Profile (McIntosh et al., 1999) and three studies (Chistol et al., 2018; Kral et al., 2015; Shmaya et al., 2017) used the longer Sensory Profile (Dunn, 1999). Both are parent report measures. Children with feeding difficulties were found to have lower total scores on the Short Sensory Profile, indicating more atypical sensory processing, when feeding difficulties were measured by questionnaire (Leader et al., 2020a, 2020b) and by assessment of the number of food groups refused (Padmanabhan & Shroff, 2020). Although, Tanner et al. (2015) found that the total Short Sensory Profile score did not differ between groups with and without selective eating, taste/smell sensitivity did. Having impaired taste/smell sensitivity was correlated with intake of fewer foods in the past year (Tanner et al., 2015), less variety on the BAMBI (Lane et al., 2014; Tanner et al., 2015), and increased food fussiness (Smith et al., 2020). On the Sensory Profile, taste/smell sensitivity is included within the Oral Sensory Sensitivity factor. Atypical Oral Sensory Sensitivity was correlated with increased food refusal on the FFQ (Chistol et al., 2018), less variety on the BAMBI (Shmaya et al., 2017), food neophobia (Kral et al., 2015), and food fussiness on the CEBQ (Kral et al., 2015). Chistol et al. (2018) further classified children as having typical or atypical oral sensory over-sensitivity (i.e., having a low tolerance for taste/smell and food texture stimuli). When stratified in this way, children with atypical oral sensory over-sensitivity exhibited twice as much food refusal and consumed significantly fewer fruits and vegetables. Atypical oral sensory under-sensitivity was not examined. Zickgraf et al. (2020) differentiated smell from oral texture sensitivity (which is not separated on the Short Sensory Profile or Sensory Profile) by using items adapted from the Eating Habits Survey (Wildes et al., 2012). Oral texture sensitivity, but not smell sensitivity, was significantly correlated with selective eating. Suarez et al. (2014) explored sensory hyperreactivity using a study specific tool at two time points. There was no change in sensory processing over time and hyperreactivity at baseline predicted severe food selectivity 2 years later.

Two studies evaluated sensory perception in an experimental setting. Increased food neophobia was exhibited by children who had difficulty categorizing odors (Luisier et al., 2015) and who rated familiar food images as more unpleasant (Luisier et al., 2019).

There is clear evidence that impaired sensory processing is positively associated with feeding difficulties in children with ASD. Altered sensory perception appears to also be positively associated with food neophobia, but current evidence is from two small studies and thus warrants further investigation.

Cognitive and Adaptive Skills

Cognitive skills were evaluated in four studies using a variety of standardized assessments. The choice of standardized assessment measure was dependent on the age and verbal ability of the child being tested. Zachor and Ben-Itzchak (2016) and (Prosperi et al., 2017) reported no association between cognitive skills and feeding difficulties.

The relationship between food selectivity and cognitive skills differed by assessment tool in the study by Postorino et al. (2015). Among children who were assessed using a nonverbal intelligence test, the Leiter International Performance Test-Revised, children with food selectivity scored significantly lower than children without food selectivity. Bitsika and Sharpley (2018) found that more severe self-reported eating behaviors were associated with lower IQ scores on the Wechsler Abbreviated Scale of Intelligence (2nd edition). Interestingly, this study included all girls and the relationship was only significant using self-reported eating behaviors (not parent report). Bitsika and Sharpley (2018) further analyzed subtests of the IQ assessment to find that it was specifically the matrix reasoning component (i.e., pattern completion) of the perceptual reasoning index that was associated with self-reported eating behaviors on the Swedish Eating Assessment for ASD. Further, the item that directly assessed feeding difficulties related to selective intake ["I only like to eat certain foods (a maximum of 10)"] was one of two items identified as having a strong inverse relationship with matrix reasoning. The other item was related to the sensory experience of mealtime ("I am annoyed by the sounds others make when I am eating"). This study suggests that feeding difficulties among girls may be related to impaired nonverbal reasoning.

Adaptive skills were evaluated using the Vineland Adaptive Behavior Scales in three studies. Postorino et al. (2015) and Leader et al. (2020a) found no association. Zachor and Ben-Itzchak (2016) reported lower adaptive scores (i.e., more impairment in daily living, communication, social, and motor skills) among children with food selectivity compared those without.

The association between cognitive skills and feeding difficulties is mixed, with emerging evidence that some specific cognitive processes (e.g., nonverbal reasoning) may be correlated with feeding difficulties. Adaptive skills appear to not be associated with feeding difficulties, but relatively few studies have evaluated this relationship.

Challenging Behavior

Feeding difficulties positively correlated with challenging behavior in three out of four studies (Leader et al., 2020b; Postorino et al. 2015; Prosperi et al. 2017). Tanner et al. (2015) did not find any significant differences in anxiety/depression, somatic complaints, internalizing behaviors, or externalizing behaviors scores on the Child Behavior Checklist-CBCL (Achenbach & Rescorla, 2000, 2001) between children with and without selective eating. However, Postorino et al. (2015) and Prosperi et al. (2017) also used the CBCL to evaluate behavior and found that children with food selectivity had significantly higher total, internalizing behavior, and externalizing behavior scores. Feeding difficulties were precisely defined as eating 50 or fewer foods in the past year by Tanner et al. (2015), whereas Postorino et al. (2015) and Prosperi et al. (2017) used broader definitions. Further, the sample size in the study by Tanner et al. (2015) was small thus reducing the statistical power and ability to detect group differences. Leader et al. (2020b) used the Autism Spectrum Disorder-Comorbid for Children, ASD-CC (Matson et al., 2009) to evaluate psychopathology and emotional difficulties. Total scores on the ASD-CC were significantly higher, indicating more symptoms, among children with feeding difficulties. Taken together, these studies suggest that when children with ASD also have feeding difficulties, parents tend to report increased concerns about overall behavior.

Weight Status

There was no association between body mass index (BMI) and feeding difficulties in six out of seven studies (Bandini et al., 2017; Postorino et al., 2015; Sharp et al., 2013b, 2018; Smith et al., 2020; Tanner et al., 2015). When examining the relationship over a six year period, Bandini et al. (2017) found no significant correlation between change in food refusal and change in weight status. In the only study where feeding difficulties were positively correlated with weight status, Pham et al. (2020) found that sensitivity to the smell of food was more common and aversion to food textures was less common among children who had obesity and severe obesity.

Gastrointestinal Symptoms

GI symptoms were variably defined across studies. The definitions included different combinations of symptoms (e.g., constipation, vomiting). Three out of five studies found no statistically significant difference in presence of any GI symptoms between those with and without feeding difficulties (Leader et al., 2020a; Postorino et al., 2015; Vissoker et al., 2018). Although the differences were not significant, both Postorino et al. (2015) and Vissoker et al. (2018) observed a higher prevalence of GI symptoms in the food selectivity groups compared to the non-food selectivity groups. Leader et al. (2020b), using identical methodology to Leader et al. (2020a), found that those who reported food selectivity on the STEP-CHILD questionnaire, had significantly more GI symptoms than those who did not report food selectivity. The mean severity scores from the food selectivity subscales of the STEP-CHILD were notably higher in the study by Leader et al. (2020b) as compared to Leader et al. (2020a). Therefore, the significant association between food selectivity and GI symptoms observed by Leader et al. (2020b) may be attributable to more severe food selectivity in that sample.

Prosperi et al. (2017) performed subgroup analyses on preschool aged children with food selectivity only, constipation only, and combined food selectivity and constipation. The group of children who exhibited both food selectivity and constipation had significantly higher scores on the sleep problems, self-injurious behaviors, and anxiety problems subscales of the CBCL. Interestingly, this subgroup did not have significantly different IQ or ASD severity scores. The authors suggest that the cumulative effects of constipation and food selectivity result in a behavioral profile that is more severe than would be predicted by the child's IQ and ASD severity.

Most studies grouped various GI symptoms together and found no association with feeding difficulties. However, there is evidence that a specific symptom, constipation, may be associated with increased feeding difficulties.

Parenting Stress

Three studies identified stress among parents as problematic, but it was correlated with feeding difficulties in only one study. Postorino et al. (2015) found that parents of children in the food selectivity group had significantly higher total and subscale scores on the Parent Stress Index-Short Form (PSI-SF) compared to children without food selectivity. In contrast, Thullen and Bonsall (2017) found that although food selectivity [on the BAMBI using a four factor structure (DeMand et al., 2015)] was reported as the most frequent and most problematic eating behavior, it was not associated with the total score on the PSI-SF. The other domains of the BAMBI (disruptive mealtime behaviors, food refusal, and mealtime rigidity) were significantly and positively associated with the total PSI-SF score. Using this methodology, Thullen and Bonsall (2017) were able to parse out food selectivity from other mealtime behaviors and demonstrate that it may be the child's associated behaviors rather than the restricted diet itself that is stressful for parents.

Curtin et al. (2015) examined spousal stress, which is a different concept than parental stress as it focuses on the parent's perception of how the child's behavior at mealtime impacts their spouse or their relationship with their spouse. Compared to a control group of typically developing children, the parents in the ASD group reported more spousal stress. However, in regression analysis, there was not a significant relationship between food selectivity and spousal stress.

The relationship between parental stress and feeding difficulties is complicated. There is evidence that it is the mealtime behaviors, not just intake of a restricted variety of foods, that parents find stressful.

Discussion

This systematic review identified eight corrleates of feeding difficulties that have been empirically studied in at least three studies. The majority were cross-sectional studies, which precludes establishing causality. Many studies included small sample sizes, which limits the power to detect group differences. Additionally, results from the studies reviewed may not be generalizable to diverse populations as samples were predominantly White. Most studies included a majority of male participants, which is expected given that boys are four times more likely to receive a diagnosis of ASD compared to girls (Baio et al., 2018). However, the unique findings in the study by Bitsika and Sharpley (2018) which enrolled only girls, highlights the need to evaluate sex differences in the presentation of feeding difficulties.

A significant limitation to evaluating the child and parent correlates of feeding difficulites in children with ASD is that cross study comparision is difficult when a variety of terminology and assessment methods are used. The consistent use of precisely defined terminology is needed. Feeding difficulty related to selective intake was used as an umbrella term in this review to capture the variety of ways that the construct has been described in the literature. Food selectivity was the most common term used, but its use was not consistent. Food selectivity has been precisely defined by Bandini et al. (2010) to capture three measurable domains of selective food intake: food refusal, limited food repertoire, and high frequency single food intake. Defining and measuring food selectivity along these three domains is encouraged as it is quantifiable and promotes cross-study comparison.

Most studies used parent report measures which may be biased by the fact that parental assessment and rating of eating behaviors is influenced by social, economic, and cultural factors as well as the parents' own eating behavior (Adamo & Brett, 2014). Dietary recalls and intake assessments like the FFQ are also prone to misreporting. Mealtime observations in the laboratory or at home provide an objective assessment of food intake and eating behaviors; however, they are more time and resource intensive. Additionally, there are limitations to assessing feeding difficulties in older children. First, use of parent report measures of dietary intake may be less accurate since older children are more independent in eating and consume meals outside of the home. Second, parents may grow accustomed to their child's eating behaviors and rate the behavior as less severe or stop offering non-preferred foods.

Despite these limitations to cross-study comparison, several clinically relevant relationships emerged with multiple opportunities for future research.

The Trajectory of Feeding Difficulties

There is evidence that feeding difficulties among children with ASD persist throughout childhood. While some aspects of feeding difficulties improve with advancing age, eating remains atypical for many older children. In Bandini et al. (2017), 44% of the sample continued to display high food selectivity (refusal of greater than 33% of foods offered) six years later. Suarez et al. (2014) showed that 58% of the sample had food selectivity that either remained problematic or worsened two years later. By comparison, in a large population based longitudinal study (the Avon Longitudinal Study of Parents and Children), picky eating was persistent in only 8% of cases followed from 24 to 65 months old (Taylor et al., 2015). Thus, the trajectory of feeding difficulties in children with ASD differs from picky eating in typically developing children, which tends to peak around age three and most cases resolve without intervention (Taylor & Emmett, 2019). Longitudinal studies of large, representative samples with data collection at multiple time points are needed to fully describe the trajectory of feeding difficulties. Additionally, data related to seeking and receiving treatment should be gathered to explore the long-term efficacy of intervention and control for the confounding effect of treatment.

Characteristics of Children with Feeding Difficulties

There is strong evidence that children with ASD and feeding difficulties have impaired sensory processing. There is emerging evidence that detail-oriented processing and cognitive rigidity contribute to feeding difficulties in children with ASD.

The positive relationship between feeding difficulties and impaired sensory processing was consistent across all studies and previously established in the review by Cermak et al. (2010). Hyper- or hypo-reactivity to sensory input constitute a symptom within the restricted, repetitive behavior domain of the ASD diagnostic criteria (American Psychiatric Association, 2013). In response to sensory input, the child may engage in active or passive self-regulation behaviors (Dunn, 2007). A child may be hyperreactive to the taste, smell, appearance, or texture of food items, thus causing them to become overwhelmed when that food is presented. In response, the child may become irritable (passive strategy) or run away from the table (active strategy). Hyporeactivity has not been extensively studied in the literature; however, this may lead a child to engage in sensory seeking behaviors (active strategy) that result in the overconsumption of specific food items or being uninterested in eating (passive strategy). Future studies should focus on discriminating the impacts of taste, smell, and texture hyper- and hypo-reactivity on feeding difficulties.

Individuals with ASD have been shown to perform highly on tasks that require detail-focused processing, but may struggle with global processing (Happé & Frith, 2006). This specific cognitive style may contribute to feeding difficulties by making it difficult to generalize food across contexts and formulate the "whole" (food item) from the "parts" (food characteristics). The child may instead focus on specific features of the food, such as the appearance, taste, smell, and texture. Bitsika and Sharpley (2018) demonstrated that among girls with ASD, there is an association between feeding difficulties and impaired nonverbal fluid reasoning, which is related to global processing. The visual processing of pictured food items by children with ASD was also consistent with a detail-focused approach (Luisier et al., 2019). Cognitive rigidity, which was found by Zickgraf et al., (2020) to be an independent predictor of selective eating, may further impede the child's ability to tolerate variation in the characteristics of food items or accept food that does not meet their rigid expectations. Prosperi et al. (2017) and Suarez et al. (2014) also found positive relationships between RRB, which includes rigidity as well as other behaviors, and feeding difficulties. Additional research is needed to test the hypotheses that detail-focused processing and rigidity contribute to feeding difficulties as the majority of research to date has focused on broad cognitive functioning.

ASD Severity and Feeding Difficulties

The relationship between ASD severity and feeding difficulties was variable. When evaluated by clinician observation only (i.e., ADOS-CSS), feeding difficulties were not associated with ASD severity. However, measures that utilized

parent report of behavior (e.g., SRS, ADI-R) were sometimes associated. There are two explanations for this pattern of findings. First, when feeding difficulties are present parents may perceive their child's ASD to be more severe due to how disruptive the child's selective intake and associated behaviors are to daily life. These behaviors may not emerge during administration of the ADOS. Second, ASD severity may be correlated with disruptive mealtime behaviors, but not with selective intake itself. Using multiple measures of feeding difficulties, including parental questionnaire and direct observation, Aponte and Romanczyk (2016) suggest that children with more severe ASD engage in more disruptive behaviors when presented with a nonpreferred food, but are not more selective than those with milder ASD.

Adaptive functioning, or the ability to complete daily living skills (e.g., getting dressed), was also inconsistently correlated with feeding difficulties. Adaptive functioning is affected by the interaction between age, intellectual functioning, and ASD severity (Hill et al., 2015). Therefore, future studies should control for these confounders when evaluating how adaptive functioning and feeding difficulties are related.

GI Correlates of Feeding Difficulties

GI symptoms are four times more common in children with ASD compared to children without ASD (McElhanon et al., 2014). Given the high prevalence of both feeding difficulties and GI symptoms in children with ASD as well as the frequent overlap of these symptoms that is observed clinically, it was surprising that three studies found no statistically significant difference in GI symptoms between those with and without feeding difficulties. Despite the lack of statistical significance, it is possible that for some children with feeding difficulties, GI symptoms are either a cause or a consequence of their eating behaviors. For example, a child with reflux may restrict their food intake to items that do not cause unpleasant symptoms, or a child may develop constipation as a result of their restricted intake. Longitudinal studies are needed to assess directionality of these relationships. Prosperi et al. (2017) proposed that a specific behavior profile that includes sleep problems, anxiety, and self-injurious behavior exists for children with both constipation and food selectivity. This has significant implications for clinical practice and replication in a larger sample is needed.

Feeding Difficulties and Body Weight

A hypothesized link between feeding difficulties and obesity due to a preference for calorically dense foods and a rejection of fruits and vegetables has been proposed (Matheson & Douglas, 2017). This was not supported by this review. While feeding difficulties as a whole were not associated with weight status, the study by Pham et al. (2020) suggests that there are specific characteristics (e.g., sensitivity to smell) that influence food choices and may contribute to obesity in some individuals with ASD. Medications, which are frequently prescribed for behavior among children with ASD, are possible confounders that were not adequately assessed or controlled across studies. For example, risperidone can lead to rapid weight gain, especially among children who experience increased appetite after starting medication (Scahill et al., 2016). In contrast, stimulants (e.g., methylphenidate) can cause decreased appetite (Sturman et al., 2017). Future studies should gather careful data on medication use to fully characterize how medication may impact appetite, food variety, and weight change.

Parenting Stress

Parents of children with ASD experience higher levels of stress than parents of typically developing children or children with other disabilities (Hayes & Watson, 2013). Feeding is a daily caregiving activity that may evoke stress. Based on the studies reviewed, the relationship between feeding difficulties and parenting stress may be mediated by behavior. Children with feeding difficulties exhibit more problematic behaviors at mealtime (Curtin et al. 2015; Padmanabhan & Shroff, 2020; Sharp et al., 2013b; Thullen & Bonsall, 2017). Additionally, children with feeding difficulties display more challenging behaviors overall (Leader et al., 2020b; Postorino et al., 2015; Prosperi et al., 2017). Future research should focus on distinguishing the influences of feeding difficulties, mealtime behaviors, and overall maladaptive behaviors on parental stress and explore how each affect family functioning. A mixed methods approach would be particularly advantageous as it would allow for the integration of quantitative data related to food intake with parent and sibling interviews about mealtime.

Strengths and Limitations

This review has several strengths. We systematically searched the literature for cognitive, behavioral, physiological, and familial factors that have been empirically studied as correlates of feeding difficulties in children with ASD. The study results for eight correlates were synthesized to describe the relationship between these correlates and feeding difficulties related to selective intake in children with ASD. This review expands upon previous systematic reviews by evaluating the literature since 2013. There are a few limitations. This review focused on feeding difficulties related to selective intake, but children with ASD do have other feeding difficulties that were not evaluated. Only the published literature in peer-reviewed journals was searched, thus is possible that additional findings exist in unpublished data and dissertations. Finally, this review was restricted

to studies that used quantitative methodologies although qualitative data is valuable to fully describe and understand feeding difficulties in children with ASD.

Conclusion

Clinicians caring for children with ASD will likely encounter feeding difficulties. It is important to recognize that feeding difficulties are a significant and persistent problem for children with ASD. As they likely will not resolve spontaneously, early identification and treatment are necessary. Recognition that feeding difficulties are related to the child's sensory processing profile is critical to understanding the child's behaviors and guiding treatment recommendations. For example, an occupational therapist can specifically address the child's impaired sensory processing through sensory integration therapy. Children with feeding difficulties are more likely to exhibit challenging behaviors at mealtimes, which can increase parental stress. In addition to assessing the child's diet, clinicians should also ask about mealtime behaviors and support families in developing strategies to use at mealtime when maladaptive behaviors occur. Finally, feeding difficulties appear to be related to GI symptoms, especially constipation, in some individuals. Although consistent relationships were not found, it is important for clinicians to assess for feeding difficulties in children who present with GI symptoms and to consider current food repertoire when making dietary recommendations for children.

Future research should address the methodological weaknesses identified and focus on testing specific relationships between correlates and feeding difficulties in diverse populations of children with ASD. Longitudinal studies will be valuable in establishing causality.

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Declarations

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