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Research Article

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Attention Deficit Hyperactivity Disorder and Dysregulated Eating: What Nurses Need to Know

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Abstract

This study was conducted to identify features of dysregulated eating in the context of children living with attention deficit hyperactivity disorder (ADHD). A deeper understanding of the association between various eating behaviours and specific moderators unique to ADHD was sought to help healthcare providers identify measurable and predictive features that direct nutritional assessment, support, and interventions. Using the Fineout-Overholt, Melnyk, Stillwell, and Williamson (2010) method, seven studies that included children between the ages of 4 to 15 from the Czech Republic, Greece, Germany, Iran, and Korea were reviewed. Results revealed patterns of dysregulated eating which involved non-traditional eating schedules, increased eating frequency, episodes of overeating, preference for calorically dense food, high intake of sugary foods and beverages, and diets consisting of higher amounts of processed and fast foods. In conclusion, underlying symptomology characteristics such as impulsivity, inattention, and emotional dysregulation may serve to mediate dysregulated eating behaviours in children living with attention deficit hyperactivity disorder (ADHD). Early recognition and intervention could help alter the progression of the dysregulated eating behaviour and its negative sequelae.

Keywords: *ADHD, Attention Deficit Disorder with Hyperactivity, Child, Eating behaviour.*

1. Introduction

Inattention, hyperactivity, and impulsivity are the primary symptoms of attention deficit hyperactivity disorder (ADHD). These symptoms begin in childhood, and can be mild, moderate, or severe as they continue into adulthood [1, 2]. ADHD is subdivided into three subtypes based on symptom presentation: (a) predominantly inattentive or easily distracted and unable to stay on task, (b) predominantly hyperactive-impulsive or being on the go, unable to wait their turn, and reacting before considering consequences, and (c) a combined type defined by both inattentive and hyperactive symptoms [2]. The symptoms of ADHD adversely affect academic, behavioural, and/or social-emotional functioning [3]. To illustrate, approximately 20-30% of children living with ADHD meet the criteria for depression and experience a 5.5 times greater risk of developing a depressive disorder than adolescents without ADHD [4].

It has been noted that deficits in self-regulation are common in a substantial number of children living with attention deficit hyperactivity disorder (ADHD), and that eating dysregulation may be an early indicator of ADHD [5]. Available research findings suggest that the lifetime prevalence of attention deficit hyperactivity disorder (ADHD) is significantly associated with the lifetime prevalence of eating disorders [6-9]. Most prevalent is binge eating disorder (BED), characterized by episodes of eating large amounts of food that are more than what most individuals would eat in a similar time period [10]. The impact of dysregulated eating is significant during childhood as this is a critical period of growth and development. In effect, children experiencing ADHD and dysregulated eating patterns were found to be at a 1.5 times increased risk for being overweight compared to age matched controls [7-9.11]. Negative outcomes may include obesity, slow growth, shorter stature, suboptimal cognitive development, and psychosocial complications (e.g., low self-esteem, poor body image, depression), both concurrently and long term [12,13]. Health risks associated with obesity include hypertension, cardiovascular disease, and type-2 diabetes [13-15].

Research has focused on adults between the ages of 18 and 44 or adolescents with diagnosed eating disorders as defined in Table 1 [16,17]. To date, the specific eating characteristics and patterns in children with attention deficit hyperactivity disorder (ADHD) are not well understood. Exploring the association between various eating behaviours and specific moderators unique to attention deficit hyperactivity disorder (ADHD) could have clinical practice significance such as the importance of healthcare providers screening children with attention deficit hyperactivity disorder (ADHD) for increased risk of disordered eating and associated health problems. Early recognition and intervention could help alter the development or maintenance of the dysregulated eating behaviour and its negative sequelae. Accordingly, this study was conducted to evaluate the association between core characteristics of attention deficit hyperactivity disorder (ADHD) and distinct dysregulated eating patterns and behaviours.

Table 1. Overview of criteria for categories of eating disorders (Continued)

Bulimia Nervosa (BN) Diagnosis	Related OSFED
All BN criteria met: A. Recurrent episodes of binge eating (eating within a discrete period of time, an amount of food definitely larger than what most individuals would eat in a similar time period under similar context) with concurring sense of lack of control over eating B. Recurrent inappropriate compensatory behaviors to prevent weight gain (e.g., self-induced vomiting; misuse of laxatives, diuretics, or other medications; fasting; or excessive exercise). C. The binge eating and compensatory behaviors both occur, on average, at least once a week for 3 months. DSelf-evaluation is unduly influenced by body shape and weight. E.The disorder does not occur exclusively during episodes of AN. Severity: Mild: 1-3 episodes of compensatory behaviors /week Moderate: 4-7 per week Severe: 8-13 per week Extreme: ≥14 per week	BN (of low frequency and/or limited duration): All criteria for BN are met, except that the binge eating and inappropriate compensatory behaviors occur, on average, less than once a week and/or for less than 3 months.
Binge Eating Disorder (BED) Diagnosis	**Related OSFED**
A. Recurrent episodes of binge eating (eating within a discrete period of time, an amount of food that is definitely larger than what most individuals would eat in a similar period of time under similar context) and a sense of lack of control over eating during the episodes B. The binge eating episodes are associated with three or more of the following: • Eating much more rapidly than normal. • Eating until feeling uncomfortably full. • Eating large amounts of food when not feeling physically hungry. • Eating alone because of feeling embarrassed by how much one is eating. • Feeling disgusted with oneself, depressed, or very guilty afterwards. C. Marked distress about the binge eating. D. Binge eating occurs, on average, at least once a week for 3 months.	BED (of low frequency and/or limited duration): All of the criteria for binge-eating disorder are met, except that the binge eating occurs, on average, less than once a week and/or for less than 3 months.
E. The binge eating is not associated with the recurrent use of inappropriate compensatory behavior as in BN and does not occur exclusively during the course of BN or AN. Severity: Mild: 1-3 episodes of binge eating/week Moderate: 4-7 Severe: 8-13 Extreme: ≥14	

**Adapted from "DSM-5: Eating Disorders. 350-363." Copyright by the American Psychological Association [16] and [17]*

2. Related works

In 1972 Dr. Virginia Douglas, a clinical researcher at McGill University, identified a deficit in self-regulation as the prominent factor in the difficulties experienced by individuals living with attention deficit hyperactivity disorder (ADHD). Self-regulation requires self-awareness (acknowledgement of what is occurring in the present situation), inhibition (ability to restrain from acting on impulse and to evaluate the circumstances, options, and consequences), and both immediate and long-term strategies to attain the appropriate goal [18]. Self-regulation deficits, including deficits in emotion regulation and impulsivity, are similarly implicated in the maintenance of the eating disorder Bulimia Nervosa (Table 1) as individuals engage in binge eating or compensatory behaviors without considering long-term consequences [19,20]. Greater deficits in self-regulation have been associated with greater eating pathology of more frequent binge eating and use of compensatory behaviors [21]. Also, the inattention associated with ADHD is thought to contribute to a lack of awareness of hunger signals while focused on a task which can later lead to binge eating [22-24] and poor meal and snack planning [13,21].

As evidence accrues, attention deficit hyperactivity disorder (ADHD) and eating disorders have been found to share a common psychobiological etiology of poor inhibitory control and genetic variants of the serotonergic system [25-26]. Primarily, the glucose, dopamine, and serotonin pathways and genetic receptor deficiency that influence dysregulation in executive function [27] create difficulties in inhibition, planning, and satiety [28,29]. Executive function involves neurocognitive processes that maintain appropriate problem-solving skills to attain a later goal [13,26]. Such processes are negatively impacted in individuals living with attention deficit hyperactivity disorder (ADHD) due to underdeveloped executive function [30]. The most consistent executive function deficits associated with ADHD are in response inhibition, vigilance, working memory, and planning. These deficits, further believed to play a significant role in dysregulated eating behaviours [27], influence the ability to adopt a plan and strategy to respond in a manner to attain the appropriate goal. Response processes are interrelated as shown in imaging studies showing structural and functional alterations in the frontal and striatal brain circuits involving dopamine, primarily a deficit in the number of receptors for both ADHD and eating disorders [6]. Dopamine plays a vital role in reward and movement regulation in the brain, giving a sense of pleasure as well as motivation to meet essential needs. Because of this, it is believed that self-medicating with food activates the underactive dopamine pathway resulting in an increase in the level of dopamine. The inability to delay gratification (inhibitory control) and regulate arousal and focus (vigilance) impact working memory, which guides actions of recall of consequences and ability to plan [31]. Children with lower inhibitory control have been found to self-serve larger portions and multiple food servings [32]. Associated impulsivity contributes to binge eating (see Table 1). These behaviours are considered forms of self-soothing and self-medicating with food to handle daily frustrations experienced while living with attention deficit hyperactivity disorder (ADHD). The result is dysregulated eating patterns, and both ADHD and dysregulated eating have been found to increase the risk of obesity [15,17,33].

Literature concerning dysregulation with reference to eating behaviours in the pediatric population was scarce even though binge eating (Table 1) and loss of control eating behaviours begin at a much earlier age than the diagnosis of an eating disorder [2,6,30]. Terms such as *disturbed* [34], *loss of control* [28,29], or *aberrant* [35] have been used interchangeably with the term *dysregulation* to describe abnormal eating patterns. Dysregulated eating behaviours and patterns associated with attention deficit hyperactivity disorder (ADHD) were often not clinically evaluated until the child presented with pathologic changes in appearance, body mass index, and/or somatic complaints requiring medical attention. Understanding characteristics associated with attention deficit hyperactivity disorder (ADHD) and dysregulated eating is a first step in changing the trajectory of dysregulated eating behaviours to reduce or prevent the development of obesity and eating disorders. Such knowledge can help improve self-esteem, self-regulation, and healthy body mass index (BMI) as well as prevent diabetes.

3. Method

A systematic review of the literature was conducted using the seven-step method of Fineout-Overholt, Melnyk, Stillwell, and Williamson [36]. This method ensured retrieval of relevant information and consisted of the following steps: Step 1: Formulating and asking a clinical question based on a practice problem, Step 2: Conducting a literature search using appropriate databases for relevant studies, Step 3: Performing a rapid critical appraisal of the studies, Step 4: Integrating the evidence with clinical expertise and patient preference and values, Step 5: Evaluating the outcomes of the practice decision based on the evidence, and Step 6: Synthesizing the evidence and presenting the results to other health providers.

3.1. Search methods

The clinical question was "Are children living with attention deficit hyperactivity disorder (ADHD) at increased risk for dysregulated eating compared to children who do not experience ADHD? To address the question and support the implementation of a screening protocol, evidence was sought to identify patterns of eating in children diagnosed with ADHD compared to children without ADHD. Using the PICO format, the following components were explored: population of interest (P: "children"), the concept of interest (I: "children living with ADHD"), comparison (C: "children without ADHD"), and outcome (O: "increased risk of dysregulated eating"). Synonyms for each of the key concepts, as defined by the components of the PICO question, were explored. The second step of the method included collaboration with librarians at the university and local hospital to ensure inclusion of appropriate databases and relevant literature.

The search entailed using PubMed, ERIC, PsycINFO, and Cumulative Index to Nursing & Allied Health Literature (CINAHL) databases with the search string of "attention deficit hyperactivity disorder AND eating disorders AND children or adolescents or youth or child or teenager." Publication dates were unrestricted. Peer-reviewed journal articles published in English were included where the full text was available and children under the age of 18 years were identified as living with attention deficit hyperactivity disorder (ADHD). Studies incorporating children taking medications known to suppress appetite, studies of children seeking bariatric treatment, and

studies involving children with comorbidities or diagnosed eating disorders were excluded. Children with defined eating disorders were excluded to ensure retrieval of research identifying eating patterns characteristic of children prior to fulfilling criteria for psychiatric defined eating disorders. Finally, a manual search was conducted of retrieved citations.

3.2. Search Outcome

The process of retrieving the studies of interest is presented in a PRISMA Flowchart [37] (Figure 1). The retrieved studies represented research conducted in the Czech Republic, Greece, Germany, Iran, and Korea. From the initial search with Pubmed using the MeSH terms *eating, child,* and *attention deficit disorder with hyperactivity* which resulted in 243 articles published between 1972 and 2020, 71 were considered for further review. Articles that did not pertain to ADHD, eating patterns in children, or eating behaviours were excluded. A search using the databases of ERIC, PsycINFO, and CINAHL concurrently was conducted using the terms *ADHD* AND "*eat* behavior*" AND *child NOT autism, adult,* and *medication,* resulted in 547 articles.

The articles retrieved included 26 articles from PubMed and 17 from combined database search for a total of 44 articles. Duplicates were removed automatically and 44 articles that met the inclusion criteria were evaluated for relevance to the question. Due to their focus on unrelated factors (i.e., genes, animal studies, Asperger's, depression, conduct disorder, use of medication, or adults), a further 36 articles were excluded. The 7 remaining articles were from PubMed.

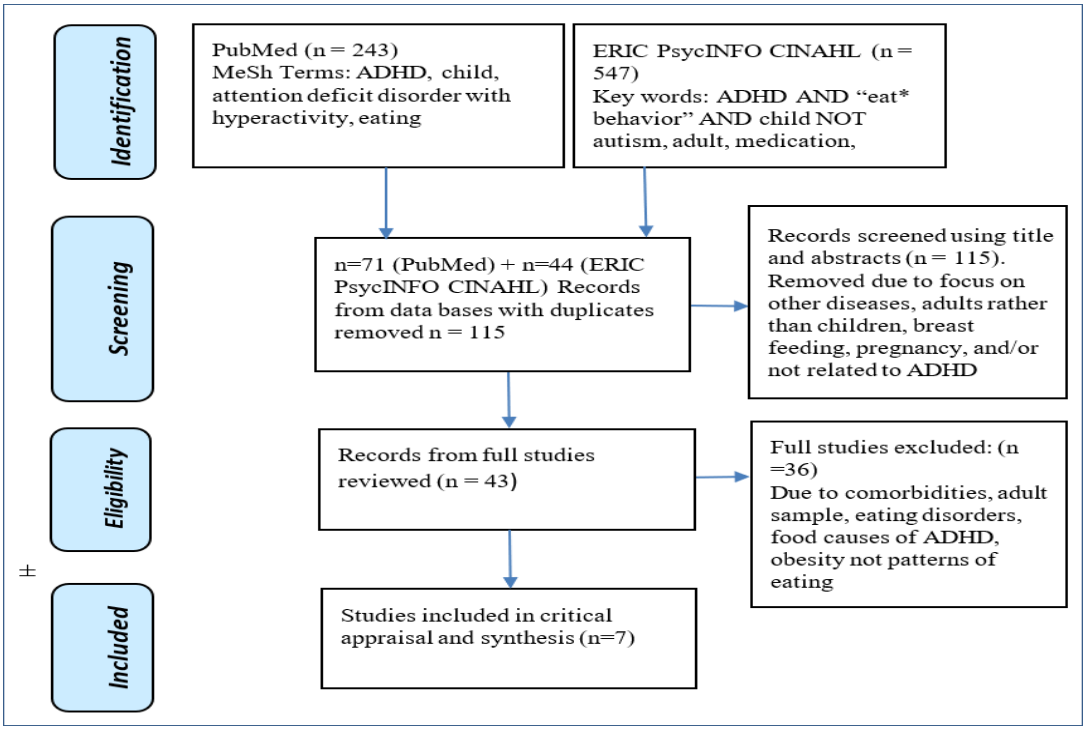

Figure 1: Prisma search strategy pathway. Adapted from "Preferred Reporting Items for Systematic Reviews and Meta-Analysis: The PRISMA Statement," by D. Moher, A. Liberati, J. Tetzlaff, and D. Altman, 2010, International Journal of Surgery, vol.8, no.8, p. 658.

3.3. Quality Appraisal

The next step involved critically reviewing the articles to identify key characteristics and analyzing credibility, validity, and value [38]. A quality appraisal of the studies was conducted by reviewing the research design. The studies included 4 cross sectional studies [32,39-41], 2 case-controlled studies [42,43], and 1 experimental study [44]. The initial appraisal of the 7 studies consisted of ranking each study based on the research design, from highest to lowest as follows: Level I- Systematic review or Meta-analysis; Level II- Randomized controlled trial; Level III- Controlled trial without randomization; Level IV- Case-control or cohort study; Level V- Meta-synthesis; Level VI- Descriptive Studies; Level VII- Expert Opinion [36]. The retained studies were cross-sectional, cohort, and case-control studies (Level IV) and experimental (Level III). Together the studies are deemed as moderate quality.

3.4. Design rigor

A more in-depth appraisal of the validity of the studies was conducted using a critical appraisal guide to address five essential elements (i.e., purpose of the study, sample size, design rigor, framework, and the validity and reliability of the measurement instruments used). The purpose in all the studies was to elucidate eating patterns of children living with ADHD and the associated characteristics which have been shown to put these children at risk of dysregulated eating and greater tendency towards unhealthy food. The sample size ranged from 192 to 500 children with the experimental study [44]. The sample sizes in the case-control studies were large enough to allow the control of confounding factors. In the cross-sectional studies using a confidence interval of 95%, the sample size allowed for a confident effect size. Possible confounding variables such as age, sex, and socioeconomic status (SES) were identified and controlled for in 6 studies [32,39,40,42-44]. This strengthened validity. As well, validity was enhanced because the participants of most studies were not being treated with stimulants [39,40,42-44] or were instructed to discontinue medication for 48 hours prior to testing [32]. Three studies used randomization [32,39,42] which minimizes selection bias. One study [41] used a convenience sample, recruited through advertising at a hospital and the hospital newspaper, which could have introduced selection bias.

3.5. Framework

All 7 of the reviewed studies used a theoretical framework or conceptual model to guide the process of comparing eating behaviours. Six studies [32,39-43] used the Working Memory Model [45,46] where core deficits in ADHD (e.g., inattention, hyperactivity, and impulsivity) are theorized to impact behavioural symptoms such as dysregulated eating. The framework used in one study [44] was derived from the Tripartite Pathway Model, which attributes ADHD symptoms to deficits in inhibition, temporal processing, and motivation [47]. There is no agreement about the underlying pathway to dysregulated behaviours. However, there is agreement that the core characteristics of ADHD (e.g., impulsivity or loss of impulse control) significantly mediate loss of control eating described by Reinblatt [6] as a form of binge eating. All findings of the studies reviewed supported the premise that early problems with self-regulation are the starting point of persistent dysregulation and are characteristics of ADHD [48].

3.6. Validity of instruments

Six of the seven studies confirmed the diagnosis of ADHD by a psychiatrist [39,42] or use of a validated culturally appropriate questionnaire [32,40,43,44]. In one study [41], an unvalidated questionnaire was translated to ensure cultural appropriateness. To evaluate eating dysregulated behaviours, 4 studies used validated dietary questionnaires [39,40,42,44]; only 2 [40,41] reported the instrument's reliability (Cronbach alpha as 0.77-0.89 and 0.57-0.82 respectively). All questionnaires were self-report which could introduce bias. Measurement error is inherent in self-reported dietary assessment instruments due to random within-person variation [49]. Individuals may over or under estimate portion size and respond based on their belief of what the interviewer expects; thus, the self-report questionnaire method of gathering data is not without limitations. However, self-report has been validated in relation to interview data. Especially when considering the children's ages, this method is valid and a reasonable way of acquiring this type of information [49].

Body weight was calculated and reported in six studies using BMI and specific cut off values for weight to height for boys and girls separately, at specific age intervals. The cut-points used in the Centers for Disease Control and Prevention (CDC) method are based on the 5th and 95th percentiles of BMI for age and gender. The World Health Organization (WHO) method uses cut points at 2 standard deviations (relative to 3rd and 97th percentiles) below and above the mean to categorize children as underweight and obese, respectively. Both these methods were used in three studies [40,41,43]. Two studies [39,42] used the International Task Force for children, while one [44] used the >90% and 97%, height to weight to categorize overweight and obesity respectively. In the studies that calculated BMI using self-reported measures of height and weight rather than direct measures (i.e., [39,42]), measurement bias was a threat to validity. One study reported significant attrition due to comorbidities, incorrect form completion, or missing data [41].

3.7. Data abstraction

Data contained in the studies that addressed findings of eating behaviours associated with ADHD were extracted. Other data extracted included descriptive information about the sample, sample size, measurement instruments, data collection, and analysis as shown in Table 2.

Table 2: Data abstraction.

Author	Abbasi et al.	Azadbakht et al.	Kim et al.	Leventakou et al.	Ptacek et al.	Wilhelm et al.	Woo et al.
Year	2019	2012	2018	2016	2014	2011	2014
Country	Iran	Iran	Korea	Greece	Czech Republic	Germany	Korea
Framework	Working memory Model	Working memory Model	Working memory Model	Working memory Model	Working memory Model	Tripartite Pathway Model	Working memory Model
Design Method	Cross-sectional	Case Control	Cross-sectional	Cross-sectional	Cross-sectional	Quasi experiment	Case Control
Sample							
Age	4-12 Mean 7 +/- 1	7-9 Mean 8 ± 1	5-13 Mean 9.4+/-1.7	4 Mean 4	6-10 Mean NR	7-15 Mean NR	7-12 Mean 9± 1
Gender	N=500 M=82	N=375 M=52%	N=12 350 M= 49%	N= 471 M=59 %	N=200 M=100%	N=94 M=100%	N=192 M=34%
Setting	Isfahan Psych clinic	Tehrani elementary schools	Cheonan elementary schools	Crete 2007 Birth cohort	Prague	Aachen Hospital	Busan 2 University Hospitals
Instrument	BMI M DSM-5 D FFQ	BMI M DSM IV Q FFQ	BMI SR DSM IV FFQ	BMI SR DSM IV Q BEF CEBQ	BMI NR DSM IV Conner's	BMI DSM IV D FBB HKS	BMI NR DSM IV D
Findings	Diet Patterns Processed Calorie dense High sugar Healthy	Diet Patterns Sweet Fast food Healthy High sugar	Behaviors High sugar Over eat > Speed	Behaviours Emotional eating Over eat Eat not hungry High food response	Behaviours Skip meals Meals >5/d Sugar drink preference	Behaviours > speed (1st 30 min) Uncontrolled snacking Delayed aversion	Diets Tradition Seaweed -egg Low fat-high carb Healthy snack

**Note. BEF BMI M=body mass index- measured, SR= self-reported; CEBQ= child eating behavior questionnaire; DSM IV Diagnostic and Statistical Manual Fourth Edition; D=Diagnosed, Q= questionnaire; DSM-5 = fifth edition; FFB HKS = German Conners Questionnaire; FFQ= food frequency questionnaire; M= male; NR not reported*

4. Results

Seven eligible studies reported on the eating behaviours of children living with attention deficit hyperactivity disorder (ADHD). Themes identified through abstraction include food quality and food quantity associated with dysregulated eating behaviours.

4.1. Characteristics of study samples

The studies were ethnically diverse including children from specific areas in Germany [32], Greece [41], Iran [39,42], Korea [39,43], and Czech Republic [44]. Five studies included children between the ages of 6 and 15 [32,39,40,43,44]. One included both preschool and school age children between the ages of 4 and 12 [42]; one focused on children who had been followed prenatally until 4 years of age [41]. All studies that included both sexes were found to under represent girls (18%-48%); only boys were included in two studies [32,44]. Biederman et al. [48] and Russell et al. [49] found a higher prevalence of ADHD with lower socioeconomic status. The underlying cause has not yet been not yet elucidated; however, it is understood that food availability is influenced socially, culturally, economically, and geographically. Leventakou [41] found that lower socioeconomic status predicted greater prevalence of attention deficit hyperactivity disorder (ADHD).

4.2. Food quality

Of the five studies evaluating eating characteristics related to food preference, two [39,42] reported that children with attention deficit hyperactivity disorder (ADHD) demonstrated higher preference for high sugar, high fat, highly processed, and high caloric foods, and a pattern of high consumption of fast food compared to other children. Children with the highest *Western dietary pattern* rating, based on eating high fat and high calorie foods, had greater odds of having ADHD in comparison to children in the healthy eating pattern which was inversely associated with ADHD (OR = 0.46; 95% CI, 0.38-0.91; p= 0.01) [42]. In evaluating patterns of eating different types of food, children with ADHD were reported as being at greater risk to choose and consume foods and snacks categorized as *unhealthy* [40,44]. The foods categorized as *unhealthy* were high in sugar and/or fat, were processed, and included fast foods, soft drinks, and instant noodles. Sugary drinks were found to make up almost half of the children's daily intake [44]. Alternatively, children without ADHD were reported to have a traditional healthy diet [43].

4.3. Food quantity

Children living with attention deficit hyperactivity disorder (ADHD) were found to exhibit markedly diminished adherence to a traditional breakfast, lunch, and dinner schedule, and significantly higher frequency (>5/day) of irregular eating times [32]. A significant association between ADHD and overeating behaviour was associated with consumption of *unhealthy* food, the number of overeating episodes per week, and eating speed [44].

4.4. ADHD and eating behaviours

Impulsivity, inattentiveness, and hyperactivity as the core characteristics of attention deficit hyperactivity disorder (ADHD) are thought to mediate the relationship between ADHD and dysregulated eating behaviours. Impulsivity may play an important role in creating vulnerability for binge eating [6]. A lack of impulse control, an inhibitory deficit, and persistent difficulties typical in ADHD (e.g., inattention to/diminished awareness of hunger and satiety cues, distractibility, hyperfocus on ingesting sweet or salty foods which stimulate dopamine) increase the likelihood of episodes of overeating and eating in the absence of hunger. This result is supported by Yao et al. [50] who found the prevalence of ADHD symptoms as high as 35% to 37% for BN and AN binge eating/purging subtype versus 18% for AN restricting subtype in a large Swedish sample (N =1165) of adults clinically diagnosed as having eating disorders. Yao et al further found that common genetic risk variants for ADHD were significantly associated with eating disorder symptoms, and that ADHD symptoms during early childhood predicted binge-eating behaviours during adolescence. These results help demonstrate why eating disorders and ADHD co-occur, and underscore the importance of screening for eating disorder symptoms in individuals who experience ADHD.

Eating is thought to be a form of self-soothing in individuals living with attention deficit hyperactivity disorder (ADHD), where the receptors for dopamine in the part of the brain that activates executive function like focus and sustained attention are decreased, and the brain is slower to absorb glucose [51]. The reduced glucose metabolism results in less energy available to the attention center in the prefrontal cortex for both individuals living with ADHD and those with obesity or eating disorders [52]. Consequently, affected individuals may seek out foods high in glucose which increase dopamine and serotonin, providing a sense of pleasure and calmness [53-55].

Attention deficit hyperactivity disorder (ADHD) and binge eating behaviours are strongly linked to dopamine dysregulation. Individuals with ADHD and Bulimia Nervosa have decreased dopamine receptor binding and release. Dopamine pathways are involved in impulsive personality traits and the reward system [23]. Imaging studies have found structural and functional alterations in the frontal and striatal regions in both ADHD and EDs, particularly altered brain circuits involving dopamine [56]. Malfunctioning in dopamine receptors and resultant decreased levels of dopamine support this theory. The reward deficiency theory is closely linked as it is believed that self- medicating with food activates the under active dopamine pathway resulting in increase in the level of dopamine. This is a shared process for both individuals with ADHD and BED and a maladaptive way of regulating dopamine levels [56].

The intake of sugary, high-carbohydrate foods changes the brain's neurochemistry by increasing serotonin, a neurotransmitter, which contributes to feelings of wellbeing, reduced irritability, and improves overall mood and learning. Dopamine is essential for controlling impulses. It is also an essential part of the body's reward circuit. People whose brains are low in dopamine often self-medicate with food because of its ability to temporarily activate dopamine in the reward pathway.

Consequently, increased attention deficit hyperactivity disorder (ADHD) symptoms are associated with food responsiveness (reward sensitivity) and emotional overeating (eating to temper negative emotions) in preschool children [41]. High reward sensitivity is influenced by the rewarding aspects of appetitive stimuli such as the palatability of foods. Positive emotional eating activates the dopaminergic system, initiating behaviour to obtain the reward thereby reinforcing the consumption of certain foods [57]. In fact, eating speed was found to be initially

more rapid in children with ADHD [58]. Higher sensitivity to reward was associated with a stronger enjoyment of food, higher food responsiveness (i.e., desire to eat in the absence of hunger or satiety), and more emotional overeating when experiencing negative emotions [50]. It is important to note that even though children with ADHD prefer high fat, high sugar, and calorically dense food, and eat larger amounts more frequently, younger children may present with normal weight or underweight; this emphasizes the critical need for further evaluation in this age group [59].

5. Discussion

The systematic review provided a summary of the results of seven studies that examined the eating behaviours of children living with attention deficit hyperactivity disorder (ADHD). The majority of outcomes reported a significant effect of ADHD on eating behaviours in children [32,39-42,44]; one study found an association with healthy traditional eating predictive of lower incidences of ADHD [43]. The core ADHD characteristics of impulsivity, inattention, and hyperactivity were found to be associated with dysregulated eating behaviours. ADHD has an effect on eating behaviour due to the difficulties affecting the ability to plan, regulate desire for rewards, and manage daily negative experiences. These difficulties increase eating at irregular times, eating to feel better, and, in turn, overeating.

In the studies reviewed, the majority of outcomes evaluated were related to food preference with only two studies evaluating the schedule of eating which could significantly influence risk of obesity [32,40]. One study found low socioeconomic status predicted greater prevalence of attention deficit hyperactivity disorder (ADHD) [41]. This finding is worth further consideration as low socioeconomic status is reported to generally increase the likelihood of poor mental health in children by 1.18 to 3.34 times [49], and specifically to relate to a higher prevalence of ADHD [48, 49] [60].

In the studies, sample sizes were appropriate but were too small to further differentiate attention deficit hyperactivity disorder (ADHD) by their subtypes which are categorized by prominent symptoms. Many of the studies identified children of the combined subtype (inattention and hyperactivity) as this is the predominant subtype in males. Leventakou and colleagues (2016) findings were in contrast to previous studies in which executive function deficits were found to mediate dysregulated eating [26,29,57]. Executive function is related to self-regulation, a skill developed within the first decade of life which serves to regulate behaviour, cognition, and emotion. The contrasting results may have been due to the fit of the measurement tool with the age of the children. The children were four years of age and the evaluation tool used may not have been adequate to evaluate executive function in this age group. Attentional control through regulation of cognition and emotion has found to develop substantially between the ages of three and four years with further substantial effortful control through age seven [58]. Therefore, an appreciable difference may not have been identified at this age. Future research should seek clarification as to whether the subtypes of ADHD, categorized by symptoms, significantly predict eating behaviours. This research would need larger sample sizes, consistently validated measurement instruments, and direct measures of height, weight and intake. Professional practice and academic programs could provide a more comprehensive curriculum pertaining to children's mental health to better equip healthcare providers to effectively address dysregulated eating behaviours in healthcare settings.

5.1. Implications for Nurse Practitioners

Many nurse practitioners (NPs) work in primary care settings, making these NPs well positioned to conduct inquiry into and evaluation of eating patterns during scheduled well child visits. The NP performs patient-directed health assessments, diagnosis, and management of acute and chronic conditions [61]. NPs and other healthcare providers use a standard evidence-based infant/child health maintenance tool (the Rourke) to evaluate growth and development during routine child wellness visits [62]. However, this tool does not provide guidance on how to evaluate eating behaviours. The Canadian Practice Guidelines for attention deficit hyperactivity disorder (ADHD) have been developed and reviewed by a multidisciplinary team of ADHD specialists, pediatricians, psychiatrists, psychologists, family physicians, nurses, educators, and community stakeholders from Canada and the US. The guidelines are accessible through the Canadian ADHD Resource Alliance [63], and guide diagnosis, management, and treatment across the life span for individuals living with ADHD. Recent identification of the associated risk of eating disorders and obesity related to dysregulated eating is discussed; however, guidance or resources on how to approach the issue with family and individuals is not provided. To effectively enact the health care provider role, awareness of the manifestations of dysregulated eating will ensure comprehensive inquiry about dietary patterns and use of appropriate resources.

The synthesized findings of this review highlight the need for supplemental evaluation of eating patterns for children living with the dysregulated eating of attention deficit hyperactivity disorder (ADHD) due to the risk of inadequate nutrition, obesity, and eating disorder development. The patterns between ADHD and eating disorders suggest that family history may help with early detection and risk identification of the two disorders. ADHD has been shown to predict eating disorder symptoms; regular screening for ADHD symptoms in those with eating disorders and for eating disorder symptoms in those with ADHD may hasten detection of and appropriate intervention for comorbid conditions [50]. Thus, this study's findings alert healthcare providers of the necessity to screen for both eating disorders and ADHD when symptoms appear for either disorder. When interviewing and counseling pediatric patients and their parents regarding eating behaviours in the context of ADHD, understanding of the manifestations and implications of dysregulated eating patterns is necessary. Individual barriers to disclosing non-normative eating include associated stigma and awareness of societal prejudices and discrimination against those with ADHD [55]. Providing education to the general population can assist people in identifying symptoms or risk behaviours, lessening the stigma, and seeking early advice to improve outcomes

5.2. Limitations

Given that all the studies were derived from medical research and the role of the nurse practitioner and nursing care strategies were not addressed, this is an area requiring further research. As well, the studies were predominantly focused on male children and this contributes to unrecognized attention deficit hyperactivity disorder (ADHD) issues in females prior to adolescence when eating disorders become more prevalent. Although ADHD and obesity are global issues, the

generalizability of our synthesis is limited due to cultural variability (i.e., there were no studies representing children from Canada or the United States). However, the seven included studies reported similar prevalence of ADHD and, even though cultural food differences were identified, all the studies consistently found significantly higher intakes of fast food, sugary foods and beverages, and calorically dense foods with children diagnosed with ADHD. As such, these behaviours are detrimental to physiological and psychological development and health.

Conclusion

This study was conducted to identify features of dysregulated eating in the context of children living with attention deficit hyperactivity disorder. The overall methodological quality of the studies was moderate. The evidence suggests underlying core characteristics of attention deficit hyperactivity disorder (ADHD), such as impulsivity, inattention, and emotional dysregulation, are mediators in dysregulated eating behaviours. An awareness of how executive function dysregulation impacts psychological, behavioural, cognitive, and social domains provides a better understanding of the associated problems and complexity of eating behaviours associated with ADHD in children. Nurses and other health professions can encourage open dialogue of the daily lived experiences of individuals with ADHD, and, in particular, identify dysregulated eating. However, it is not known if all children with ADHD have dysregulated eating or which children will develop eating disorders. Further exploration is needed to determine identifiable characteristics of dysregulated eating to facilitate early recognition and intervention. This review encourages further rigorous research studies to provide stronger evidence of the different manifestations of disordered eating in the context of ADHD. There is a need for high quality research that provides more descriptive evidence of dysregulated eating in the various subtypes of ADHD and that includes girls. Given the disproportionate rate of eating disorders, obesity, depression, and other challenges among children living with ADHD, early identification of dysregulated eating behaviours is crucial.

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Conflict of interest

No conflict of interest has been declared by the authors.

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