



Why are individuals with autism spectrum disorder at risk group for unhealthy weight?

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ABSTRACT: Several studies have indicated that the prevalence of unhealthy body weight in individuals with autism spectrum disorder (ASD) is high. It is unclear whether factors related to the weight status of children and adolescents with ASD are the same or different from factors associated with the weight status of typically developing children (TDC). The objective of this review was to identify key factors associated with the higher rates of unhealthy weight observed in individuals with ASD and create a structural model, which could be used for *future autism intervention research*. This review summarizes the current state of knowledge on the genetic basis of obesity in ASD, special treatment (behavioral and medical, including diet and psychotropic medications), psychological (depression and anxiety) as well as somatic comorbid disorders such as feeding problems, sensory processing disorders, gastrointestinal problems and sleep disorders, physical activity and sedentary behaviors, loneliness and social isolation, and family functioning (maternal depression and stress).

KEY WORDS: autism spectrum disorder, underweight, overweight, obesity, risk factors

Introduction

Nowadays, autism is one of the major health care problems in numerous countries (Newschaffer 2003). Autism spectrum disorder (ASD) is a complex set of neurodevelopmental diseases that occur in early childhood. The main symptoms, called the autistic triad, are: (1) communication deficits, such as responding inappropriately in conversations and misreading nonverbal interactions, (2) social deficits, such as difficulty with building

and understanding friendly relations appropriate for the age, and (3) appearance of restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association; Grzadzinski; World Health Organization). Recently, a significant increase in the prevalence rate of ASD has been observed (Matson and Kozłowski 2011). In Canada, ASD affects one in every 66 children and adolescents aged 5–17 (Report of the National Autism Spectrum Disorder (ASD) Surveillance System. Autism Spectrum Disorder

among Children and Youth 2018) while in Poland, according to the epidemiological studies conducted in 2012, one in 2941 has been diagnosed with ASD (Piskorz-Ogórek et al. 2015). Generally, autism occurs four times more often in males than in females and is increasingly diagnosed worldwide (Lisik 2014).

It is important that professionals working with cases of neurodevelopmental disorders are not only aware of the presence of typical symptoms of ASD, but also have knowledge about comorbid disorders. Unfortunately, according to Suchowierska and Walczak's study (2013), knowledge of Polish pediatricians about autism is incomplete. The problem is that pediatricians are usually the first professionals to whom the concerned parents turn.

It is unclear whether factors related to the weight status of children and adolescents with ASD are the same or different from factors associated with the weight status of typically developing children (TDC) (Zuckerman et al. 2014). Given the above, the objective of this review was to identify key factors associated with the higher rates of unhealthy weight observed in individuals with ASD and create a model, which could be used for the future autism intervention research.

Material and methods

An all-embracing literature search of the PubMed database was conducted for papers published between January 2000 and June 2019. The search was performed for English language articles using following keywords: "BMI and ASD", "obesity and ASD", "genetic basis and ASD", "health and ASD", "food selectivity and ASD", "GF and CF diet and ASD", "depression and ASD", "maternal depression

and ASD", "sensory disorders and ASD", "sleep problems and ASD", "behavior analysis treatment and ASD", "physical activity and ASD", "loneliness and ASD", "genes and obesity", "obesity and depression" and "prevalence and ASD".

Articles were included in this review, if they were relevant to the topic of this review and they met the following two criteria: (1) publication in a peer-reviewed journal, and (2) full-text article available.

Results

Weight status of individuals with ASD

Several studies have indicated that the prevalence of overweight and obesity is high in autistic children and adolescents (Curtin et al. 2005; Xiong et al. 2009; Curtin et al. 2010; Broder-Fingert et al. 2014; Corvey et al. 2016; Granich et al. 2016; Healy et al. 2019; Levy et al. 2019). On the basis of scientific literature review, it can be generally concluded that the prevalence of excess weight (overweight and obesity) among children and adolescents with ASD is in the range of 27.5–75.4%, on average 47.8%. There are significantly higher odds of being overweight or obese for children and adolescents with ASD, in comparison to typically developing children and youths, controlling for age, gender, race/ethnicity and income. On the grounds of Healy and colleagues' study (2019) of 875,963 patients with ASD aged 10–17, it can be concluded that the odds of overweight and obesity are significantly higher (OR = 1.48, $p = 0.04$; and OR = 1.49, $p = 0.02$, respectively) in comparison to typically developing youths (17). In turn, Zeng and colleagues (2017) having ex-

amined 1,045,538 individuals with ASD found out that only the prevalence of obesity was significantly higher in this group (OR = 1.84, 95% CI: 1.37– 2.48, $p < 0.001$), while the prevalence of overweight was not significantly different (OR = 1.07, 95% CI: 0.83–1.38, $p = 0.62$). All the scientific studies cited above focused on children and adolescents with ASD, almost nothing is known about adults with ASD (Happé 2012). Obesity among patients with ASD tends to continue into adulthood at the rate of 42.0% (Strahan 2015). In Croen and colleagues' study (2015), medical problems, such as gastrointestinal disorders, sleep disorders, seizure, obesity, dyslipidemia, hypertension and diabetes, as well as psychiatric disorders, including depression, anxiety, bipolar disorder and suicide attempts were significantly more common in adults with ASD diagnosis ($n = 1,507$) in comparison to controls ($n = 15,070$). The prevalence of obesity was 33.9% among adults with ASD versus 27.0% of the control group.

Both, overweight and obesity are risk factors for the incidence of multiple comorbidities, such as type 2 diabetes, cardiovascular diseases, sleep apnea, cancers, psychological and social disorders (Guh et al. 2009; Strahan 2015). Despite the results of the scientific research, only 4.0% of Polish pediatricians studied by Suchowierska and Walczak (2013) pointed out that children with autism may gain weight.

However, some studies have revealed that underweight has also been observed among patients with ASD. Marí-Bauset and colleagues (2016) indicated that the sex-and age-adjusted odds ratios for being underweight were 2.41 in children with ASD in comparison to healthy children.

Genetic basis of ASD

It is currently well-known that autism has a genetic basis. On the grounds of twin and family studies, the concordance rates for monozygotic twins are 70.0–90.0% in comparison to dizygotic twins – 20.0–30.0% (Curtin 2014). Both, inherited and de novo single-nucleotide polymorphism and copy-number variants (CNVs, misplaced or duplicated segments of chromosomes), play a role in ASD's pathogenesis (Curtin 2014). Microarray and exome sequencing studies over the past decade have shown that de novo protein-altering variants could contribute to approximately 25.0% of cases of ASD (Sebat et al. 2007). It is also worth mentioning that there are many diseases with a genetic basis in which ASD is one of the leading symptoms, such as monogenic diseases e. g fragile X syndrome (FXS), tuberous sclerosis (TSC1 and TSC2), Rett syndrome (MeCP2), type I neurofibromatosis (NF1), Angelman syndrome (UBE3A), Smith syndrome, Joubert syndrome, syndromes hamartomatic tumors associated with mutations in the *PTEN* gene. Single-gene disorders associated with ASD account for ~5% of cases (Lisik 2014). Deletions and duplications in various genomic loci (CNV) were indicated in 10.0–20.0 % individuals with idiopathic ASD. The most common chromosomal aberration detected in patients with ASD was 15q11-13 duplication found in 1.0–3.0% of them, also deletions in 1q21.1, 2p16.3, (involving *NRXN1* gene), 2q37, 7q22q13.3, 16p11.2 (600 bp) 22q21q23, Xp22 and duplications in 7q11.23, 16p13.1, 17p11.2 (Lisik 2014).

In patients with ASD, mutations of genes encoding synaptic cell adhesion molecules and skeleton proteins associated with synaptic functions such as

presynaptic neurexin (*NRXN1*, *NRXN2*, *NRXN3*), postsynaptic neurexin ligands (*NLGN1*, *NLGN3*, *NLGN4X*, *NLGN4Y*) and the SHANK protein family (*SHANK1*, *SHANK2*, *SHANK3*), have been repeatedly observed (Lisik 2014; Wang et al. 2018). Deletions of the *ProSAP2* / *SHANK3* code in chromosome 22q13 were among the main genetic abnormalities in neurodevelopmental disorders, and *ProSAP2/SHANK3* code mutations were observed in patients with ASD, mental retardation and schizophrenia (Uchino and Waga 2013).

Genomic imbalances and high rates of recurrent CNVs are also emerging as risk factors for obesity. The genetic basis of different types of obesity, including monogenic and polygenic obesity, pleiotropic syndromes and chromosomal rearrangement are also well-documented now. Monogenic obesity includes the involvements of Leptin (*LEP*) gene, leptin receptor (*LEPR*), Proopiomelanocortin (*POMC*), Melanocortin-4 receptor (*MC4R*), single-minded gene 1 (*SIM1*), Proprotein convertase subtilisin/kexin type 1 (*PCSK1*), Neuropeptide Y (*NPY*). Polygenic obesity is due to Adrenoceptor beta 1 (*ADRB1*), *ADRB2*, *ADRB3* and Uncoupling protein 1 (*UCP1*), *UCP2*, *UCP3* (Roy 2016). Sitek and colleagues (2014) revealed the association between the *FTO* gene and obesity in Polish school-children and also suggested a greater role of genetic factors in children at the early stage of ontogeny compared to adolescence and adulthood.

The most associated with ASD are duplications and deletions in 16p11.2. This deletion has been observed among 15.0% patients with ASD. Moreover, this type of deletion is also associated with early childhood obesity. Other CNVs probably associated with both, obesity

and autism, are deletion in 11p14.1 and duplication in 15q11.2 (Curtin 2014). *MAGAD1* (part of the *MAGE* gene family) associated with the Prader-Willi syndrome, may contribute to progressive obesity with deficit in social interactions – the part of ASD symptomatology (Pinto et al. 2010). Sharma and colleagues (2012) analyzed 541 genes connected with autism and 412 genes related to obesity and found 36 of them associated with both, autism and obesity.

Since October 2017 in the database of the program 'Autism says MSSNG' there have been more than 7,000 genomes coming from individuals with ASD and their members – this is the most important source of information about the genetic basis of ASD (www.autismspeaks.org).

The latest research carried out by Brandler and colleagues (2018) on paternally inherited cis-regulatory structural variants have suggested that rare inherited noncoding variants predispose children to ASD, with differing contributions from each parent.

Comorbid psychological and somatic disorders

There are numerous disorders and health problems observed in patients with ASD that can negatively affect the metabolism and contribute to the accumulation of adipose tissue. A lot of children and adolescents with ASD suffer from medically relevant disorders that may have a negative impact on their growth. Gastrointestinal disorders, such as vomiting, diarrhea, constipation, abdominal pain, bloating, gaseousness, belching and reflux are often observed among patients with ASD. Also metabolic disorders, including creatine deficiency, syndromes urea cycle disorders, Wilson's disease, Lesch-Ny-

han syndrome, Smith–Lemli–Opitz syndrome and hormone disorders, such as higher level of triglycerides and LDL/HDL, lower level of HDL, higher level of IGF-1, IGF-2, IGFBP-3, GHBP, TT, FT and leptin and lower level of AG, DG, GH are very common in this group (Mills et al. 2007; Kim et al. 2009; Bauman 2010; Al-Zaid, Alhader and Al-Ayadhi 2014).

Gastrointestinal disorders

Gastrointestinal disorders are often observed among individuals with ASD – they can affect 9.0–54.0% of patients (Wasilewska et al. 2009). The most common are: abdominal pain (44.0% vs. 9.0% in controls), intestinal gases (54.0% vs. 19.0% in controls), flatulence (34.0% vs. 5.0% in controls), belching (24.0% vs. 9.0% in controls), reflux (16.0% vs. 5.0% in controls), loose stool (32.0% vs 2.0% in controls), and unpleasant stool odour (49.0% vs. 0% in controls) (Horvath and Perman 2002). These symptoms often result from gastrointestinal pathology which consists of gastro-oesophageal reflux, ileum ileum, absorption and digestive disorders, overgrowth of intestinal pathogens, abnormal bowel permeability, as well as numerous food allergies. Gastrointestinal problems may result from abnormalities in the regulation of the immune system, disturbances in the digestion of gluten and casein and the presence of yeasts.

On one hand, gastrointestinal problems may cause body mass loss. On the other hand, epidemiologic data indicated that obesity is associated with chronic gastrointestinal disorders (Ho and Spiegel 2008). Therefore, gastrointestinal problems can contribute to an unhealthy body weight, either underweight or overweight, and obesity in children and adolescents with ASD.

Sensory processing disorders

Children with ASD very often suffer from sensory processing disorders, including irregularities in the reception and processing of sensory stimuli. These disorders may affect 56.0–70.0% (Hazen et al. 2014) up to 90.0% children with ASD diagnosis (Suarez 2012). Restricted stereotyped behaviors, one of the main symptoms of ASD, include sensory and motor aspects, such as unusual sensory interests and stereotyped body movements (Gal et al. 2007). Sensory problems seem to have a biological basis (Hazen et al. 2014). There are three types of sensory processing disorders: sensory modulation, sensory discrimination, and sensory-based motor disorders. Children with sensory modulation disorder have difficulties in regulating and organizing the degree and intensity of responses to sensory input in multiple sensory modalities (auditory, visual, tactile, vestibular, and oral). Children with sensory discrimination disorder have difficulties in the processing of spatial and temporal qualities of touch, movement, body position, vision and audition. Children with sensory-based motor difficulties, often exhibit poor proprioceptive processing, clumsiness, poor gross-motor skills and manipulation skills, and poor bilateral coordination (Gal et al. 2007). Sensory processing disorders may be one of the causes of food selectivity and affect body weight.

Sleep disturbances

Data coming from epidemiologic studies suggest that short sleep duration is associated with weight gain (Chen et al. 2008). Sleep disturbances are frequent in children with ASD and can occur in

52.0–73.0% individuals with ASD (Levy et al, 2019; Curtin 2014). The spectrum of sleep disturbances observed in children with ASD includes bedtime resistance problems, insomnia, parasomnias, sleep disordered breathing, morning arising problems, and daytime sleepiness (Devnani and Hegde 2015).

Food selectivity

According to Bandini's definition (2010), food selectivity, also named picky eating, include three domains: food refusal, limited food repertoire, and high-frequency single food intake. Both, food refusal and limited food repertoire, can be observed in individuals with ASD. What is important, limited food repertoire may be associated with nutrition inadequacy (Bandini et al. 2010). Leo Kanner, who in 1943 was the first scientist to describe the syndrome currently called "autism", highlighted feeding problems (Kanner 1943). Behavioral feeding disorders include selective eating, food refusal, and aversive eating behaviors, such as food refusal, choking, gagging, tantrums, and expulsion with no medical basis (Gentry and Luiselli 2008; Ledford and Gast 2006). Children with ASD present more mealtime disruptive behaviors in comparison to typically developing children (Gentry and Luiselli 2008). Feeding problems can affect up to 89.0 % children with ASD diagnosis and usually occur up to the age of 3, even in the first year of life. They can be one of the first alarming symptoms and can be observed before other unusual behaviors, such as aggression or self-aggression, appear (Dominick et al. 2007). In the Cermak and colleagues' study (2010), 59.0% of autistic children ate less than 20 types of dishes. Choosing a dish by children

with ASD can be guided by consistency, colour, product band or name, package or the way of serving food. Therefore, some children can eat only yellow food, some can eat only crispy food and others can only drink from one cup (Schreck et al. 2004; Schreck and Williams 2006).

There are various causes of these feeding problems. First of all, the causes resulting from symptoms can be indicated, such as concentration of details, perseveration, impulsivity, and fear of novelty; second, the causes resulting from comorbid symptoms, e.g. sensory-based feeding problems (textural aversion to specific kind of food), and medical conditions, such as esophageal problems, swallowing disorders or motor delay; and, finally, the social causes, e.g. parental anxiety and reinforcement of negative feeding patterns (Ledford and Gast 2006).

Moreover, adolescents with ASD seem to prefer energy dense food, such as chips, cake, hot dogs and pizza, and these preferences could lead to obesity (Strahan 2015).

Depression

A growing body of research has demonstrated the increased prevalence of comorbid depression among individuals with ASD (Strang et al. 2012; DeFilippis 2018). The prevalence of adolescence depression in general population is about 12.0%, whereas in the ASD group it can range between 9.0–26.0% (DeFillips 2018). It has been suggested that the prevalence of depression is positively associated with age and higher functioning forms of ASD (DeFillips 2018). In a different study conducted by Rai and colleagues (2018), children with ASD and ASD traits had higher depres-

sive symptom scores than the general population by the age of 10, which persisted to the age of 18. However, Strang with colleagues (2012) indicated an increased risk for depression and anxiety symptoms in children and adolescents with ASD without intellectual disability, regardless of age, IQ or ASD symptoms.

The association between depression and obesity is ambiguous. Although some studies have indicated a certain relation between obesity and depression, other studies have not confirmed it (Askari et al. 2013; Trambacz-Oleszak et al. 2018). A relation of that kind is complex and may be influenced by sociodemographic, psychosocial and cultural factors. However, psychological disorders comorbid with ASD, including depression and anxiety, are possible risk factors associated with unhealthy weight in this group.

Treatment

Behavior analysis treatment

Applied Behavior Analysis (ABA) was identified as the treatment for children with ASD in the early 1980s and has been considered to be one of the most effective method of therapy. Moreover, it has been the only method with scientific confirmation (Foxy 2008). Appropriate behaviors are positively reinforced by a praise, a hug, a check mark or a favorite activity, whereas maladaptive behaviors, such as aggression, are not reinforced and alternative behaviors are taught through positive reinforcement (Foxy 2008). It is necessary to mention that food can be one of reinforcements used, then the association between ABA and excess weight observed in individuals with ASD can exist.

Dietotherapy

Nowadays, complementary and alternative medical (CAM) therapies are increasingly introduced. In the Wong and Smith study (2006), more than half of parents of children with ASD admitted using CAM therapies for the child, 70.0% of them were biomedical: diet and supplementation. The results of using elimination diets, including the most popular low-sugar, gluten free (GF) and casein free (CF), and their effect on autistic's symptoms are inconclusive (Mulloy et al. 2010). It could be concluded that scientific evidence for the purposefulness of routine exclusion of gluten and casein from the diet of children with ASD (Trambacz and Gołaska 2013) is still missing. It is worth mentioning that one of the possible adverse effects is improper balance of meals, resulting in quantitative and qualitative food deficiencies. Children with ASD, due to frequent food preferences, spontaneously refuse to consume certain products, which means that even before the elimination diet is used, they remain in the group of increased risk of nutritional deficiencies. In Marí-Bauset and colleagues' study (2015), ASD individuals on the GFCF diet had a lower body mass, lower body mass index, and lower total energy, also lower pantothenic acid, calcium, phosphorus and sodium intake, but a higher intake of fiber, legumes, and vegetables.

Pharmacotherapy

It has been well documented that psychotropic medications are associated with body weight gain. Second-generation antipsychotics (SGA) can cause clinically-significant weight gain but the impact on body mass is related to the type of

medicines: weight gain appears to be the highest with clozapine and olanzapine, then by risperidone and quetiapine, and the least with ziprasidone and aripiprazole (McCloughen and Foster 2011). The use of psychotropic medications is very common in patients with ASD diagnosis. Approximately 30–60% of children and youths with ASD take at least one psychotropic drug. The most common medications used by patients with ASD are antipsychotics, stimulants, and antidepressants (Siegel and Curtin 2014).

Physical activity and sedentary behaviors

The association between physical activity and sedentary behaviors with overweight and obesity is well documented in scientific literature. A lot of studies have been conducted on physical activity in children and adolescents with ASD. Several studies have confirmed that individuals with ASD more often engage in sedentary behaviors.

Reluctance to take physical activity among children and adolescents with ASD may result from social impairments, sensory disorders or motor delays (Corvey et al. 2016). Rosser and colleagues (2005) showed that children with ASD were less active compared to typically developing peers, but the difference in moderate to vigorous physical activity (MVPA) was not significant. They also concluded that there was association between physical activity level and age: older children were less active, whether with or without ASD diagnosis. However, in the study conducted by Pan (2008), the autistic children were less likely to engage in MVPA – they spent only 27 minutes of MVPA compared to 35 minutes of MVPA among typically developing

children. The other study (Macdonald et al. 2011) showed that younger children with ASD were significantly more physically active than older children.

Autistic children can participate less in different types of physical activities with peers due to problems with establishing relationships with them. Also, parents of children with ASD diagnosis may be afraid of some disruptive behaviors and misunderstanding on the part of others and try to isolate their children. Lots of common misconceptions of autism existing in contemporary society create barriers for individuals with ASD, which may lead to lower physical activity (Pleban et al. 2014).

Although several studies have proved lower physical activity among individuals with ASD, Corvey (2016) drew a conclusion based on the data from the 2011–2012 National Survey of Children's Health (NSCH, $n = 49,586,134$ children aged 6–17, including 986,352 with ASD diagnosis) that there was no difference in the level of physical activity between children and youths with or without ASD. However, it needs to be highlighted that the difference in the prevalence of obesity between children with ASD (16.4%) and typically developing peers (9.9%) was significant. The difference in sedentary behaviors among children with different levels of ASD symptoms was also observed: individuals with moderate ASD were less likely to be sedentary compared to children with mild ASD, but this finding was no longer observed after controlling for secondary conditions and medication use (Corvey 2016).

Loneliness and social isolation

One of the three major autistic symptoms are difficulties in social interaction. Indi-

viduals with ASD have a limited ability to establish and maintain relationships with other people, which may lead to loneliness and social isolation (Kasari 2014). Both social isolation and loneliness, are associated with mortality and morbidity. Social isolation is a risk factor for the development of obesity (Cacioppo et al. 2011; Nonogaki et al. 2007). Nonogaki and colleagues (2007) showed that the social isolation in mice promoted obesity due to primary decreased energy expenditure and secondary increased food consumption which were independent on the disturbed leptin signaling and could lead to type 2 diabetes.

Family functioning: parental stress and depression

The diagnosis of ASD in a child may be stressful for all family members, especially for the mothers. It is well established in scientific literature that mothers of children with developmental and psychiatric difficulties are at the risk group for experiencing greater distress compared to mothers of typically developing children. The study conducted on Polish parents of children with ASD diagnosis found that mothers and fathers of autistic children had a higher level of stress and lower quality of life (Pisula and Porębowicz-Dörsmann 2017).

The meta-analysis synthesized 17 studies conducted by Tate and colleagues (2015) confirmed a significant association between psychological stress experienced by mothers and the body mass index of their children. One of possible explanations of this association is that maternal stress can change parenting behaviors, e.g. meal preparation and transportation to organized physical activity and can also reduce parent sensitivity

or disrupt bonds of secure attachment formation, decreasing children's ability to learn self-regulation skills, such as control of eating behaviors (Tate et al. 2015). However, not all studies on maternal stress and children obesity have confirmed association between these two factors. Results from a meta-analysis made by O'Connor and colleagues (2017) revealed that there was no evidence for association between maternal stress and children's healthy or unhealthy dietary intake, but fairly confirmed the evidence for the link between maternal stress and children's lower physical activity and higher sedentary behaviors (O'Connor et al. 2017).

Also, a growing body of literature highlights the role which maternal depression plays in the development of obesity in children. The prevalence of depression among mothers of autistic children seems to be high. 76.8% of the mothers studied by Jose and colleagues (Jose et al., 2017) reported depression which was significantly associated with their physical health and quality of life. Mothers of children with severe autism had higher levels of depression compared to those whose children had mild and moderate (29.6%) degrees of autism. Also in Al-Towairqi and colleagues study (2015), depression among mothers of children with ASD was significantly higher compared to the controls. Socio-demographic factors, such as number of siblings, family income, level of mother's education, showed no significant impact on maternal depression. The only significant factor was the mean age of autistic child. However, in the study conducted by Lerthattasilp and colleagues (2015) the prevalence of depression among caregivers of children with ASD was low – 5.9%.

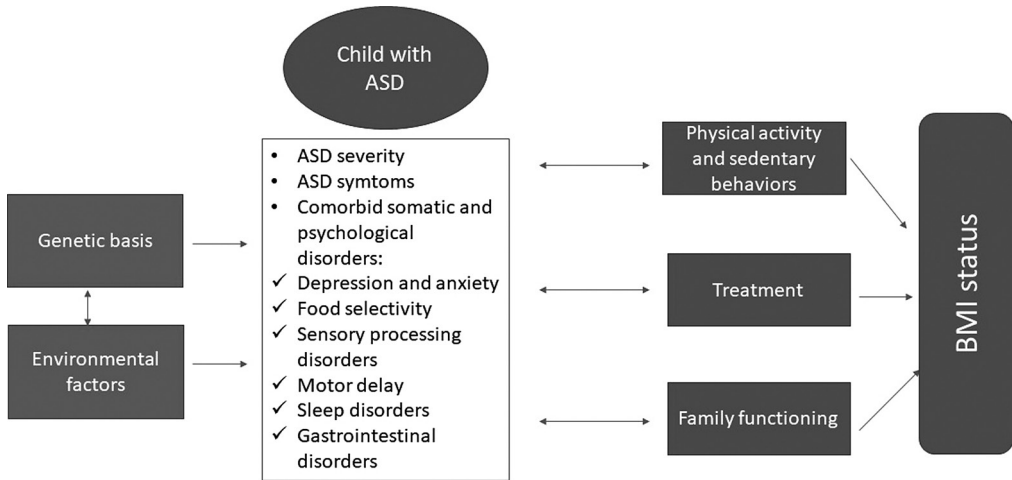


Fig. 1. Main risk factors for unhealthy weight among individuals with ASD

To summarize the findings, a structural model was created that maintained key risk factors for unhealthy weight in individuals with ASD (Fig. 1). This model can be used for future autism intervention research.

Concluding remarks

Maintenance of a healthy body weight could be significant in the prevention of many diseases which may occur in the later stage of ontogeny. Children and adolescents with ASD diagnosis are at the risk group for unhealthy weight. Although an increasing number of research studies have focused on children and adolescents with ASD, not many of these studies have related to the weight status of these individuals. Also, very little is known about the general health and body mass index of adults with ASD. There are a lot of factors associated with BMI status of individuals with ASD: personal effects resulting from symptoms, genetic, medical (comorbid somatic disorders), psychological (comorbid psychological disorders, such as depression and anxiety),

treatment (diet, psychopharmacology, behavioral therapy) and social (physical activity, sedentary behaviors, family functioning). All these factors have been analyzed in this article. The studies quoted above focused on selected factors only. Zuckerman and colleagues (2014) undertook a comprehensive analysis of the main factors associated with obesity in children with ASD. They found out, based on bivariate analysis, that the socioeconomic factors, such as age, gender, caregiver's educational level, race/ethnicity and autism severity were not related to BMI status of children with ASD. Socioeconomic factors are usually associated with weight status in general population. Also gastrointestinal symptoms and using CAM (both risk factors were analyzed in this article) were not significantly important. Only restricted and repetitive behaviors, affective problems and sleep problems were associated with the BMI status of children with ASD (Zuckerman 2014). Even though our knowledge about the prevalence of underweight, overweight and obesity and associated factors in individuals with

ASD is growing, longitudinal research is still missing. This type of research would show the real impact of risk factors on unhealthy weight in children, adolescents and adults with ASD diagnosis.

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