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PEDIATRIC TYPE 2 AND MONOGENIC DIABETES (O PINHAS-HAMIEL, SECTION EDITOR)

Attention Deficit/Hyperactivity, the Metabolic Syndrome, and Type 2 Diabetes

Zohar Landau[1,2,3] · Orit Pinhas-Hamiel[3,4,5]

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Abstract

Purpose of Review To present current data on the coexistence of attention deficit hyperactivity disorder (ADHD) and the metabolic syndrome and type 2 diabetes mellitus in adults and children and to discuss possible mechanisms.

Recent Findings Emerging data suggest that risk factors for obesity and insulin resistance such as diabetes during pregnancy and intrauterine growth failure may also have a role in the development of ADHD. Furthermore, ADHD and obesity share lifestyle factors, such as abnormal eating patterns, binge eating, and a sedentary lifestyle. ADHD is a risk factor for components of the metabolic syndrome, particularly obesity and type 2 diabetes mellitus, and also hypertension, both in adults and youth.

Summary Associations of ADHD with obesity, diabetes, and hypertension have been ascertained, and various mechanisms have been proposed. Research is needed to decipher the shared genetic, pharmacological, and lifestyle risk factors. Individuals with ADHD should be treated as a high-risk group for cardiometabolic complications.

Keywords Attention deficit hyperactivity disorder (ADHD) · The metabolic syndrome · Hypertension · Type 2 diabetes · Dyslipidemia · Obesity

Introduction

Several chronic diseases have been associated with increased occurrence of the metabolic syndrome (MetS) and its components [1–4]. Their associated treatment medications, decreased mobility, and common pathways in the development of these conditions have been suggested as possible explanations for their coexistence. Attention deficit hyperactivity disorder (ADHD) is the most common neurodevelopmental disorder in childhood. ADHD prevalence was shown to increase by 33% during 1997–1999 and 2006–2008 [5]. In parallel, childhood obesity has risen by alarming rates over recent years. An increasing number of studies have assessed the prevalence of obesity in individuals with ADHD and also the rates of ADHD in individuals with obesity. Although findings are mixed across studies, meta-analytic evidence shows a significant association between ADHD and obesity, regardless of possible confounding factors such as psychiatric comorbidities [6]. The association between obesity and the metabolic syndrome (MetS) is well known; however, less is known about associations of ADHD with the MetS and its components. Understanding and identifying medical and mental conditions that are associated with and contribute to the MetS are essential to developing targeted interventions. We will review evidence of the coexistence of these disorders in adults and in children and highlight possible mechanisms.

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✉ Orit Pinhas-Hamiel
orit.hamiel@sheba.health.gov.il

Zohar Landau
landau.zohar@gmail.com

[1] Pediatric Division, Barzilai Medical Center, Ashkelon, Israel

[2] Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel

[3] Maccabi Juvenile Diabetes Center, Raanana, Israel

[4] Pediatric Endocrine and Diabetes Unit, Sheba Medical Center, Edmond and Lily Safra Children's Hospital, Ramat-Gan, Israel

[5] Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

Attention Deficit Hyperactivity Disorder, the MetS, and MetS Components—Definitions and Prevalence

Attention Deficit Hyperactivity Disorder

Attention deficit hyperactivity disorder is a childhood-onset neurodevelopmental disorder characterized by developmentally inappropriate and impairing inattention, motor hyperactivity, and impulsivity [7•]. ADHD symptoms typically emerge early in childhood [8], and the disorders carry into adulthood approximately 50% of the time [9]. In addition, adult-onset ADHD describes ADHD symptoms that arise for the first time after childhood. Thus, as of 2013, with the introduction of DSM-5, ADHD is no longer classified as a childhood disorder but as a chronic lifelong disorder.

ADHD affects 6–12% of school-aged children and 4–5% of adults. Males are more likely to receive the diagnosis than females, with ratios ranging from 2:1 to 9:1. Affected females tend to display lower rates of hyperactivity and aggression and to be more likely diagnosed with the ADHD/inattentive type than males [5]. A dramatic increase in the rate of ADHD diagnoses occurred over the last decades [10, 11].

The etiology of ADHD is complex and incompletely understood, although there appears to be a high level of heritability of the condition, indicating a significant genetic component [12]. Environmental risk factors include maternal smoking during pregnancy, prematurity, and low birth weight [13].

MetS

The MetS describes a constellation of metabolic abnormalities that are associated with visceral adiposity. These disorders include insulin resistance, hypertension, hypertriglyceridemia, low levels of high-density lipoprotein cholesterol (HDL), and central obesity [14]. The MetS is diagnosed by the co-occurrence of three of these five aforementioned metabolic abnormalities. The MetS is common and its incidence has been rising for several decades. Recent data indicate that about 25% of the adults in the USA have MetS and suggest that it accounts for much of the population-attributable risk for premature cardiovascular mortality [15]. Among children, the median prevalence of MetS in whole populations was 3%, in overweight children 12%, and in obese populations 29% [16].

We did not find a study that assessed the prevalence of the MetS among adults or adolescents with ADHD. Obesity and each of the other components of the MetS will be discussed separately and are summarized in Table 1.

ADHD and Obesity

Obesity rates are increasing worldwide and constitute a huge public health concern because of their associations with chronic diseases like diabetes, hypertension, cardiovascular disease, and cancer. Two recently published meta-analyses examined the association between ADHD and obesity while controlling for confounding factors such as medications, sex, age (children and adolescents, or adults), socioeconomic status, and comorbid disorders. A clear association between ADHD and obesity was found in the meta-analysis by Cortese and Tessari, which included more than 700,000 children and adults, of whom 48,161 had ADHD [6]. The finding was validated in both children and adults separately; and results were similar in both epidemiological and clinical populations. The risk of obesity was higher in adult ADHD than in childhood ADHD, indicating that the risk increases over time.

A meta-analysis by Nigg and colleagues, which included more than 700,000 individuals, reported a non-statistically significant association between obesity and ADHD in children, a possibly clinically significant association in girls, and a significant association in adults [27]. Thus, the two meta-analyses indicate a significant association of ADHD with the risk of obesity in adults, but they differ in relation to the magnitude of the association in children.

A similar picture is evident from studies of children and adults in obesity clinics; accordingly, a higher than expected prevalence of ADHD was reported among patients who attend these clinics [28]. Adults with extreme obesity and remitted affective disorders had particularly high prevalence of ADHD [29]. ADHD was also more prevalent among bariatric surgery patients than among the general population [30]. These findings are clinically relevant since screening for and treating previously unrecognized ADHD in individuals with obesity may positively impact obesity outcome [31]. Of note, the prevalence of obesity among individuals with ADHD receiving medical treatment (13.8%) was decreased by about 40% compared with those not medicated (19.2%) [6].

ADHD and Waist Circumference

Data from the National Longitudinal Study of Adolescent Health, a nationally representative sample of adolescents followed from 1995 to 2009 in the USA, including 11,666 respondents, identified a linear association between the number of inattentive and hyperactive/impulsive symptoms (not a diagnosis of ADHD) in adolescence and waist circumference at a mean age of 29 years [21].

ADHD and T2DM

The data presented above show an association between ADHD and T2DM-related risk factors, such as obesity and

Table 1 Prevalences of metabolic syndrome components in general populations and in populations of individuals with ADHD

	Age (years)	Ref no.	No. with no ADHD	No. with ADHD	Prevalence no ADHD (%)	Prevalence in ADHD (%)	Prevalence ratio	OR (95% CI)	*P*
T2DM	18–64	[17••]	5,551,807	61,129	1.6	3.9	2.4		
	50–64	[17••]	1,661,074	4864	3.5	6.1	1.7		
	18–64	[18]	95,256	31,752	2.8	2.3			
	18–64	[18]	Depression 29,965	ADHD with depression 29,965	3.9	2.3			
	< 18 18–29	[19••]	71,898	35,949	0.21	0.83		2.8 (2.0–4.1) 3.3 (1.4–7.6)	
	5–15	[20]	21,510	4302	0.3	0.8		2.7 (1.8–4.2)	
Hypertension	18–64	[17••]	5,551,807	61,129	4.5	8.5	1.9		
	50–64	[17••]	1,661,074	4864	10	16.7	1.6		
	18–64	[18]	95,256	31,752	7.3	7.1			
	18–64	[18]	Depression 29,965	ADHD with depression 29,965	9.8	7.4			
	29	[21]	10,753	913	17.2	17.5		1.1 (0.7–1.8(	
	12–18	[22]	4524	272 111 on stimulants	2.7 3.6	2.0			
	7–17	[23]	*	55	2	5.5			
Lipids	11–17	[24]	6898	666					
TG (mg/dl)					110 ± 66	118 ± 74			0.01
HDL (mg/dl)					56 ± 13	56 ± 14			0.17
LDL (mg/dl)					91 ± 26	89 ± 26			0.03
TG (mg/dl)	8–12	[25]	88	88	68 ± 8	69 ± 6			0.51
HDL (mg/dl)					46 ± 4	45 ± 4			0.16
LDL (mg/dl)					82 ± 3	74 ± 4			0.001
TG (mg/dl)	6–12	[26]	29 (boys)	32 (boys)	97 ± 22	104 ± 25			0.3
HDL (mg/dl)					48 ± 6	43 ± 7			0.002
LDL (mg/dl)					80 ± 14	100 ± 16			< 0.001
Waist circumference	29	[21]	10,753	913	98 cm	101 cm			< 0.05

hypertension. However, little is known about the association between ADHD and T2DM.

The prevalence of ADHD in adults has been estimated as 2.5 ± 5% [32]. Associations of adult ADHD with metabolic conditions were examined through the linkage of multiple Swedish national registers [17••]. A total of 5,551,807 adults (49.19% females), aged 18 to 64 years, were identified and assessed for clinical diagnoses of adult ADHD and T2DM. ADHD was diagnosed in 61,129 (1.10%) at some point in their adult life. Adults with ADHD showed an increased prevalence of T2DM (3.9%) compared with those without ADHD (1.6%); the prevalence ratio was 2.4. T2DM was more prevalent in males than in females, 4.3% vs. 3.6%.

Using the Taiwan National Health Insurance Research Database, 35,949 adolescents and young adults with ADHD and 71,898 age- and sex-matched controls were followed for up to 9 years [19••]. Those diagnosed with ADHD had a higher risk of developing T2DM than did the controls, after adjustment for demographic characteristics: among adolescents (hazard ratio (HR) = 2.8; 95% CI, 2.0–4.0) and young adults (HR = 3.2; 95% CI, 1.4–7.6). In addition, those with ADHD had a shorter mean ± SD duration between enrollment and onset of T2DM than did the controls: 3.2 ± 2.3 vs. 4.1 ± 2.1 years, $P = 0.004$. Long-term use of atypical antipsychotics was associated with a higher likelihood of subsequent T2DM: HR = 2.8, 95% CI, 1.7–4.6. Although the observation of a correlation does not indicate causation, these findings merit further study about the relationship between ADHD and T2DM.

In another study from Taiwan, which included 4302 newly diagnosed subjects (age 5–15 years) with ADHD and 21,510 matched controls, a prior diagnosis of T2DM was higher among individuals with than without ADHD (0.8 vs. 0.3%, $P < 0.001$) [20].

Despite the small number of relevant studies, the co-occurrence of ADHD and T2DM may be important as the inattention and disorganization, which are associated with ADHD, could make it difficult for patients with T2DM to

adhere to treatment regimens and impact their glycemic control. Indeed, in a recent study, among 250 adult patients with T2DM, 7.2% were diagnosed with ADHD based on the Adult ADHD Self-Report Scale. Their HbA1c levels were 8.9% (CI 8.2; 9.5) compared with 7.5% (CI 7.4; 7.6) in adults without ADHD [33].

ADHD and Hypertension

Methylphenidate and amphetamines are commonly used in the treatment of ADHD in children and adults. By increasing noradrenergic and dopaminergic transmission, these agents may raise blood pressure. Indeed, a modest but significant increase in blood pressure and heart rate is a well-known adverse effect of stimulants that has been documented in several retrospective and prospective studies in adults [18].

In a large Swedish epidemiologic study ($n = 5{,}551{,}807$ adults; 61,129 with ADHD), those with ADHD showed an increased prevalence of hypertension (8.5%) compared with those without ADHD (4.5%); the prevalence ratio was 1.90 [17••]. Hypertension was more prevalent in males (9.5%) than in females (7.4%).

Data from the National Longitudinal Study of Adolescent Health in the USA, mentioned above [21], revealed hypertension in 12.6% (4343) of young adults who had inattentive and hyperactive/impulsive symptoms in adolescence. Linear associations were found in the number of such symptoms with both diastolic and systolic blood pressure. Notably, quantifying ADHD symptoms in this study was done via retrospective self-report. In contrast to these studies, prevalence estimates of hypertension were similar between 31,752 adults with ADHD and 95,256 non-ADHD controls in a study based on US health care claims [22].

Associations of ADHD with pre-hypertension and hypertension in children have been investigated in several studies. One of these was based on data from the U.S. National Health and Nutrition Survey, which included 4907 children aged 12–18 years, of whom 383 (10.7%) were diagnosed with ADHD; of these, 111 (3.4%) were treated with central nervous system stimulants. The findings showed that children with ADHD on stimulants were significantly younger and more often male and white than those with ADHD not on medication and those without ADHD. One hundred sixty (2.7%) had blood pressure in the hypertensive range, and 637 (12.4%) in the pre-hypertensive range. The prevalence of HTN or pre-HTN was not different in children with ADHD, between those on stimulants and without medication, and between children with and without ADHD [23].

In a Canadian study, blood pressure was measured in 55 children (47 males) aged 7 to 17 years with ADHD, with an average BMI z-score of -0.4 ± 1.2 [34]. All children were medicated; the majority (82%) were treated with various types of stimulant agents. Elevated office blood pressure values were more prevalent than in the data from the Canadian Health Measures Survey; 9% had blood pressure > 90th percentile and 5.5% > 95th percentile. Ambulatory blood pressure monitoring confirmed masked hypertension in 3.6%, the absence of the normal reduction in early morning blood pressure compared with average daytime pressure (non-dipping) in 51% and "white coat hypertension" in 5.5%. In this study, 78% of the children had disturbed sleep (according to a sleep disturbance scale for children questionnaire). Prevalent sleep non-dipping in this population was associated with sleep disturbances but the clinical significance of this finding requires further investigation.

Associations of stimulant medication with blood pressure and heart rate were assessed over 10 years in 579 children, aged 7–9 years in the Multimodal Treatment Study of Children with ADHD (MTA) [35]. Stimulant treatment did not increase the risk for pre-hypertension or hypertension over the 10-year period of observation [35].

Review of the literature demonstrated associations of stimulant medications and atomoxetine with increases in systolic and diastolic blood pressure (BP, 1–4 mmHg) and with heart rate (HR, 1–6 bpm) in children, adolescents, and adults [36]. Though these trends were statistically significant, they were of small magnitude and generally with little or no clinical significance.

In summary, data are not consistent; while several studies showed higher prevalence of hypertension among persons with ADHD, others showed no difference. This may be due to differences in the age groups included, the criteria for diagnosis of ADHD, and reported vs. measured blood pressure. It is unclear whether the association observed between adult ADHD and hypertension was mediated by stimulant treatment for ADHD.

ADHD and Lipids

No difference was observed in the proportions of adults with triglycerides > 200 mg/dl or HDL levels < 40 mg/dl and between 98 adults with ADHD who were untreated and 100 adults without ADHD of similar age and sex distribution [24]. Significantly higher proportions of the ADHD group had LDL levels above 160 mg/dl (5% vs. 0% respectively, $P = 0.03$).

Among children, based on data from the nationwide, population-based German Health Interview and Examination Survey for Children and Adolescents, serum levels of total cholesterol, HDL, triglycerides, and LDL were compared between participants with ADHD and a control group. [25] Of 6898 participants aged 11–17 years, 9.7% (666) had a physician-based diagnosis of ADHD or suspected ADHD. No difference was found between the groups in triglycerides and HDL levels. A small, but significant and inverse association was found between LDL levels and symptoms of ADHD.

In another study, serum levels of total cholesterol, HDL, triglycerides, and LDL were examined in 88 children aged 8–12 years who were diagnosed with ADHD and 88 healthy children [26]. Triglyceride and HDL cholesterol levels were similar between the groups, whereas LDL levels were significantly higher in the ADHD group. Of note, obese children were excluded from this study. In a smaller study, lipid levels in 32 boys diagnosed with ADHD were compared with those of a control group of 29 healthy subjects [37]. Triglyceride levels did not differ significantly between the groups; LDL and HDL levels were significantly lower in the ADHD than the control group.

Among 42 individuals with ADHD, median age 16, lipid levels were measured starting treatment and after 3 months of continuous treatment with methylphenidate. LDL decreased by 5.0 mg/dl ($P < 0.016$), and triglycerides decreased by 8.0 mg/dl ($P < 0.016$). Changes in the levels of HDL, apolipoprotein A, and apolipoprotein B were non-significant, and Lp(a) levels decreased by 2.0 mg/dl ($P < 0.0007$). Methylphenidate improved the lipid profile by decreasing triglycerides, LDL-C, and Lp(a).

In summary, only minor or no differences were found in triglyceride and HDL levels between individuals with and without ADHD.

Risk Factors Associated With the Development of the MetS Among Patients With ADHD

Similar risk factors for obesity and ADHD exist, such as diabetes during pregnancy and intrauterine growth failure and such lifestyle factors as abnormal eating patterns, binge eating, and a sedentary lifestyle (Fig. 1).

ADHD and Lifestyle

A study from China that compared several parameters of lifestyle in children aged 9–13 years, with and without ADHD, reported that children with ADHD symptoms more frequently combined eating with sedentary behaviors: snacking when using a computer or sitting in a car, eating snacks and drinking soda at bedtime, and using a computer and smartphone at bedtime [38•]. A high prevalence of abnormal eating behaviors was found in obese adult patients with ADHD compared with obese adult patients without ADHD: these included eating between-meal snacks, binge eating episodes, and night eating [39]. These eating behaviors might increase the risk of becoming overweight or obese.

A possible explanation is related to the characteristics and symptoms of ADHD: patients with ADHD have poor planning, significantly greater impulse control deficits, and less control of their eating than children without ADHD [40].

In contrast to the data presented above, one study did not find differences in health habits between adults with and without ADHD, despite the observation of robust differences in a wide range of adverse health risk indicators, such as lipid profiles, diastolic blood pressure, and BMI [24]. However, no differences were identified in health habits [24].

Sleep Disturbances

In both adults and children, sleep disturbances are commonly associated with ADHD [41, 42]. Up to 83% of adults with ADHD reported problems with sleep. Similarly, various sleep disturbances were found by actigraphy and polysomnography studies among children and adults with ADHD, including delayed sleep onset, difficulties in awakening, increased nocturnal activity, reduced sleep efficiency, and a reduced proportion of rapid eye movement (REM) sleep [43].

Similarly, several meta-analyses of adult and pediatric studies concluded that short sleep duration increases the odds of obesity [44]. This association was stronger in boys than in girls, and specifically, an association between central obesity and sleep duration was observed in boys but not in girls. Thus, the deterioration of the sleep-wake cycle appears as a common denominator between ADHD and obesity, impaired glucose tolerance, diabetes, and the MetS.

Medications

Stimulants such as methylphenidate and dexamphetamine are the first-line pharmacological treatments for ADHD, and the noradrenaline reuptake inhibitor atomoxetine is the second-line treatment. Each of these treatments increases catecholamine availability [7•]. Associations of these medications with blood pressure were discussed above.

Treatment with methylphenidate, which acts as a central nervous system stimulant, resulted in a decrease in BMI standard deviation score at 1–3 years following treatment initiation [45]. Furthermore, treatment with methylphenidate resulted in improvement in the lipid profile, as demonstrated by significant decreases in levels of total cholesterol, triglycerides, LDL, and Lp(a) [46].

Patients who are unresponsive or intolerant to their initial monotherapy may require an adjunctive or alternative drug therapy. Atypical antipsychotic (AAPs) medications are often prescribed off-label for the treatment of ADHD. Risperidone is one of the most frequently prescribed AAPs among patients with ADHD [47]. An exploratory study in a Canadian ADHD clinic found that nearly one in five children with ADHD was prescribed AAPs off-label to treat ADHD [48]. Also the National Hospital Ambulatory Medical Care Survey (USA) found that ADHD was the most common diagnosis associated with an antipsychotic prescription for children aged 2 to 18 years [49]. Furthermore, clinical studies have documented

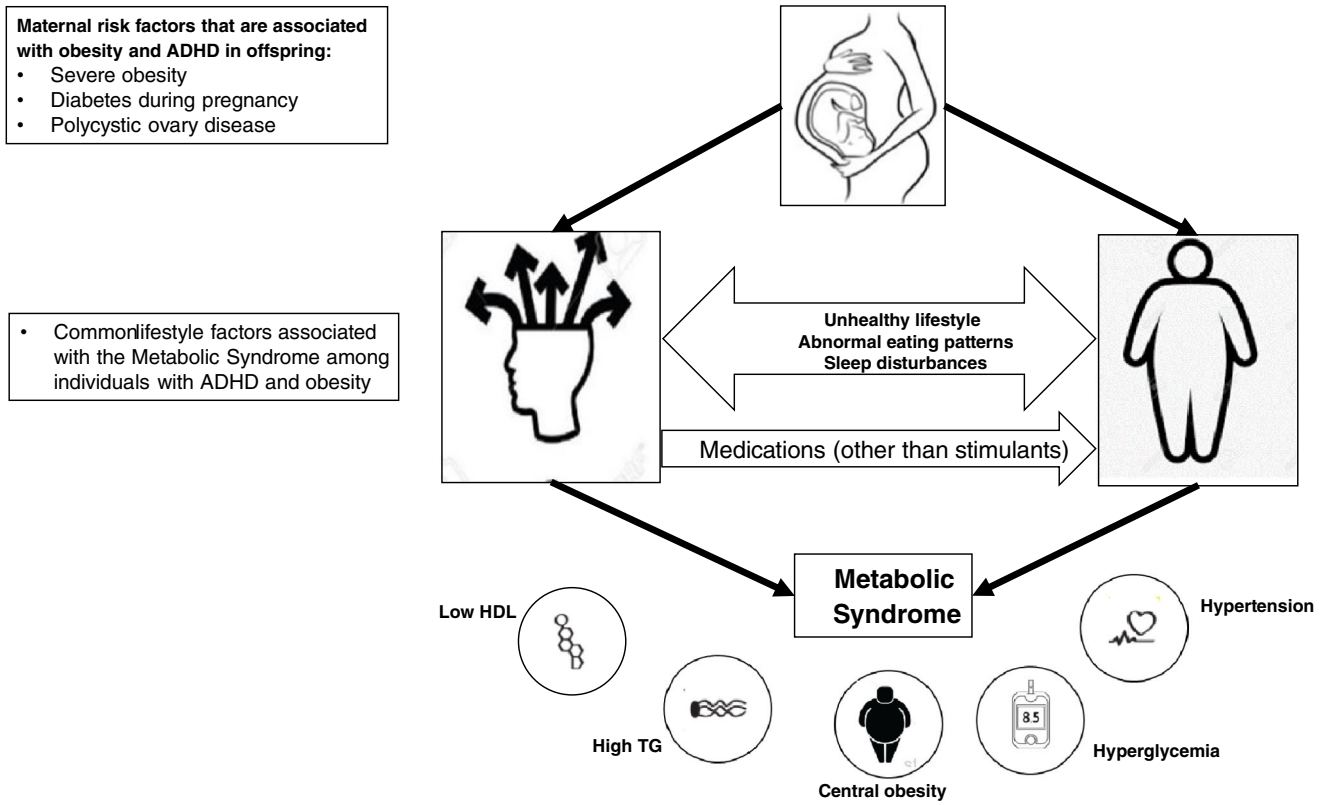

Fig. 1 Common maternal risk factors and lifestyle factors that are associated with the development of metabolic syndrome among individuals with ADHD and with obesity

that adults with ADHD tend to suffer from psychiatric disorders such as substance use, depression, bipolar disorder, and anxiety [50]. First-line medications (stimulants) for ADHD have opposite effects: decreased BMI, a favorable lipid profile, and increased blood pressure levels.

Psychiatric Comorbidities Among Patients With ADHD

A large Swedish population-based cross-sectional study found a prevalence ratio of over nine-fold for psychiatric conditions among adults with ADHD compared with adults without ADHD [17••]. Adolescents with ADHD in Taiwan were reported to have increased risks of unipolar depression and bipolar disorder. The risk was especially high among those with ADHD and comorbidity of conduct disorder or oppositional defiant disorder, and these are thus treated with more medications [51]. These disorders are linked to higher BMI and obesity and to a higher risk of MetS and T2DM. Moreover, the coexistence of these psychiatric conditions can lead to polypharmacy, including the use of AAPs. Metabolic side effects associated with AAP use, such as weight gain, MetS, and T2DM are of concern [52].

Regarding depression and anxiety, the association between all five MetS risk factors and adult ADHD was analyzed in participants, aged 18 to 65 years, in the Netherlands Study of Depression and Anxiety (NESDA). Participants were categorized according to three subgroups: controls ($n = 554$), participants with depressive/anxiety disorders and without ADHD ($n = 1566$), and those with depressive/anxiety disorders with ADHD ($n = 183$) [50]. Although a wide range of comprehensive analyses and models were performed, no clear associations between MetS, obesity-related outcomes, and clinical comorbid ADHD symptoms were found. Thus, this study did not support the notion that comorbid adult ADHD predisposes to MetS.

Polycystic Ovary Syndrome and ADHD

The male preponderance of ADHD suggested that ADHD may be influenced by prenatal androgen levels. Polycystic ovary syndrome (PCOS) is characterized by hyperandrogenism. Following the supposition that androgens are implied in the etiologies of both ADHD and PCOS, current and childhood ADHD symptoms were compared between 40 women with PCOS aged 18–35 years and 40 healthy women who had regular menses [53]. Women with PCOS had significantly higher total current and total childhood ADHD scores than controls. However, there were no correlations between ADHD symptoms and serum hormone levels, including testosterone in women with PCOS.

Maternal Factors: Pre-gestational Overweight and Obesity, Weight Gain, Diabetes, and PCOS and the Risk of ADHD in Offspring

Considerable interest has arisen regarding the possible role of the prenatal environment in the development of ADHD. Prenatal exposure to metabolic disturbances is associated with increased risk of offspring neurodevelopmental impairment. Nationwide registries were used to link data of all live births in Finland between 2004 and 2014 ($n = 649{,}043$). Associations were assessed for the independent and combined factors: maternal obesity, pre-gestational diabetes mellitus (PGDM), and gestational diabetes mellitus (GDM), with outcomes of the offspring [54]. Severely obese mothers had an 88% increased risk of having a child with ADHD or a conduct disorder (HR = 1.88; 95% CI = 1.58–2.23), compared with mothers with a normal BMI. PGDM implied a further risk increase for ADHD and conduct disorder (HR = 6.03; 95% CI = 3.23–11.24). GDM did not have a substantial effect on the risk for these offspring disorders.

Of 333,182 children included in a retrospective birth cohort study, 37,878 (11.4%) were exposed to diabetes in utero (522 were exposed to type 1 diabetes mellitus (T1DM), 7822 to T2DM, and 29,534 to GDM requiring antidiabetes medications). Compared with children unexposed to diabetes, the adjusted HRs for ADHD were 1.57 (95% CI 1.09–2.25), 1.43 (1.29–1.60), and 1.26 (1.14–1.41) for children exposed to T1DM, T2DM, and GDM, respectively, during a median of 4.9 year follow-up [55]. The hierarchy of risks suggests that the severity of maternal diabetes (T1DM vs. T2DM vs. GDM requiring antidiabetes medications) influences the risk of ADHD in offspring of mothers with diabetes.

Similarly, using health and population data registers for all children born in Sweden during 1984–2008, 58,912 ADHD cases (68.8% male) were identified and matched to 499,998 unaffected controls, by sex and birth month/year [56]. Maternal PCOS increased the odds of ADHD in offspring by 42%, after adjustment for confounders (OR 1.42, 95% CI 1.26–1.58). The risk for ADHD was higher among obese mothers with PCOS (OR 1.68, 95% CI 1.31–2.17) and was highest among obese mothers with PCOS and other features of the metabolic syndrome (OR 2.59, 95% CI 1.02–6.58).

Further, in a Scandinavian study, pre-pregnancy overweight, obesity, and being overweight and gaining a large amount of weight during gestation were directly associated with higher risk of ADHD, as examined in over 12,000 school-aged offspring [57].

Conclusions

From a clinical perspective, the relationship between ADHD and obesity is well known. Increased prevalences of T2DM and of hypertension have been reported. Dyslipidemia does not appear to be significantly associated with ADHD. Further studies are required to decipher the genetic and biochemical mechanisms behind associations of ADHD with T2DM. Since patients with ADHD are a high-risk group for cardiometabolic complications, health care providers should pay particular attention to the various aspects of lifestyle and metabolic syndrome, with the aim of improving mental and physical health in patients with ADHD.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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