

# Relationship between attention deficit hyperactivity disorder and temporomandibular disorders in adults: a questionnaire-based report

B. STELCER<sup>1,2</sup>, A. SÓJKA-MAKOWSKA<sup>3</sup>, N. TRZESZCZYŃSKA<sup>2</sup>, J. SAMBORSKA<sup>4</sup>, G. TEUSZ<sup>5</sup>, M. PRYLIŃSKI<sup>3</sup>, M. ŁUKOMSKA-SZYMAŃSKA<sup>6</sup>, E. MOJS<sup>2</sup>

<sup>1</sup>Faculty of Food Science and Nutrition, University and Health Sciences, Poznan, Poland

<sup>2</sup>Department of Clinical Psychology, University of Medical Sciences, Poznan, Poland

<sup>3</sup>Clinic of Prosthodontics and Gerostomatology University of Medical Sciences, Poznan, Poland

<sup>4</sup>Department of Dental Surgery and Periodontology, University of Medical Sciences, Poznan, Poland

<sup>5</sup>Department of Social Counselling, Faculty of Educational Studies, Adam Mickiewicz University, Poznan, Poland

<sup>6</sup>Department of General Dentistry, Medical University, Lodz, Poland

*Bogusław Stelcer and Anna Sójka-Makowska equally contributed to the work*

**Abstract. – OBJECTIVE:** The symptoms of the attention deficit hyperactivity disorder (ADHD) persist in the adult years of life in most cases. They appear in adults with accompanying psychosocial problems. Temporomandibular disorder (TMD) refers to signs and symptoms associated with pain of non-dental origin in the oro-facial region, functional and structural disruptions of the masticatory system, especially the temporomandibular joints (TMJs) and masticatory muscles. The aim of the study was to show the relationship between the presence of ADHD symptoms in adulthood, in relation to the intensity of pain experienced in the face and problems connected to the TMD symptomatology, as well as sleep disorders.

**PATIENTS AND METHODS:** The study group consisted of 252 individuals aged 18-55 years of both sexes, generally healthy. Each participant was asked to fill in several questionnaires, namely: ASRS (the World Health Organization ADHD Adult Self-Report Scale), DIVA (18 questions, 9 for concentration and attention disorders with an option in adulthood and childhood, 9 for hyperactivity and impulsivity with an option in adulthood and childhood), Athens Insomnia Scale, Stanford Sleepiness Scale (SSS), DC/TMD classification (Diagnostic Criteria for Temporomandibular Disorders – biaxial diagnostic criteria based on the biopsychosocial model).

**RESULTS:** Results show that when ADHD symptoms observed in childhood persist, personality disorders, social relations disorders and affective disorders are found more often in adults than motor hyperactivity.

**CONCLUSIONS:** There is a positive association between ADHD and the occurrence of symptoms of TMD in adults. This study confirmed this picture, extending it to include pain and sleep disorders.

*Key Words:*

Attention deficit hyperactivity disorder, Temporomandibular disorder, Temporomandibular joints, Inattention, Impulsiveness, Hyperactivity, Emotional dysregulation, Stress, Adulthood, Childhood.

## Introduction

The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) describes the attention-deficit hyperactivity disorder (ADHD) as a childhood-onset developmental disturbance that persists for at least six months and across different situations, and comprises three core symptoms, such as inattentiveness, impulsivity, and/or motor unrest<sup>1</sup>. This syndrome begins in childhood and is a lifelong condition. The clinical picture of the ADHD includes problems with learning, disturbed relationships with loved ones, social difficulties, and the occurrence of various problematic behaviors. The DSM-5 commission included ADHD in the section of neurodevelopmental disorders, along with autism spectrum disorders and intellectual disability<sup>1,2</sup>. Neuropsychological

studies have shown that adults with ADHD have abnormalities related to alertness, speed of motor perception, working memory, verbal learning, and inhibition of responses<sup>3</sup>. In line with the latest trends, it is noticed that the symptoms of ADHD also persist in the adult years of life in most cases. Symptoms are present in adults with accompanying psychosocial problems<sup>4</sup>.

### ***Diagnosis of ADHD***

The criteria for diagnosis are identical for children and adults. The symptoms are measured on a five-dimensional scale that includes executive dysfunctions, inattention, impulsiveness, hyperactivity, emotional dysregulation, and other disabilities<sup>5</sup>. Symptoms must persist for at least 6 months. The condition for the diagnosis of ADHD in adults is the presence of several symptoms – not necessarily diagnosed – before the age of 12<sup>5</sup>. A diagnosis can be confirmed after excluding the presence of other entities that better explain the symptoms (defiant behavior, schizophrenia or mood disorders).

### ***Symptoms of ADHD***

Symptoms of the attention problems include difficulties in completing long tasks, being quickly distracted, losing objects and forgetting. In adults with ADHD, many of the symptoms of inattention are also classified as executive deficits. ADHD in adults is primarily manifested by difficulty in maintaining attention on the task for a long period of time. Patients with ADHD often have difficulty organizing activities, prioritizing, completing tasks and managing time. The next group of symptoms is described as hyperactivity and impulsiveness. They are related to the patient's activity. In adults, this is manifested by restlessness (including psychomotor agitation) and excessive talkativeness (DSM-5)<sup>1</sup>. Adults with ADHD due to attention disorders often have problems at work: they are not dutiful, do not finish tasks, and their operation is ineffective; due to increased impulsiveness, they have difficulties with adequate responses to stress, are irritable, anxious, and aggressive<sup>6</sup>. Moreover, adults with ADHD, show psychiatric problems 3-7 times more often than the control population. Additionally, 38% of them exhibit mood disorders, 47% of the adult population with persistent ADHD have anxiety disorders, and 15% have an addiction<sup>6</sup>. It is confirmed that full symptoms are observed in 29% of patients<sup>7</sup>. Most studies<sup>8-12</sup> on children with ADHD symptoms indicate that sleep disturbances

can result in neurobehavioral deficits or aggravate the symptoms of the disorder. It is believed that sleep disorders contribute to an increase in the manifestation of ADHD symptoms (inattention, hyperactivity, and impulsivity) and that ADHD can lead to poor sleep quality. However, these associations have not been well defined so far<sup>13,14</sup>.

### ***Prevalence of ADHD***

ADHD is seen as one of the most common mental disorders in children<sup>15</sup>. It also occurs in adults with accompanying psychosocial problems<sup>4</sup>. In many European countries, ADHD in adults is underdiagnosed and undertreated. This can lead to unnecessary suffering for these people, their relatives and their environment<sup>16</sup>. Recently, the prevalence rate was estimated to be about 5% of children worldwide (APA, 2013). In a recent meta-analysis<sup>8</sup>, the pooled prevalence estimation of ADHD in children and adolescents was more than 7%. A study<sup>17</sup> involving children diagnosed with the syndrome reported that the disorder persisted during adolescence and adulthood in about 2/3 of people. Other epidemiologically derived data showed that 4-5% of college aged students and adults have ADHD<sup>6</sup>. Another study<sup>18</sup> estimated that 50-70% of children diagnosed with ADHD still had significant symptoms of this disorder as young adults.

However, the prevalence of ADHD in adults is lower than the corresponding prevalence estimated in children and adolescents. The 18-24 age group contributed to the most of adult ADHD cases. It may happen that patients fully develop or just enter the so-called "partial remission" state, in which some symptoms are present, but they can lead to a deterioration in psycho-social functioning. Sometimes there is a significant reduction in the symptom severity during adolescence, but in such cases these people cope worse with everyday life tasks and demands than their healthy peers in a well-matched control population<sup>19,20</sup>. ADHD was until recently considered a problem of childhood and adolescence, without any effect on later life<sup>21</sup>. In general, it seems that ADHD is more common in childhood and the symptoms tend to regress with the advance in age<sup>16,21-23</sup>. Compared with childhood ADHD, adult ADHD is relatively neglected in epidemiological studies, largely due to the absence of well-established and validated diagnostic criteria<sup>24</sup>. Until recently, many attempts have been made to estimate the prevalence of adult ADHD in the general population<sup>16,25</sup>. When defining adult ADHD with

the DSM-IV criteria, Willcutt<sup>26</sup> estimated that the pooled prevalence of adult ADHD was 5%, based on 11 studies published between 1996 and 2011.

### **Definition and Diagnosis of Temporomandibular Disorder (TMD)**

The term TMD refers to signs and symptoms associated with pain of non-dental origin in the oro-facial region, as well as functional and structural disruptions of the masticatory system, especially the temporomandibular joints (TMJs) and masticatory muscles<sup>27-29</sup>. The said symptoms are related to TMDs, comorbid with headaches, and pain of the neck, and are also associated with emotional stress<sup>30</sup>. In order to diagnose TMD, formal diagnostic criteria should be fulfilled. A new dual-axis Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) were developed in 2014<sup>27</sup>. Axis I is a standardized series of diagnostic tests based on clinical signs and symptoms. It involves a physical evaluation which leads to a TMD diagnosis. In Axis II, special attention is given to graded chronic pain, depression, anxiety, somatic symptoms, jaw functional limitations, and oral behaviors<sup>27,28</sup>.

### **Symptoms of TMD**

TMD symptoms include pain in the area of the masticatory muscles or temporomandibular joints, crepitation, disk displacements, and restrictions or asymmetries in the movements of the lower jaw<sup>29,30</sup>. Parafunctional activities and increased chewing forces may lead to various consequences: microfractures of the tooth enamel, gum recession, loss of teeth, hypersensitivity of teeth to hot/cold/sweet, headache, ear buzzing/ringing, neck pain, clicking/stiffness/pain in the temporomandibular joints (TMJ), diminished opening, difficulty chewing, sore jaw muscles, changes in facial appearance, and myofascial pain syndrome (masticatory myalgia)<sup>31-36</sup>.

### **Prevalence of TMD**

The prevalence of TMDs among the general population is considered to be 5%; there are studies suggesting that approximately 5%-60% of the population experience at least one TMD symptom<sup>23,29</sup>. According to research by Ryan et al<sup>33</sup>, the prevalence of TMDs peaks among people aged 25-45, and it seems that women are more affected than men. Research conducted by Loster et al<sup>37</sup> on a group of 260 young Polish adults also showed higher prevalence of TMJ symptoms for females. Among adolescents between 14 and 18 years old, TMDs have a prevalence of about 30%<sup>28,38-40</sup>. The

study conducted by Lauriti et al<sup>41</sup> on a sample of 81 adolescents aged 14 to 18 years showed 74.1% of them had TMD symptoms.

### **Etiology of TMD**

The etiology of TMD is multifactorial and may result from trauma, repetitive microtrauma, from parafunction (both occlusal and not occlusal), as well as systemic and psychological factors<sup>42</sup>. Parafunctions in dentistry refer to those activities of the stomatognathic system that would be considered to fall outside functional activities (e.g., tongue habits, masticating on one side, lip/cheek biting) and bruxism (clenching, grinding, and tapping the teeth). Nowadays the association between depression and stress and different physical symptoms of TMD is widely recognized<sup>43,44</sup>. Psychosocial factors, such as stressful life events, emotional disturbances, psychological distress, and psychiatric disorders (hypervigilance, depression, anxiety, post-traumatic stress disorder, and neurosis)<sup>45-48</sup> could contribute to TMD.

The aim was to explore relationships between:

- a) presence of symptoms of concentration and attention disorders, hyperactivity, and impulsivity disorders in adulthood and occurrence of pain experienced in the TMJ area and problems connected with the muscular and articular system;
- b) psychosocial functioning, somatic symptoms of stress, and TMJ dysfunction.

Based on this information, we hypothesize that there is a relationship between ADHD and the occurrence of TMD symptoms in a group of students.

### **Research Hypotheses**

Hypothesis 1: there are significant differences between adults with ADHD and adults without ADHD in terms of the experience of pain and its impact on the functioning of the individual and possible problems related to temporomandibular joint disorders.

Hypothesis 2: there are significant differences between people with diagnostic concentration and attention disorders in childhood and people without diagnostic concentration and attention disorders in childhood, in terms of the severity of TMD symptoms.

Hypothesis 3: there are significant differences between people with diagnostic hyperactivity and impulsivity disorders in adulthood and people without diagnostic hyperactivity and impulsivity disorders in adulthood in terms of the severity of TMD symptoms.

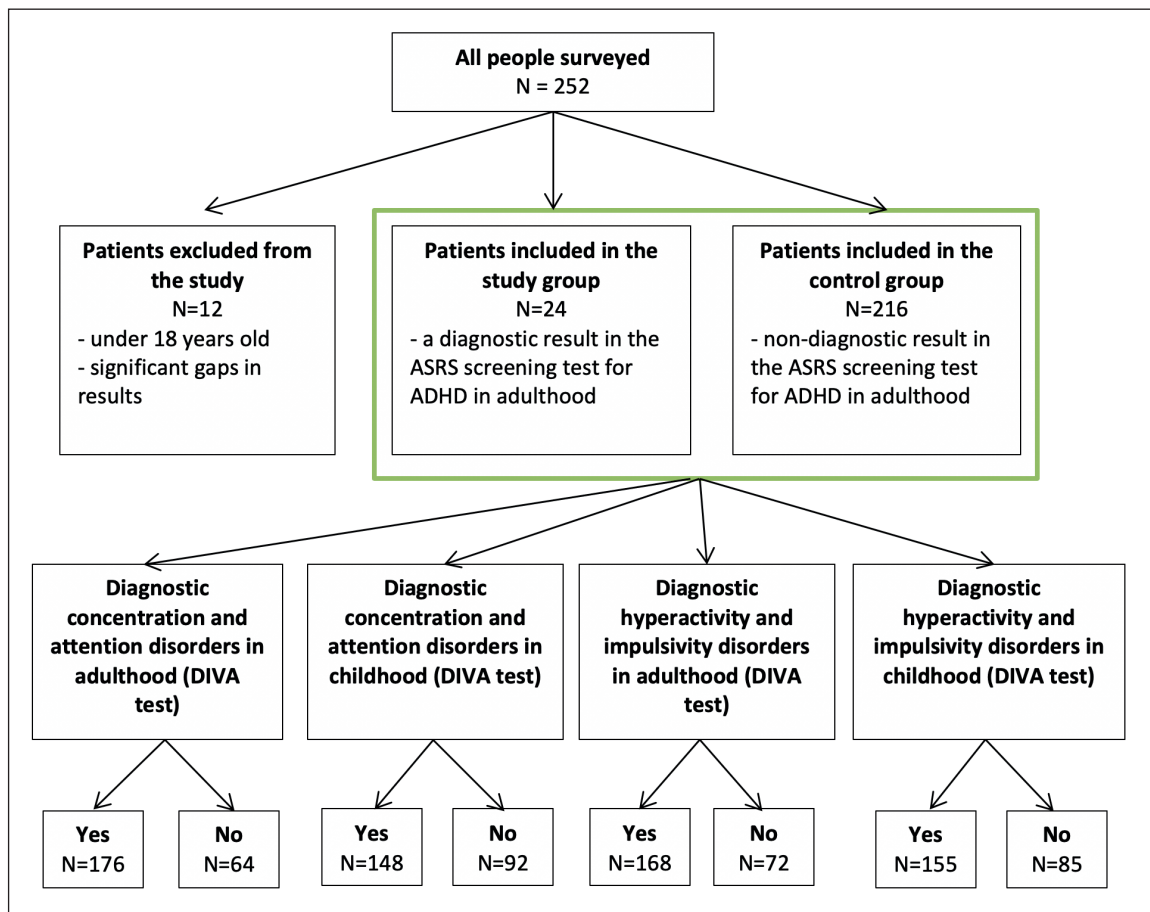


Figure 1. Flow diagram of the research.

Hypothesis 4: there is an association between the severity of sleep disorders, ADHD symptoms and TMD symptoms.

## Patients and Methods

### Study Design

The study was conducted between 2019 and 2021. Completing the questionnaire was voluntary, and the questions did not cover the personal sphere. The study was carried out on adult patients according to the criteria shown in Table I.

### Participants

The study group consisted of 252 generally healthy individuals of both sexes. Twelve patients who did not meet the inclusion criteria were excluded from the survey. In total, 240 people were included in the analysis, 24 people were qualified to the study group with ADHD symptoms, and 216 assigned to the control group. The occur-

rence of symptoms characterizing ADHD (i.e., attention disorders), and – in light of the latest approaches – inattention and hyperactivity in a developmental perspective were assessed. Among the total number of 240 people qualified for the study, attention disorders were found in childhood (n=148) and adulthood (n=178). Hyperactivity was demonstrated in childhood in (n=155) 155 survey subjects and (n=168) in 168 interviewees in adulthood (Figure 1).

### Research Tools

In order to verify the research hypotheses, research tools were used facilitating an assessment of ADHD symptoms and accompanying sleep rhythm disorders.

Tools used in the study:

- Adult Self-Report Scale - ASRS (WHO, 2003): the World Health Organization ADHD Adult Self-Report Scale (ASRS) is a widely used diagnostic tool to assess the ADHD symptoms in clinical psychiatry. The used



**Table I.** Inclusion and exclusion criteria for the study group and the control group.

	Inclusion Criteria	Exclusion Criteria
Study group	<ul style="list-style-type: none"> <li>- willing to participate in the study</li> <li>- between 19 and 55 years old</li> <li>- general good health</li> <li>- a diagnostic result in the ASRS screening test for ADHD in adulthood</li> </ul>	<ul style="list-style-type: none"> <li>- unwilling to participate in the study</li> <li>- psychiatric diseases such as schizophrenia and affective disease</li> <li>- under 18 years old</li> <li>- mental retardation</li> <li>- addictions (psychostimulants)</li> <li>- significant gaps in results</li> </ul>
Control group	<ul style="list-style-type: none"> <li>- willing to participate in the study</li> <li>- age between 19 and 55 years old</li> <li>- male or female</li> <li>- general good health</li> <li>- non-diagnostic result in the ASRS screening test for ADHD in adulthood</li> </ul>	

version consists of 6 questions. These questions address the manifestation of ADHD in adults. Respondents are required to use a 5-point Likert scale to indicate the frequency of occurrence of symptoms (0 = never; 1 = rarely; 2 = sometimes; 3 = often; 4 = very often). For all items, responses of “often” or “very often” are considered positive (indicated by shaded boxes on the questionnaire). Patients are considered to screen positive on the ASRS-v1.1 if they endorse 4 or more questions at these threshold levels<sup>21</sup>. This method was used to verify hypotheses 1 and 4.

- Diagnostic Interview for ADHD in adults (DIVA 2.0): it is composed by 18 questions, 9 for concentration and attention disorders with an adulthood and a childhood option, 9 for hyperactivity and impulsivity with an adulthood and a childhood option. Additionally, for each variable it is possible to determine whether the symptoms have a diagnostic value. A Polish version of the test was used for the study. The psychometric properties of the test were confirmed by the authors of the tool at the Diva Foundation. The Diva method was used to verify hypotheses 1, 2, 3 and 4.
- The Athens Insomnia Scale (AIS): it is an eight-item self-reported questionnaire that measures the intensity and effects of insomnia, based in the International Statistical Classification of Disease and Related Health Problems - 10<sup>th</sup> Revision (ICD-10) diagnostic criteria for insomnia<sup>5</sup>. The first 5 items

assess sleep induction, awakenings during the night, early morning awakening, total sleep time, and overall quality of sleep. The remaining 3 items pertain to the sense of well-being, overall functioning, and sleepiness during the day. In our study, respondents were required to rate positively if they experienced sleep difficulties at least thrice per week during the last month. A total score was obtained after summing all responses, and the total score ranged between 0 and 24, where the commonly accepted cut-off was 6. Additionally, a higher AIS score indicates a higher level of insomnia. Each item is rated on a 4-point numerical rating scale (where 0 = “no problem at all” and 3 = “very serious problem”). This questionnaire is a scale used in a large variety of clinical and research settings where the quantification of insomnia is required. The AIS has remarkable psychometric properties with a Cronbach’s alpha of 0.9<sup>49-52</sup>. This method was used to verify hypothesis 4.

- Stanford Sleepiness Scale (SSS): it is composed by 7 questions useful for assessing the current level of sleepiness. The Stanford Sleepiness Scale (SSS) assesses the level of sleepiness of a subject at any given moment. It consists of choosing an answer that most accurately reflects the subject’s current state. Selecting answers with 4 points or more suggests sleep problems<sup>53</sup>. This method was used to verify hypotheses 1 and 4.

**Table II.** Comparison of the incidence of TMD signs and symptoms in adults with and without ADHD.

<b>Variable</b>	<b>Adults with ADHD (Study Group) % (n=24)</b>	<b>Adults without ADHD (Control Group) % (n=216)</b>
<b>Acoustic symptoms</b>		
Does your jaw make a clicking or snapping noise when you chew, open, or close your mouth?		
No	54.2 (13)	77.8 (168)
Yes	45.8 (11)	22.2 (48)
Do you feel skipping in the temporomandibular joint (TMJ)		
No	58.3 (14)	71.3 (154)
Yes	41.7 (10)	28.7 (62)
<b>Occlusal parafunctions</b>		
Do you clench your teeth during the day or grind your teeth at night?		
No	45.8 (11)	69.4 (150)
Yes	54.2 (13)	30.6 (66)
<b>Non-occlusal parafunctions</b>		
Do you chew gum, bite your nails, pens, bite your lips, cheeks?		
No	37.5 (9)	37.0 (80)
Yes	62.5 (15)	63.0 (136)
<b>Ear symptoms of TMD</b>		
Do you have a hearing impairment and/or dizziness?		
No	58.3 (14)	69.0 (149)
Yes	41.7 (10)	31.0 (67)
Do you hear noise or ringing in your ears?		
No	62.5 (15)	75.5 (163)
Yes	37.5 (9)	24.5 (53)
<b>Headache</b>		
Have you had headaches or migraines in the last six months?		
No	33.3 (8)	35.2 (76)
Yes	66.7 (16)	64.8 (140)
<b>Pain symptoms caused by parafunctions among others</b>		
Do your jaws hurt or feel numb when you wake up in the morning?		
No	79.2 (19)	83.3 (180)
Yes	20.8 (5)	16.7 (36)

- Diagnostic Criteria for Temporomandibular Disorders (DC/TMD): they represent biaxial diagnostic criteria based on the biopsychosocial health model, axis I and II diagnostic protocols, which provide a comprehensive assessment of a TMD patient. Axis I assesses a diagnosis with respect to signs and symptoms of TMD. In Axis II, special attention is given to graded chronic pain, depression, anxiety, somatic symptoms, jaw functional limitations, and oral behaviors. It has two options: a set of shorter initial screening instruments and a set of instruments for expanded assessment. The standard DC/TMD symptom questionnaire includes questions that help to reveal the history, duration, and whether any

functional activity can modify the complaint by either aggravating or relieving it. The major symptoms which were enquired included TMJ pain, headache, jaw joint noise (acoustic symptoms), skipping in the temporomandibular joint (TMJ), hearing impairment, and/or dizziness (ear symptoms), and the occurrence of oral behavior (occlusal and non-occlusal parafunctions)<sup>27,31,35,42,45,54,55</sup>. The responses for all questions, except for the description of the pain, were recorded in a dichotomous manner. Taking into account the duration of complaints (pain and discomfort) in recent history, 30 days were used as a benchmark for questioning complaints and modifying factors<sup>27</sup>. All questions were adapted to the

Polish reality and translated into Polish. DC/TMD classification was used to verify hypotheses 1, 2, 3 and 4.

**Statistical Analysis**

Descriptive statistics and verification of the compliance of the distribution of variables with the normal distribution were obtained using the SPSS 26.0 Statistic program (IBM Corp., Armonk, NY, USA) for the scores of the Athens Insomnia Scale, Stanford Sleepiness Scale, DIVA Questionnaire and TMD Questionnaire. The results of the Shapiro-Wilk test, shown in Table I, indicate lack of compliance with the normal distribution of all variables. Variables such as the Athens Insomnia Scale, concentration and attention disorder in childhood, hyperactivity and impulsivity in adulthood, hyperactivity and impulsivity in childhood, pain intensity, effect of pain intensity on daily activities, number of days in the last 6 months when the patient could not work due to pain, and somatic symptoms of stress, were characterized by a right-skewed and leptokurtic distribution of the results obtained. Such distribution means that the respondents had low and little differentiated results in the scope of the above-mentioned variables. On the other hand, the variables examined by the Stratford Sleepiness Scale (concentration and attention disorders in adulthood, and possible problems related to the muscular and articular systems), were characterized by a right-

skewed and platykurtic distribution of the results obtained, which means that the respondents were characterized in the above-mentioned variables with mostly low and highly varied results.

Since all the variables obtained in the course of the study do not have features close to the normal distribution, non-parametric tests have been used to verify the research hypotheses: Mann-Whitney U and Spearman’s rho. The assumed significance level in our study is alpha=0.05, so significant results are  $p<0.05$ .

**Results**

The study included 240 individuals aged 19-42 (M=21.99; SD=2.36), of which 216 (90%) were women and 24 (10%) were men. The study group (ADHD patients) included 24 individuals (10%), and the control group comprised of 216 healthy individuals (90%).

Table II presents a comparison of the frequency of signs and symptoms of TMD in adults with and without ADHD. The difference in the frequency of TMD symptoms in adults with ADHD and without ADHD was not statistically significant.

Table III presents data showing how adults responded to research questionnaires assessing sleep disorders and DC/TMD symptoms.

The study and the control group differed significantly in terms of severity of sleepiness, con-

**Table III.** ADHD symptoms in adulthood and Insomnia, Sleepiness, DIVA test results, and presence of the TMD symptoms (DC/TMD) – Mann-Whitney U test.

Variable	ADHD in adulthood				Mann-Whitney U	p
	Control Group (no ADHD) (n=216)		Study Group (with ADHD) (n=24)			
	M	SD	M	SD		
Athens Insomnia Scale	6.22	3.72	7.58	4.14	-1.73	0.084
Stanford Sleepiness Scale	3.14	1.20	4.08	1.10	<b>-3.65**</b>	0.001
Concentration and attention disorders in adulthood	2.47	1.85	5.46	2.17	<b>-5.61**</b>	0.001
Concentration and attention disorders in childhood	1.57	1.78	3.42	2.52	<b>-3.52**</b>	0.001
Hyperactivity and impulsivity in adulthood	2.02	1.86	3.38	2.24	<b>-3.05**</b>	0.002
Hyperactivity and impulsivity in childhood	1.52	1.64	2.04	1.88	-1.54	0.124
Pain intensity of TMJ (VAS)	2.69	2.17	4.25	2.77	<b>-2.81**</b>	0.005
Effect of pain intensity on daily activities	2.60	2.20	3.67	2.84	-1.88	0.060
Number of days in the last 30 days when the patient could not work due to pain	7.37	14.90	8.79	18.68	-0.71	0.481
Possible problems related to the muscle tension and TMJ	1.82	1.42	2.79	1.69	<b>-2.72**</b>	0.006
Somatic symptoms of stress	7.42	4.95	9.87	6.10	<b>-1.99*</b>	0.047

\* $p<0.05$ , \*\* $p<0.01$ .

centration and attention disorders in adulthood, concentration and attention disorders in childhood, hyperactivity and impulsivity in adulthood, the intensity of pain, and possible problems related to the muscular tension and TMJ, as well as the somatic manifestation of stress. Adults with ADHD were characterized by a greater intensity of the above-mentioned symptoms compared to healthy individuals.

The results of the Mann-Whitney U test, presented in Table IV, show significant differences between people with diagnostic attention and concentration disorders in childhood and those who did not show this disorder in childhood, in terms of the number of days in the last 30 days in which the patient could not perform work because of pain. Individuals without diagnostic attention and concentration disorders in childhood were unable to work due to pain for a greater number of days in the last 30 days compared to people with diagnostic attention and concentration disorders in childhood.

Results of the Mann-Whitney U test presented in Table V show significant differences between people with diagnostic hyperactivity and impulsivity disorders in adulthood and people not exhibiting the features of this disorder, in terms of possible problems related to the muscular and articular system. The table shows that in adulthood, hyperactivity and impulsivity disorders are associated with a greater possibility of demonstrating problems related to the muscular and articular systems compared to people without diagnostic disorders.

The results of the Spearman's rho test, presented in Table VI, indicate significant weak positive relationships between the severity of sleep disorders measured by the Stanford Sleepiness Scale and by the Athens Insomnia Scale and concentration and attention disorders in adulthood and childhood, hyperactivity and impulsivity disorders in adulthood and TMD symptoms, as well as somatic stress symptoms. This means that the intensity of somatic symptoms, corresponding to the DC-TMD classification, rises with the increase in insomnia or, alternatively, sleepiness, concentration and attention disorders in adulthood and childhood, and disorders of hyperactivity and impulsivity in adulthood.

## Discussion

The syndrome of disorders defined as ADHD is a mental health disorder with a dominant compo-

nent of symptoms in the behavioral sphere<sup>19,42,56-59</sup>. The Adult Self-Report Scale (ASRS) is a reliable and valid instrument for assessing this syndrome. It is suitable to be used in clinical and research settings<sup>57</sup>. In those cases where ADHD symptoms observed in childhood persist, symptoms such as personality disorders, social relations disorders, and affective disorders and others are found more often in adults than motor hyperactivity symptoms. This study confirmed this relationship and extended it to include TMJ, TMD, muscle pain, and sleep disorders<sup>60-63</sup>.

Etiological factors associated with TMD are: psychological (stress, anxiety, tension), structural (occlusion), repetitive microtrauma from parafunctional habits (both occlusal and not occlusal related) and external traumas<sup>30,42,64</sup>. Individuals usually clench their teeth during the day and grind when they are sleeping, but this can occur at some stage in early awakening<sup>65</sup>. Over time, continuous pressure can damage the TMJ<sup>66,67</sup>. The results of this study indicated that the incidence of occlusal parafunctions in adults with ADHD was not significantly different but higher than in adults without symptoms of ADHD. The incidence of not occlusal parafunctions was similar in both groups. Pain and numbness in the face filled in adults after waking in both groups were similar. Assessment of the relationship between concentration disorders in childhood and the presence of symptoms of TMD (DC/TMD) is the verification of the H2 hypothesis (Table III). The obtained results confirm the conclusions drawn from other reports on the frequency of ADHD symptoms in adulthood. In this study, 11.11% (n=24) of adults experienced the full symptoms of ADHD. Adults demonstrated a statistically significantly higher intensity of sleepiness. At the same time, no differences were found between people with ADHD and those without symptoms, in terms of the severity of insomnia and its negative effects (Table IV). In conclusion, we can say that the assessment of ADHD symptoms is a serious research problem, because this disease entity is not accompanied by any specific symptom that would characterize only this disorder<sup>68-71</sup>.

At the same time, the clinical picture of ADHD changes with age<sup>22</sup>. In this study, it was found that people with stronger attention disorder symptoms in childhood still show them in a significantly greater degree in adulthood. However, the stronger symptoms of hyperactivity and impulsivity in adulthood had nothing to do with their severity in childhood. The study of the relationship between diagnostic hy-



**Table IV.** Diagnostic hyperactivity and impulsivity disorders in adulthood and presence of TMD (DC/TMD) symptoms – Mann-Whitney U test.

	Concentration disorders in childhood for all individuals (N=240)				Mann-Whitney U	p
	No (n=148) M	Yes (n=92) SD	M	SD		
Pain intensity of TMJ (VAS)	2.97	2.27	2.64	2.29	-1.35	0.176
Effect of pain intensity on daily activities	2.80	2.37	2.54	2.14	-0.91	0.361
Number of days in the last 30 days when the patient could not work due to pain	7.78	14.06	7.08	17.12	<b>-2.16*</b>	0.031
Possible problems related to the muscle tension and TMJ	1.95	1.48	1.87	1.48	-0.41	0.682
Somatic symptoms of stress	7.88	4.51	7.33	5.98	-1.80	0.071

\* $p < 0.05$ , \*\* $p < 0.01$ .

**Table V.** Concentration disorders in childhood and presence of TMD (DC/TMD) symptoms – Mann-Whitney U test.

	Diagnostic hyperactivity and impulsivity disorders in adulthood in all individuals (N=240)				Mann-Whitney U	p
	No (n=168) M	Yes (n=72) SD	M	SD		
Pain intensity of TMJ (VAS)	2.90	2.38	2.71	2.04	-0.11	0.909
Effect of pain intensity on daily activities	2.75	2.35	2.60	2.13	-0.08	0.936
Number of days in the last 30 days when the patient could not work due to pain	2.03	1.42	1.67	1.57	<b>-2.05*</b>	0.041
Possible problems related to the muscle tension and TMJ	7.89	4.92	7.15	5.56	-1.31	0.189
Somatic symptoms of stress	7.89	4.92	7.15	5.56	-1.31	0.189

\* $p < 0.05$ , \*\* $p < 0.01$ .

peractivity and impulsivity disorders in adulthood and the occurrence of TMD symptoms (DC/TMD) verifies the H3 hypothesis. It has been shown that adults with ADHD symptoms experience significantly greater pain as well as greater severity of problems related to the muscular and articular systems and somatic stress symptoms (Table IV).

When discussing the symptoms accompanying ADHD in adulthood, attention is drawn to the fact that symptoms may focus on the difficulty in completing tasks, poor time management, poor concentration, and others accompanying attention disorders<sup>17,19</sup>. In this context, the confirmed greater intensity of sleepiness in adults is a result that requires further detailed analysis<sup>72</sup>. A statistically significant relationship was revealed between people with attention deficit disorder symptoms in childhood and those who did not have such symptoms. It was found that subjects without diagnostic concentration and attention disorders in childhood, in the last 6 months, were unable to work due to pain for a greater number of days.

The H4 hypothesis was analyzed by assessing the relationship between the severity of sleep disorders, ADHD symptoms and the occurrence of TMD symptoms (DC/TMD) (Table V).

The above observation is part of a series of reflections on the problems of social functioning of adults with ADHD. While a diagnosis in children is easier, because the child's daily functioning is basically constantly monitored by an adult, it is more difficult to diagnose ADHD in an adult, especially if it was not diagnosed in childhood. The results obtained in this study suggest that despite the lack of diagnosis of ADHD in childhood, there is an increased risk of developing social functioning disorders in adulthood. It has been shown that severe somatic pain can contribute to relegation from school, university, or work for this reason. Studies on the relationship between ADHD and social functioning in relation to people diagnosed with this disorder in childhood showed the presence of an increased risk of developing sociopathy, alcoholism, or other addictions in adulthood<sup>73-75</sup>.

**Table VI.** Insomnia and Sleepiness Scale, results of the DIVA test and presence of TMD (DC/TMD) symptoms – Spearman’s rho correlation coefficients..

	Pain intensity of TMJ (VAS)	Effect of pain intensity on daily activities	Number of days in the last 30 days when the patient could not work due to pain	Possible problems related to the muscle tension and TMJ	Somatic symptoms of stress
Athens Insomnia Scale	0.217**	0.211**	0.271**	0.269**	0.491**
Stanford Sleepiness Scale	0.166**	0.126**	0.250**	0.120*	0.431**
Concentration and attention disorders in adulthood	0.263**	0.242**	0.218**	0.299**	0.300**
Concentration and attention disorders in childhood	0.173**	0.154**	0.127**	0.149**	0.189*
Hyperactivity and impulsivity in adulthood	0.119*	0.112*	0.225*	0.219*	0.179**
Hyperactivity and impulsivity in childhood	0.044	0.065	0.029	0.076	0.061

\* $p < 0.05$ , \*\* $p < 0.01$ .

So far, researchers have focused on problems manifested in the form of difficulties in relationships at work and within the family, a tendency to risky driving, higher rates of criminal behavior and the risk of substance abuses<sup>75</sup>.

The study showed a relationship between increased intensity of hyperactivity and impulsivity in adulthood and possibility of problems related to the TMJ system in comparison to people without diagnostic disorders of ADHD (Table VI).

In addition, a comprehensive relationship has been demonstrated between the three categories of symptoms analyzed in this study. The obtained results indicate that with the increase in insomnia or, alternatively, sleepiness, concentration and attention disorders in adulthood and childhood, and hyperactivity and impulsivity disorders in adulthood, the intensity of somatic symptoms corresponding to the DC/TMD classification increases (Table VI). Similar relationships have been confirmed in other studies<sup>60</sup>. A moderately strong correlation was established between ADHD symptomatology, sleep disorders and symptoms from temporomandibular disorders. Therefore, the comorbidity of ADHD with sleep disorders, which is part of the clinical picture of anxiety and depressive disorders, was confirmed. The relationship and nature of the above dependence require further detailed study<sup>52,76-78</sup>.

Children, adolescents, and students up to 18 years of age can usually count on their parents’

support, as well as pedagogical and psychological help. Young adults, including students, are often left on their own, without parental support, thus they are turned towards the risk of a crisis and a breakdown in their lifelines. No diagnosis or failure to take any therapy may have serious consequences and generate high emotional, material and social costs. It can also pose a threat to the health and life of the sick person. ADHD is one of the most common psychiatric disorders<sup>79</sup>.

The presence of pain and disturbances from the temporomandibular system demonstrated in this study confirm the widely studied relationship between ADHD and other somatic diseases. People with ADHD symptoms are more likely to suffer from diseases caused by an unhealthy lifestyle. They have been shown to be associated with hypertension, coronary artery disease, metabolic syndrome, and eating disorders<sup>68</sup>. Lack of care for health by people with ADHD symptoms causes a general deterioration of their health.

### Limitations

The main limitation resulted from the difficulty of making a diagnostically precise selection of the study group. This should be multistage, ranging from a retrospective childhood ADHD diagnosis, passing through the ongoing confirmation of symptoms through observation or self-report, and psychological diagnosis. This was not possible during the pandemic time. The research is continued. The

relatively small sample size of the ADHD group and different number of participants in group divided by sex were the limitations of the study.

The subject of interdisciplinary clinical diagnosis should also be the exclusion of existence, just like in children's somatic diseases or post-traumatic stress disorder (PTSD). The difficulties in everyday functioning mentioned in the diagnostic criteria, concern the majority of adults, while in the case of people with ADHD, the differentiating criterion is their intensity and persistence of symptoms<sup>80,81</sup>.

### **Research Implications**

The medical community should pay attention to the connection between TMD disorders and attention disorder symptoms, as well as their prevention and treatment.

The presence of attention deficit hyperactivity disorder symptoms in adulthood suggests that ADHD is a lifelong disorder in many patients. ADHD symptoms seen in children usually change in adulthood, and their consequences in adults are no less serious. Correct and comprehensive symptom assessment as part of a clinical examination is essential to the treatment process. The chronic nature and persistence of ADHD symptoms, as well as the disorders they cause, are essential in a proper diagnosis of this disorder in adults. Axial symptoms of attention disorders may persist into adulthood and often dominate the ADHD picture in adults. An accurate diagnosis is made difficult by the patient's strategies for coping with symptoms and styles of coping with stress. It can be helpful to use several recently developed screening and diagnostic tools to assess ADHD in adults in the process of a proper diagnosis. Due to the high prevalence of ADHD in relation to other mental disorders, clinicians should be familiar with the symptoms and the clinical picture of ADHD in adults and screen all adult patients for this condition. Scales that can quantify symptoms and emotional responses can be helpful in completing a clinical interview leading to a comprehensive patient assessment.

### **Conclusions**

There is a positive association between ADHD and the occurrence of TMD symptoms in adults.

Adults with ADHD are characterized by a greater intensity of sleepiness, concentration and attention disorders, and possible problems related

to temporomandibular disorders, as well as the somatic manifestation of stress in comparison to adults without ADHD.

In adults, hyperactivity and impulsivity disorders are associated with a greater possibility of demonstrating problems related to the muscle tension and TMJ, compared to people without diagnostic disorders.

The severity of somatic symptoms corresponding to the DC/TMD classification rise together with:

- a. an increase in insomnia or somnolence;
- b. an increase in concentration and attention disorders showing in adulthood and childhood;
- c. an increase in hyperactivity and impulsivity disorders present in adulthood.

### **Conflicts of Interest**

The authors declare that they have no conflicts of interests.

### **Ethical Approval**

An approval from the Ethics Committee of Poznan University of Medical Sciences (154/20) and written informed consents from the qualified patients were obtained.

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