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Subtypes of ADHD and their association with sleep disturbances in children

Attention deficit hyperactivity disorder (ADHD) is one of the most frequently diagnosed disorders in childhood and adolescence [6, 30] with a complex and long, but not adequately explained cause. Recently Cortese [10] reported that one of multiple causations might be developmentally abnormal brain networks in combination with an interaction of environmental influences. The typical pattern of ADHD is composed of several different heterogeneously appearing symptoms which interact complexly and show great variability across age [24, 33]. The core symptoms of ADHD are inattention, impulsiveness, and hyperactivity. Those core symptoms have to occur cross-situationally and to an atypically high extent compared to the child's level of development [1, 2].

Two-thirds of all children suffering from ADHD also have comorbid disorders [14, 19]. There is an already high comorbid impact in preschool age, which is enhanced with increasing age [6]. Both further development and severity of ADHD are negatively affected by comorbid disorders. Although it is generally believed that ADHD precedes other potentially comorbid disorders [8], it is well possible that there is a complicating interaction between ADHD and other disorders, which could hinder effective treatment and diagnosis [14]. Furthermore, ADHD persists into adulthood more often if the patient suffers from comorbid disorders, which leads to a poorer long-term prognosis for those patients [5].

Sleep disorders are a rather controversially discussed comorbid disorder of ADHD [11, 28]. Parents particularly report nightly agitation, frequent nocturnal awakenings and bedtime resistance as well as problems with sleep onset [9, 31]. Objectively, greater tiredness as well as problems with sleep onset could be verified in children with ADHD [11]. Chervin et al. [7] found an association between habitual snoring and symptoms of inattention and hyperactivity among a sample of 866 children between 2 and 13 years: Children who showed an elevated hyperactivity index had a 2.2-fold higher risk for habitual snoring (operationalized as snoring in more than half of the total sleeping time). Moreover, the authors identified a significant relation between hyperactivity, inattention, and daytime sleepiness. Gruber et al. [15] analyzed the stability of sleeping behavior in 38 boys diagnosed with ADHD and aged 6–14 years in comparison to an age-matched control sample of 64 boys. They concluded that the difference between children with and without ADHD could be observed in the instability of sleeping behavior. For the five analyzed nights, they found a significant instability for sleep onset, sleep duration, and efficacy of sleep for the boys with ADHD, but not for the control sample [15]. Likewise, Owens et al. [26] found significantly higher ratings on all scales of the Children's Sleep Habits Questionnaire (CSHQ) for children with ADHD in contrast to healthy controls. In their literature review, Jan et al. [18] reported the present evidence concerning ADHD and sleep disorders. They concluded that symptoms of ADHD are frequently related to various sleep disorders, but results are very inconsistent across various measures of sleep. Most studies based on parents' reports consistently found associations between ADHD symptomatology and sleep disorders as night waking, difficulty initiating sleep, bedtime resistance, and daytime sleepiness. In contrast, studies using actigraphy or polysomnography showed inconsistent findings. However, it was evident for Jan et al. [18] that subjective reports tended to overestimate sleep problems in contrast to actigraphy. It is unclear if actigraphy simply cannot detect those sleep problems mostly reported by parents.

As far as specific differences of sleep disorders between the different subtypes of ADHD are concerned, only few findings are available. Willoughby et al. [37] examined subtype-specific sleep disorders in 2- to 5-year-old children. Out of 1,073 patients of a large pediatric clinic, the authors selected the 193 children who scored the highest in the parent-rated child behavior checklist (CBCL) 1½–5 as well as the 114 children who had the lowest scores. The parents of those children were interviewed with the Preschool Age Psychiatric Assessment. Apart from a positive association between inattention and daytime sleepiness, no significant association between ADHD and sleep problems could be found [37]. This association between daytime sleepiness and inattention was also found by Lecendreux et al. [22], who examined 30 boys aged 5–10 years diagnosed with ADHD using polysomnography (PSG) and the Multiple Sleep Latency Test (MSLT). The measurements of the PSG did not show significant differences between the boys with ADHD and 22 matched controls, but the authors were able to identify a pattern of higher daytime sleepiness in children with predominantly inattentive ADHD and higher bedtime resistance in children with predominant-

*Both authors contributed equally to this work.

Tab. 1 The five additional items (*ai*) of the Children's Sleep Habits Questionnaire–German Version that were analyzed in this study

Item	Wording
ai1	The child needs a special object to fall asleep
ai2	At bedtime the child is ready to go to bed
ai3	At bedtime the child resists to go to bed
ai4	The child complains about sleeping problems
ai5	The child wakes up very early in the morning

Tab. 2 The subject characteristics gender, age and IQ in total and for all four diagnostic groups

Group	Sum	Gender		Age	IQ
	n (%)	Male	Female	M (SD)	M (SD)
Mixed	15 (25.00)	13	2	8.67 (2.18)	106.46 (11.96)
Inattentive	13 (21.66)	11	2	8.85 (1.86)	105.20 (14.94)
Hyperactive–impulsive	13 (21.66)	10	3	9.08 (2.02)	103.08 (12.24)
Subthreshold	19 (31.66)	19	0	8.68 (1.53)	109.33 (12.22)
Total	60 (100)	53	7	8.80 (1.83)	106.43 (12.57)

M mean, SD standard deviation.

ly hyperactive–impulsive ADHD [22]. LeBourgeois et al. [21] found the same association between predominantly inattentive ADHD and daytime sleepiness by examining 45 children aged 6–16 years suffering from ADHD as well as 29 matched controls using parent-rated questionnaires. In addition, they found a higher risk of snoring in children with predominantly hyperactive–impulsive ADHD [21].

The present study examined the prevalence of different sleep disorders in a sample of children aged 6–13 years who took part at the German University of Tübingen's program for children with attention deficits. The study's primary goal was the identification of different sleep disorders in relation to the three subtypes of ADHD. For this purpose all participating children were diagnosed according to the DSM-IV-TR.

Methods

Diagnostic measures

The diagnostic evaluation consisted of a face-to-face interview with the parents as well as the child. All children completed the Hamburg–Wechsler Intelligence Test for Children IV (HAWIK IV) [29].

To assess potential ADHD according to the DSM-IV-TR, we used the German "Fremdbeurteilungsbogen für hyperkinetische Störungen" (FBB-HKS) in the newly standardized version from 2008 [12]. It is a subjective external assessment which includes the criteria of all three subtypes of ADHD. The FBB-HKS can be used by parents as well as teachers and includes 20 items with four-stage Likert scales (0: does not apply, 1: applies a little or sometimes, 2: applies to a large extent, 3: applies especially). All items refer to one of the three core symptoms of ADHD.

The Children's Sleep Habits Questionnaire–German Version (CSHQ-DE) [32] is the validated German version of the English CSHQ [27]. At the moment, the CSHQ-DE is the only internationally comparable German questionnaire that assesses sleep disorders in children. It is a subjective parent-rated questionnaire with 48 items, which inquires sleep disorders in children at the age of 5–10 years. Its eight scales—(1) bedtime resistance, (2) sleep onset delay, (3) sleep duration, (4) sleep anxiety, (5) night waking, (6) parasomnias, (7) sleep-disordered breathing, and (8) daytime sleepiness—are composed of 33 items; further 15 items are screening items. The eight scales constitute the Sleep Disturbance Score, the questionnaire's total score. In the present study, all eight scales and the Sleep Disturbance Score were analyzed. Furthermore, five of the additional screening items were included in the analysis (**Tab. 1**). Currently, there is no German cut off for the Sleep Disturbance Score available. Schlarb et al. [32] suggested using the English cut off (combined score of 41, M=1.24) in the meantime. However, there are German cut offs for the following scales of the CSHQ-DE: (1) bedtime resistance (score =10; M=1.66), (3) sleep duration (score =5; M=1.66), (4) sleep anxiety (score =7; M=1.75), (5) night waking (score =5; M=1.66), and (8) daytime sleepiness (score =14; M=1.75).

Subjects

The sample consisted of 60 children between 6 and 13 years of age (mean age 8.80 years); 53 were male and 7 female. Only children with a symptomatology of ADHD and an IQ above 80 (M=106.43) were included in this study.

Diagnostic groups and subject characteristics

A total of 41 of the 60 tested children met the full criteria for ADHD. Of those, 15 children were diagnosed with combined ADHD, 13 with predominantly inattentive ADHD, and 13 with predominantly hyperactive–impulsive ADHD. The remaining 19 children did not fulfill all ADHD criteria, but scored just below threshold in at least one core ADHD symptom. Thus, they were considered having subthreshold ADHD. A total of 11 children received medication of stimulants, who were separated in the subgroups of ADHD as follows: ADHD-SUB (subthreshold ADHD, 5 children, 26.3% of this subgroup), ADHD-ATT (predominantly inattentive ADHD, 2 children, 15.4% of this subgroup), ADHD-MI (predominantly mixed subtype of ADHD, 1 child, 6.7% of this subgroup), ADHD-HI (hyperactive–impulsive ADHD, 3 children, 23.1% of this subgroup).

The subjects' gender, IQ, and ages are shown in **Tab. 2**. There were no significant differences in mean age, gender distribution, or IQ between the four groups.

Statistical analyses

The Statistical Package for Social Science (SPSS, Version 17.0) was used for all analyses. We tested for Gaussian distribution of all relevant variables using the Kolmogoroff–Smirnov test. Except for the scales 1–7 of the CSHQ-DE [27], the assumption of Gaussian distribution could be verified. In the analysis of the affected variables, tests without assumption of Gaussian distribution were utilized (e.g., Mann–Whitney U test, Kruskal–Wallis test). The level of significance was $\alpha \leq 0.05$.

Results

Incidence of sleeping disorders in the entire group

The incidence, means, and standard deviations of the CSHQ-DE total score as well as its subscales is shown in **Tab. 3**. Regarding the different sleep disorders' frequency, we classified mean values below 1.50 as "rarely occurring," mean values from 1.50–2.19 as "sometimes occurring," and mean values above 2.20 as "frequently occurring."

Comparing the group's mean Sleep Disturbance Score (M=1.28) with the cut off (raw score=41; M=1.24), we found a clinically significant elevated occurrence of sleep disorders in our subjects.

Elevated values for sleep disorders in children diagnosed with ADHD

To examine whether children with ADHD have a higher risk for sleep disorders than those without ADHD, we ran an unpaired t test comparing the CSHQ-DE Sleep Disturbance Score of children with subthreshold ADHD (n=19) and children with diagnosed ADHD (n=41). There was no statistically significant difference between children with subthreshold ADHD (M=1.25; SD=0.19) and children diagnosed with ADHD (M=1.29; SD=0.19; t(58)=−0.700; p=0.487), but children with ADHD showed a slightly higher value. Remarkably enough, both subgroups had scores above the clinically relevant cut off (M=1.24), so even children with subthreshold ADHD show a clinically significant elevated score for sleep disorders in the CSHQ-DE.

To test potential differences between the three ADHD subtypes and children with subthreshold ADHD, one-way ANOVA was performed; the dependent variable being the CSHQ-DE Sleep Disturbance Score. We found no significant difference between the four subgroups ($F(3)=2.208$; p=0.097). The means of the subgroups' Sleep Disturbance Score are displayed in **Fig. 1**. Clearly, children with predominantly hyperactive–impulsive ADHD have the highest mean value, while all other subgroups show almost identical values just above or at the cut off for clinical relevance.

Abstract · Zusammenfassung

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Subtypes of ADHD and their association with sleep disturbances in children

Abstract

Objective. So far, little is known about potential links between subtypes of attention deficit hyperactivity disorder (ADHD) and sleep disturbances in childhood. Therefore, this study examined the association between sleep disorders and all three subtypes of ADHD.

Methods. A total of 60 children showing attention deficit symptoms (aged 6–13 years; 88.3% boys) were diagnosed with regard to ADHD according to the DSM-IV-TR. The subtypes of ADHD diagnosed were then related to potential sleep disturbances as measured using a standardized parent-rated questionnaire (Children's Sleep Habits Questionnaire, CSHQ-DE).

Results. Clinically significant elevated scores in the CSHQ-DE's Sleep Disturbance Scale were exhibited in all 60 children. Parents of the children with primarily hyperactive–impulsive subtype reported the highest scores. Children with this subtype displayed the highest rate of specific sleep disorders, e.g., increased daytime sleepiness and higher bedtime resistance.

Conclusion. The assumption that children with ADHD show elevated scores of sleep disturbances was verified. In addition, it was possible to identify a unique pattern of sleep disturbances corresponding to the respective ADHD subtypes.

Keywords
Attention deficit hyperactivity disorder · Sleep disturbances · Hyperactivity · Impulsivity · Inattention

ADHS-Subtypen und ihr Zusammenhang mit Schlafstörungen bei Kindern

Zusammenfassung

Ziel. Bisher gibt es wenig gesichertes Wissen über den Zusammenhang der Subtypen der Aufmerksamkeitsdefizit-Hyperaktivitäts-Störung (ADHS) und Schlafstörungen in der Kindheit. Daher wird in dieser Studie der Zusammenhang von Schlafstörungen und allen 3 Subtypen der ADHS untersucht.

Methode. Bei insgesamt 60 Kindern (6–13 Jahre; 88,3% Jungen) wurde entsprechend DSM-IV-TR die Diagnose einer ADHS gestellt. Die diagnostizierten Subtypen der ADHS wurden in Verbindung gesetzt mit potenziellen Schlafstörungen im Kindesalter – gemessen mit einem standardisierten Elternfragebogen (Children's Sleep Habits Questionnaire, CSHQ-DE).

Ergebnisse. In der Gesamtstichprobe aller Kinder zeigten sich klinisch signifikant erhöhte Werte in der Gesamtskala des CSHQ-DE. Eltern von Kindern mit ADHS vom hyperaktiv-impulsiven Subtyp berichteten über die höchsten Werte. Diese Kinder zeigten auch die höchste Rate an spezifischen Schlafstörungen, wie z. B. erhöhte Tagesschläfrigkeit sowie stärkere Widerstände, zu Bett zu gehen.

Schlussfolgerung. Die Annahme, dass Kinder mit ADHS verstärkt Schlafstörungen aufweisen, wurde bestätigt. Darüber hinaus war es möglich, ein spezifisches Muster an Schlafschwierigkeiten entsprechend dem jeweiligen ADHS-Subtyp zu identifizieren.

Schlüsselwörter
Aufmerksamkeitsdefizit-Hyperaktivitäts-Störung · Schlafstörungen · Hyperaktivität · Impulsivität · Unaufmerksamkeit

Identification of a unique pattern of sleep disturbances for each subtype of ADHD

Subscales of the CSHQ-DE

The results of the statistical analyses for the subgroups ADHD-HI (predominantly hyperactive–impulsive ADHD), ADHD-ATT (predominantly inattentive ADHD) and ADHD-MI (mixed subtype of ADHD) is provided in **Tab. 4**. Children with subclinical ADHD were not included, since they did not meet the full criteria for ADHD. As explained above, we performed for subscale eight a one-way ANOVA, for all other subscales the Kruskal–Wallis test was used.

A significant difference for the scale (1) bedtime resistance (p=0.044) was found. Using the Mann–Whitney U test, we

Tab. 3 Mean values (*M*), standard deviations (*SD*) and frequency for the CSHQ-DE's scales in percent, as well as the already found German cut-off scores for the corresponding scales. For the overall Sleep Disturbance Score, the English cut-off is used

Scale	Cut-Off	M	SD	Rarely (%)	Sometimes (%)	Frequently (%)
(1) Bedtime resistance	1.66	1.12	0.29	86.6	11.7	1.7
(2) Sleep onset delay		1.53	0.77	63.3	20.0	16.7
(3) Sleep duration	1.66	1.33	0.51	75.0	16.7	8.3
(4) Sleep anxiety	1.75	1.17	0.33	81.6	15.0	3.4
(5) Night waking	1.66	1.19	0.31	93.3	6.7	0.0
(6) Parasomnias		1.17	0.19	93.4	6.7	0.0
(7) Sleep-disordered breathing		1.07	0.16	96.7	3.3	0.0
(8) Daytime sleepiness	1.75	1.58	0.37	38.4	53.3	8.3
(9) Overall sleep disturbance	1.24	1.28	0.19	88.3	11.7	0.0

Rarely score does not exceed 1.49, **sometimes** score between 1.50 and 2.19, **frequently** score higher than 2.20.

Tab. 4 Mean ranges (*MR*), mean values (*M*), standard deviations (*SD*), and relevant statistical parameters of the CSHQ-DE analysis

Scale	ADHD-ATT	ADHD-HI	ADHD-MI		
Kruskal–Wallis test	MR	MR	MR	χ^2	p
(1) Bedtime resistance	17.31	25.92	19.93	6.255	0.044*
(2) Sleep onset delay	18.69	22.73	21.50	1.066	0.587
(3) Sleep duration	22.35	24.31	16.97	3.347	0.188
(4) Sleep anxiety	19.08	25.46	18.80	3.899	0.142
(5) Night waking	19.31	21.54	22.00	0.489	0.783
(6) Parasomnias	16.04	24.04	22.67	3.769	0.152
(7) Sleep-disordered breathing	16.50	22.65	23.47	5.254	0.072^T
One-way ANOVA	M (SD)	M (SD)	M (SD)	F	p
(8) Daytime sleepiness	1.64 (0.37)	1.71 (0.32)	1.41 (0.36)	2.880	0.068**

*p<0.05; **p<0.10; df =2**ADHD-ATT** predominantly inattentive ADHD, **ADHD-HI** predominantly hyperactive–impulsive ADHD, **ADHD-MI** mixed subtype of ADHD.

Tab. 5 Mean ranges (*MR*) and relevant statistical parameters of the CSHQ-DE additional item (*ai*) analysis

Item	ADHD-ATT	ADHD-HI	ADHD-MI		
Kruskal–Wallis test	**MR**	**MR**	**MR**	χ^2	**p**
(ai1) Needs object to fall asleep	21.75	22.15	18.07	1.533	0.465
(ai2) Ready for bed at bedtime	20.21	26.96	15.13	10.446	0.005*
(ai3) Resistance to go to bed	18.17	22.73	20.43	1.566	0.457
(ai4) Complains about sleep problems	18.00	22.62	20.67	2.977	0.226
(ai5) Early waking	15.50	21.81	23.37	5.678	0.058**

*p<0.05; **p<0.10, df = 2**ADHD-ATT** predominantly inattentive ADHD, **ADHD-HI** predominantly hyperactive–impulsive ADHD, **ADHD-MI** mixed subtype of ADHD.

could identify a significant difference between the groups ADHD-ATT and ADHD-HI (U=49.00, z=−2.331; p=0.020). The parents of children with predominantly hyperactive–impulsive ADHD reported more bedtime resistance problems than those of children with predominantly inattentive ADHD. There were no statistically significant differences for the subscales (2) sleep onset delay, (3) sleep duration, (5) night waking, and (6) parasomnias.

Moreover, a tendency for a significant difference for the *subscale (7) sleep-disordered breathing was* observed. The subsequent Mann–Whitney U tests indicated a significant difference between the groups ADHD-HI and ADHD-ATT (U=58.50, z=−2.132; p=0.033) as well as a significant difference between ADHD-MI and ADHD-ATT (U=65.00, z=−2.248; p=0.025). Both children with predominantly hyperactive–impulsive and mixed subtypes showed more sleep-disordered breathing symptoms than those with an inattentive subtype of ADHD.

The one-way ANOVA performed for the subscale (8) daytime sleepiness revealed a tendency for a statistically significant difference between the groups as well. Post hoc Bonferroni analyses showed a tendency for significant differences between the groups ADHD-HI and ADHD-MI (p=0.084).

Thus, the CSHQ-DE subscale analysis suggests the following pattern of differences between the subtypes of ADHD: for children with predominantly hyperactive–impulsive and those with mixed ADHD there was a tendency for a significant difference in scale (8) daytime sleepiness, with children with predominantly hyperactive–impulsive ADHD scoring higher. In children suffering from predominantly hyperactive–impulsive ADHD and predominantly inattentive ADHD, significant differences between the groups in the scales (1) bedtime resistance and (7) sleep-disordered breathing were found. For those two subscales, children with predominantly hyperactive–impulsive ADHD scored higher than children with predominantly inattentive ADHD. Furthermore, children with mixed ADHD and those with predominantly inattentive ADHD showed a significant difference in scale (7) sleep-disordered breathing. Here, children with predominantly inattentive ADHD had lower scores than children with mixed ADHD.

Additional items (ai) of the CSHQ-DE

For the additional items ai1 "The child needs a special object to fall asleep", ai3 "At bedtime the child resists to go to bed," and ai4 "The child complains about sleep problems," no statistically significant differences were found. However, a significant difference between the groups (p=0.005) for the additional item ai2 "At bedtime the child is ready to go to bed" was found. The subsequent Mann–Whitney U test revealed that the subgroups ADHD-HI and ADHD-MI differed significantly (U=41.50, z=−3.129; p=0.002). Children with predominantly hyperactive–impulsive ADHD were less likely to be ready for bed at bedtime than those with mixed ADHD. Furthermore, there was a strong tendency for a significant difference (p=0.058) for the additional item ai5 "The child wakes up very ear-

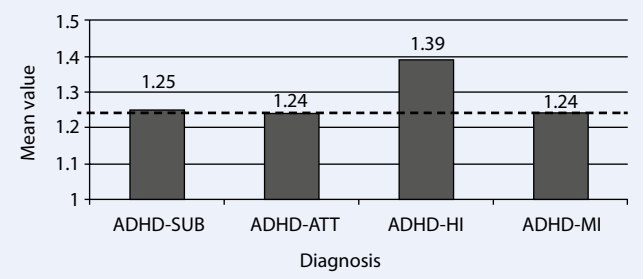

Fig. 1 ▲ Means of the CSHQ-DE sleep disturbance score for the subgroups subthreshold ADHD (*ADHD-SUB*), predominantly inattentive ADHD (*ADHD-ATT*), predominantly hyperactive-impulsive ADHD (*ADHD-HI*) and mixed subtype of ADHD (*ADHD-MI*). The *dotted line* marks the cut off for clinical relevance

ly in the morning." Mann–Whitney U tests revealed statistically significant differences for the mean values of the groups ADHD-ATT and ADHD-HI (U=54.00, z=−2.046; p=0.041) and for those of the subgroups ADHD-ATT and ADHD-MI (U=65.00, z=−2.421; p=0.015). Thus, children with predominantly hyperactive–impulsive ADHD und and mixed ADHD showed a pattern of early waking in the morning that children with predominantly inattentive ADHD did not present. The findings of all analyses are presented in ◘ **Tab. 5**.

Discussion

First of all, children with predominantly hyperactive–impulsive ADHD scored the highest on the CSHQ-DE Sleep Disturbance Score compared to the other subgroups. Thus, children with predominantly hyperactive–impulsive ADHD have an increased risk of comorbid sleeping disorders. Children with mixed ADHD, with predominantly inattentive ADHD and even those with subclinical ADHD showed Sleep Disturbance Scores above the cut off for clinically significant sleep disorders as well, but not to the same extent as children with predominantly hyperactive–impulsive ADHD. According to the CSHQ's cut off, children with ADHD show clinically significant scores for sleep disorders, thus, suffer from more sleep-related problems than the normative comparative sample. Our results are in line with those reported by Owens et al. [26], who found significantly higher rates on all scales of the CSHQ for children with ADHD in contrast to healthy controls. Restrictively, it should be mentioned that those results are based upon the validated English cut off of this questionnaire, but it can still be assumed that the difference between the Anglo-American and a hypothesized German cut off is small.

Second, we assumed that children with different subtypes of ADHD also show a different pattern of sleep disorders; this could be largely verified: children with predominantly hyperactive–impulsive ADHD displayed the highest rates of specific sleeping disorders in contrast to the other subtypes. Those were—among others—increased daytime sleepiness, higher bedtime resistance, and a higher rate of complaints about sleep problems by the children themselves. Some of these results—especially the higher bedtime resistance—are in line with the results reported by Lecendreux et al. [22]. Furthermore, children with mixed ADHD as well as children with predominantly hyperactive–impulsive ADHD showed significantly more sleep-related breathing disorders than children with predominantly inattentive ADHD. This is partly in line with the results of LeBourgeois et al. [21], who reported higher rates of snoring for children with predominantly hyperactive–impulsive ADHD. In addition, both children with predominantly hyperactive–impulsive and mixed ADHD exhibited a pattern of early waking in the morning in contrast to children with predominantly inattentive ADHD.

Summarizing, this study could verify specific patterns of sleep disorders in children with ADHD using a validated questionnaire. These patterns are illustrated in ◘ **Fig. 2**.

However, it should be taken into account that data collection was based on parent-rated questionnaires. Although Wiegand [36] stresses the fact that parents frequently give more accurate information than the children themselves (in particular concerning sleep-related breathing disorders, agitation at night, and parasomnias), with the children's increasing age, parents tend to observe their child's sleeping problems less. Overall, there are few studies on the validity of parental reports about their children's sleep. Owens et al. [26] examined the parental rating of the CSHQ's English version in comparison to their children's rating in the Sleep Self Report. In the subgroup of children suffering from ADHD, they found the parental ratings to correlate with the children's with r ranging from 0.35 to 1.00 for all items of the CSHQ [26]. The authors suggest that parents of children diagnosed with ADHD are possibly sensitized to both their children's daily and nightly behavior [26]. Schwerdtle et al. [34] found a correlation of r=0.44 (p<0.01) between the Sleep Self Report completed by preschool and elementary school children and the CSHQ-DE completed by their parents.

Restrictively, it should be noted that the connection between sleep disorders and psychiatric illnesses is complex and bidirectional: sleep disorders are associated with a broad range of emotional and behavioral disorders [17]. According to Stein et al. [35], it can be commonly expected for children with sleep disorders to show further psychic, social, or medical risks. There are many results reporting associations between sleep disorders and attention deficits, hyperactivity, and impulsiveness and a causal relationship could seldom be drawn [3, 16, 20, 23]. It was not the aim of the current study to show causal relationships between sleep disorders and attention deficits, but to distinguish different patterns of sleep problems between the three subtypes of ADHD; however, unraveling the association of sleep disorders and ADHD should certainly be one aim of further research.

Limitations

There are limitations to our results with respect to the study's selectively chosen sample: no healthy control group was included in the study. Thus, our findings can only be interpreted with regard to the three postulated subtypes of ADHD. Even though the comparison of those subtypes to children with subclinical ADHD allowed for an estimation of the severi-

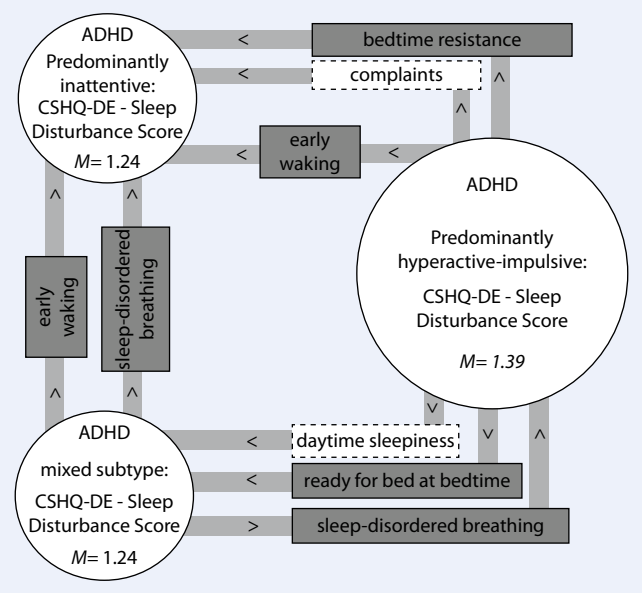

Fig. 2 ◀ The core results. Scales and items with significant differences are highlighted with *grey* background, while tendencies are marked with *dotted lines* and *white* background. The symbols < and > show the direction of association for each item in relation to the subtypes of ADHD

ty of sleeping disorders for children with a diagnosis of ADHD, following studies should ensure the implementation of a control group.

Conclusion

It was possible to identify unique patterns of sleep disorders in children with ADHD corresponding to the different subtypes. Since both ADHD and sleep disorders have high prevalence rates in childhood and are likely to persist into adulthood [4, 13, 25], the research for those two disorders should be addressed with high priority. Up to now, little is known about the mechanisms that connect ADHD and sleep disorders. We suggest that future research focuses on both integrating the already available results and on gaining new insights into the etiology of the connection between ADHD and sleep disorders.

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Conflict of interest. On behalf of all authors, the corresponding author states that there are no conflicts of interest.

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