Title: Evaluation of the Validity of Sleep Disturbance Scale for Children (SDSC) in Attention Deficit Hyperactivity Disorder (ADHD)

Running Title: SDSC Questionnaire in ADHD

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Abstract

Background: Attention Deficit Hyperactivity Disorder (ADHD) is prevalent in children and tightly associated with sleep disorders, emphasizing the clinical importance of diagnosing sleep disorders in this population. Here, we aimed to assess the validity of the Sleep Disturbance Scale for Children (SDSC) in children with ADHD.

Methods: This cross-sectional study, conducted between 2020 and 2021, involved 204 children diagnosed with ADHD and 202 healthy children as controls. Participants were recruited utilizing a convenience sampling approach through schools, community centers, and pediatric clinics. Demographic data were collected for all participants, and their parents completed the SDSC. The results of the two groups were analyzed and compared using the factor analysis method to examine question-answering patterns and item discrimination for ADHD disorder.

Results: The mean total SDSC score was significantly higher in ADHD patients compared to controls (68.1 ± 20.4 versus 57.3 ± 18.2; $P < 0.05$). ADHD cases also exhibited significantly higher scores in disorders of initiating and maintaining sleep (DIMS) (21.6 ± 7.5 versus 18.1 ± 26.9; $P < 0.001$), sleep disorder of breathing (SDB) (5.5 ± 3.5 versus 4.9 ± 2.5; $P = 0.006$), disorder of arousal (DA) (5.9 ± 4.0 versus 4.4 ± 2.7; $P < 0.001$), sleep–wake transition disorders (SWTD) (17.8 ± 6.6 versus 14.6 ± 6.2; $P < 0.001$), and sleep hyperhidrosis (SHY) (4.5 ± 3.5 versus 3.6 ± 3.1; $P = 0.013$) subscales. However, the area under the curve (AUCs) of all subscales were unsatisfactory (ranging from 0.54 to 0.63).

Conclusion: ADHD patients displayed notably higher SDSC scores, particularly in the DIMS domain, which exhibited the highest sensitivity. These findings emphasize the clinical relevance of using SDSC for diagnosing and addressing sleep disorders in individuals with ADHD.

Keywords: Attention deficit disorder with hyperactivity, Sleep wake disorders, Surveys and questionnaires

Introduction

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by inattention, hyperactivity, and impulsivity, which are pervasive, impairing, and otherwise age inappropriate (1). Difficulty regulating emotions or with executive function are main problems in patients with ADHD (2).

ADHD is the most common behavioral disorder in childhood and adolescence, affecting about 3% to 5% of children before the age of seven. This complication is more common in children in elementary school and during puberty, and many patients get better with age (3). It can be important to keep in mind that untreated hyperactivity is dangerous. Previous studies have shown that 25 to 40 percent have the disorder and have not been treated (4).

The cause of most patients with ADHD is not yet clear, but it is thought to be a multifactorial disease with a genetic origin and related to the environment. The diagnosis of ADHD is a challenging issue due to assessments of normal levels of inattention, hyperactivity, and impulsivity but this disease is mainly diagnosed by DSM-IV criteria (5, 6).

Sleep disorders are common among patients with ADHD that can be due to primary sleep disorders or side effects from stimulant medications (7). Sleep disturbance could cause severe daily fatigue, mood problems, problems in attention and concentration, behavioral problems and disorders, as well as damage to physical health and reduced quality of life (QOL). The diagnosis of sleep disorder in patients with ADHD is a challenging issue (8, 9).

Polysomnography (PSG) is recognized as the gold standard for objectively assessing sleep quality and difficulties (10), but its high cost and time-intensive nature limit its suitability for screening. In contrast, the Sleep Disturbance Scale for Children (SDSC), widely used for assessing sleep problems in children, offers a practical and cost-effective alternative. This informant-rated questionnaire, often completed by parents, not only evaluates specific sleep disorders but also provides a comprehensive measure of overall sleep disturbance (11-13). This study aimed to evaluate the validity of SDSC in children with ADHD.

Methods and material

This cross-sectional study, conducted between 2020 and 2021 at Khorshid Hospital affiliated with Isfahan University of Medical Sciences. The study involved 204 children diagnosed with ADHD and 202 healthy children as

a control group. Approval for the study protocol was obtained from the Research Committee and the Ethics Committee of Isfahan University of Medical Sciences.

Participants were recruited through a convenience sampling approach. The ADHD group consisted of children aged 6-15 years, newly diagnosed with ADHD by psychiatrists using Diagnostic and Statistical Manual of Mental Disorders (DSM)-5 criteria, and parental written informed consent. Exclusion criteria included psychiatric medication use within the past month, any sleep disorder, or previously diagnosed psychiatric disorders. Notably, the exclusion of participants with sleep disorders aimed to ensure that observed sleep disturbances were more likely associated with ADHD rather than co-occurring sleep disorders. All children in the case group underwent a psychiatric interview to exclude additional psychiatric disorders.

The control group, comprising 202 children without psychiatric disorders, was recruited from the same geographical area through schools, community centers, and pediatric clinics. The absence of psychiatric disorders in the control group was determined through a structured interview conducted by trained clinicians.

Participants' demographic data, including gender, child educational grade, parents' educational grade, and parents' age, were collected at the study's outset. Subsequently, parents completed the SDSC, a Likert-type rating scale designed by Bruni et al. (14), translated into Persian in 2014, and previously validated (15). The SDSC comprises 26 questions examining various sleep disorder domains, including disorders of initiating and maintaining sleep (DIMS), sleep disorder of breathing (SDB), disorder of arousal (DA), sleep–wake transition disorders (SWTD), disorders of excessive somnolence (DOES) and sleep hyperhidrosis (SHY) (16).

The results of two groups were compared in order to determine the following: validity of the content of the shortened questionnaire from content validity ratio and content validity index indicators, the construct validity of the shortened questionnaire by correlation methods and confirmatory factor analysis, the validity of the structure from convergence and differential validity and the predictive validity of the SDSC.

The study involved participants completing the questionnaire at the onset and again two weeks later. These responses underwent a meticulous analysis through factor analysis to discern patterns and assess discriminative items related to ADHD. The questionnaire's outcomes were then synthesized, allowing for a comprehensive comparison between the two groups. This comparative analysis aimed to determine the content validity of the

questionnaire using content validity ratio and content validity index indicators. Additionally, the study assessed the construct validity through correlation methods and confirmatory factor analysis, examined the validity of the structure via convergence and differential validity, and explored the predictive validity of the SDSC. Importantly, the Intraclass Correlation Coefficient (ICC) was calculated based on the repeated measurements to assess the test-retest reliability of the questionnaire.

The obtained data were entered into the Statistical Package for Social Sciences (SPSS) (version 24, SPSS Inc., Chicago, IL). Quantitative data were reported as mean ± standard deviation and qualitative data as frequency distribution (percentage). Independent t-test, Chi-square were used to analyze the data. P-value< 0.05 was considered as significance threshold.

Results

Table 1 details the socio-demographic characteristics of the study participants, consisting of 204 ADHD patients and 202 healthy controls. The male frequency was higher, with boys/girls ratios of 2.04/1 and 1.66/1 in the case and control groups, respectively. Notably, no significant differences were observed in age and sex between the two groups ($P > 0.05$). However, there were significant distinctions in the educational levels of children and parents ($P < 0.05$). Additionally, a significant difference was noted in mothers' age but not fathers'.

The mean total score of the SDSC was significantly elevated in ADHD patients compared to controls (68.1 ± 20.4 versus 57.3 ± 18.2; $P < 0.05$). Significant differences were also observed in specific subscales, including DIMS (21.6 ± 7.5 versus 18.1 ± 6.9; P<0.001), SDB (5.5 ± 3.5 versus 4.9 ± 2.5; P= 0.006), DA (5.9 ± 4.0 versus 4.4 ± 2.7; P< 0.001), SWTD (17.8 ± 6.6 versus 14.6 ± 6.2; P<0.001) and SHY (4.5 ± 3.5 versus 3.6 ± 3.1; P=0.013), while no significant difference was found in the DOES (12.2 ± 6.1 versus 11.4 ± 5.9; P= 0.208) subscale score (Table 2).

The SDSC demonstrated good internal consistency (Cronbach's alpha = 0.83). Removal of all items, except for items 9 (alpha=0.83), 16(alpha=0.83), and 25 (alpha=0.82), resulted in comparable internal consistency. The corrected item-total correlation ranged from -0.112 to 0.89 as shown in table 3. The highest mean corrected item-total correlation was observed for items 9 (falling sleep sweating) and 16 (night sweating) related to the SHY subscale (mean: 0.835) (Table 3).

The test-retest ICC for SDSC subscales ranged from 0.33 to 0.919. Despite lower reliability in SDB (0.333) and DA (0.468) subscales, the overall SDSC exhibited good test-retest reliability with an ICC of 0.68 (P = 0.008) (Table 4). Convergent validity, assessed by Pearson correlation coefficient (Table 5), revealed positive and statistically significant correlations (P < 0.001) across all measures, indicating good convergent validity for the SDSC.

Table 6 presents the sensitivity, specificity, and area under the curve (AUC) for SDSC total and its subscales. While AUCs for all subscales were below optimal levels (ranging from 0.54 to 0.63), the DMIS subscale showed the highest sensitivity at a cutoff score of 16. The SDSC's overall sensitivity and specificity at a cutoff score of 50.5 were 76% and 40%, respectively, with an AUC of 0.65, indicating a 65% probability of accurately predicting sleep disturbance (Figure 1).

Discussion

This study underscores the critical role of addressing sleep disorders in individuals with ADHD, employing the SDSC for diagnosis. Patients with ADHD exhibited significantly higher SDSC scores, with the total score boasting a 76% sensitivity at a cut-off of 50.5. The study delved into specific domains, revealing DIMS with the highest sensitivity and SDB with the highest specificity.

These findings highlight the effectiveness of SDSC in diagnosing sleep disorders within the ADHD population. Recent data has emphasized the significant role of sleep disorders in individuals diagnosed with ADHD (17-19). Our study aligns with Wajszilber et al. (2018), emphasizing that sleep problems are reported in an estimated 25%–50% of individuals with ADHD, and diagnosing these issues could be crucial for providing proper treatments (20). Furthermore, our research is in line with Craig et al. (2020), stressing the clinical importance of using appropriate questionnaires to diagnose sleep disorders in individuals with ADHD (21).

Sleep disturbances can influence cognitive functioning, connecting high-quality sleep with improved cognition in children and adolescents (22, 23). On the other hand, disrupted sleep may result in cognitive deficits, affecting alertness, vigilance, attention tasks, and executive functions, especially in neurodevelopmental disorders such as ADHD (24, 25).

Based on our study results, SDSC exhibited a 76% sensitivity in diagnosing sleep disorders. Previous research, such as a 2019 study by Mancini and colleagues in Australia, involving 307 children with ADHD who completed SDSC,

found that it was an effective diagnostic tool for sleep disorders in children with ADHD, with acceptable sensitivity. They reported sensitivities ranging from 46.2% to 72.8% in different domains of SDSC, and a total SDSC score cutoff of 48 showed 75% sensitivity (26). Similarly, assessments by Ohi and colleagues in 2021 revealed positive correlations between Polygenic risk scores for ADHD and both initiating and maintaining sleep disorders, as well as excessive somnolence. They also demonstrated that corrected total scores of SDSC could serve as a dependable factor in diagnosing sleep disorders with 70.6% sensitivity (27). These findings align with our study, reinforcing the effectiveness of SDSC in diagnosing sleep disorders in ADHD patients.

We crucially evaluated cut-off points for various SDSC domains, reporting their sensitivity and specificity. Our data revealed that DIMS had the highest sensitivity with a cut-off of 16, and the SDB domain exhibited the highest specificity with a cut-off of 6.5. In a study conducted by Thieux et al., they evaluated SDSC and its various domains to diagnose sleep disorders in ADHD patients. Their findings concurred with ours, highlighting that DIMS, SDB, and DA domains demonstrated the highest sensitivity and specificity among all domains (28).

The SDSC exhibited robust internal consistency. Our analysis of corrected item-total correlation identified specific items, particularly item 9 (falling asleep sweating) and 16 (night sweating), with the highest mean correlation, emphasizing the clinical importance of monitoring symptoms like night sweating when assessing sleep quality in children with ADHD(29).

Test-retest reliability is a critical aspect of assessing the stability and consistency of a measurement tool over time (30). our analysis revealed a relatively lower reliability in SDB and DA subscales. This suggests potential variability or sensitivity to external factors influencing these specific dimensions of sleep disturbances in children with ADHD. Further investigation is needed to understand these factors and enhance the measurement of these dimensions. Despite variations in specific subscales, the overall SDSC demonstrated favorable test-retest reliability, reinforcing its practicality for longitudinal assessments of sleep disturbances in children with ADHD.

Furthermore, the AUC, summarizing diagnostic accuracy (31), reflects the discrimination between individuals with and without the condition. In our study, an AUC of 0.65 suggests a moderate level of accuracy in predicting sleep disturbances using the SDSC. While not optimal, this accuracy level still provides valuable insights into the likelihood of sleep challenges in children with ADHD.

The clinical significance lies in the potential impact of diagnosing sleep disorders in ADHD patients using SDSC and implementing proper treatments, which could significantly improve the disease course. Further investigations are necessary to discern whether these disorders are linked to ADHD therapeutic strategies or independent conditions. Another advantage of SDSC is its simplicity, requiring minimal time, and parents can conveniently fill out the questionnaire in psychiatry offices' waiting rooms. However, our study has limitations. The cross-sectional design limits our ability to establish causation between ADHD and sleep disturbances. Future research with longitudinal approaches could offer a more nuanced understanding of the dynamic relationship between these variables. Additionally, the reliance on subjective parental perceptions for assessing sleep disturbance severity introduces potential biases. Incorporating objective measurements like polysomnography could enhance the precision of our findings. It's important to note that while our study used the same terms for the six subscales of SDSC as in previous research, SDSC primarily provides trait/symptom dimensions rather than definitive sleep disorder diagnoses. This characteristic should be considered in result interpretation. Furthermore, the study's restricted population and the absence of comparisons with other questionnaires suggest the need for further research in this regard.

Conclusion

Patients with ADHD exhibited significantly higher SDSC scores compared to controls. The total SDSC score demonstrated a 76% sensitivity. Moreover, we noted significantly elevated scores in various domains of SDSC among ADHD patients. According to our findings, the DIMS domain had the highest sensitivity, and the SDB domain had the highest specificity. These results hold substantial clinical importance for the diagnosis and treatment of sleep disorders in individuals with ADHD.

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Conflict of Interest: authors have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript

Ethical approval: All procedures performed in study were in accordance with the ethical standards of the Isfahan university of medical science research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards

Informed consent: Informed consent was obtained from all parents of participants included in the study.

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Data availability statement:

The database generated and analyzed during the current study are available from the corresponding author on reasonable request.

Figure 1: Assessments of AUC for different domains.

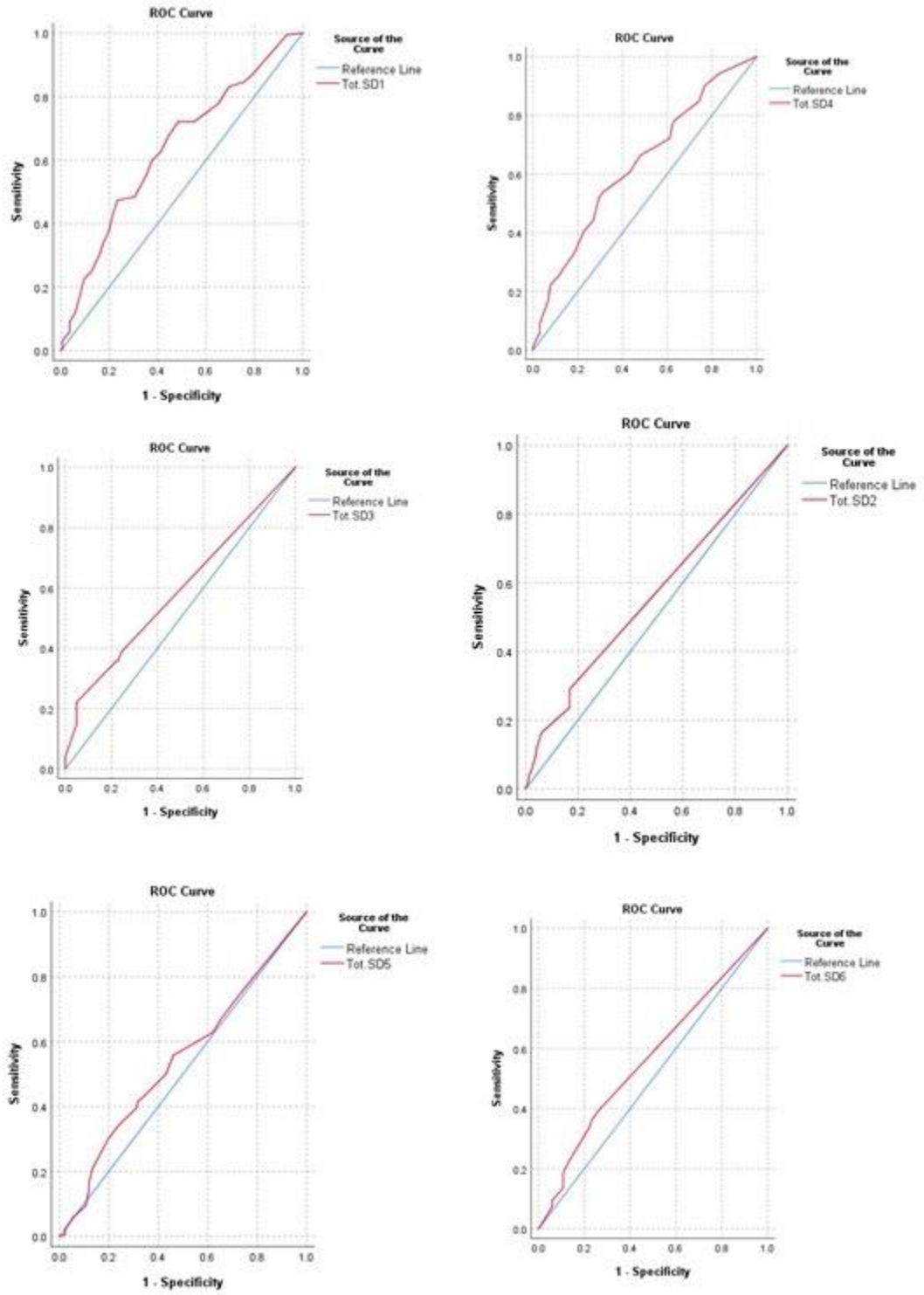

Table 1: The comparison of socio-demographic characteristics between cases and controls

	Case (n=204)	Control (n=202)	Total	p-value
Sex				0.31
Boy	137(67.2%)	126(62.4%)	263(64.8%)	
Girl	67(32.8%)	76(37.6%)	143 (35.2%)	
Child educational grade				<0.0001
Preschool	59(29.2%)	10(5%)	69(17.2%)	
Elementary school	86(42.6%)	162(80.6%)	248(61.5%)	
Middle school	57(28.3%)	29(14.4%)	86(21.4%)	
Father educational grade				<0.0001
Illiterate	1%	1.5%	1.2%	
Elementary school	41.7%	17.3%	29.5%	
Diploma	37.3%	34.2%	35.7%	
Bachelor	14.2%	32.7%	23.4%	
Graduate studies	5.9%	14.4%	10.1%	
Mother educational grade				<0.0001
Illiterate	1%	1%	1%	
Elementary school	30.4%	13.4%	21.9%	
Diploma	48.5%	29.2%	38.9%	
Bachelor	15.2%	41.1%	28.1%	
Graduate studies	20.1%	56.4%	38.2%	
Mother age				0.017
20-30	18.6%	8.9%	13.8%	
30-40	64.7%	66.3%	65.5%	
40-50	15.7%	23.3%	19.5%	
>50	1%	1.5%	1.2%	
Father age				0.081
20-30	5.9%	2%	3.9%	
30-40	50.5%	44.6%	47.5%	
40-50	34.8%	42.1%	38.4%	
>50	8.8%	11.4%	10.1%	

Values in table are mean ±SD for continuous variables and percentage for categorical variables, P-values were obtained from independent samples t-test for continuous variables and chi-square test for categorical ones. P value<0.05 is considered significant

Table 2: Comparing the total score and score of each subscale of sleep disturbance scale between cases and controls

	Case (n=204)	**Control (n=202)**	**P-value**
DIMS	21.6(7.5)	18.12(6.9)	<0.0001
SDB	5.5(3.5)	4.9(2.5)	0.006
DA	5.9(4.0)	4.4(2.7)	<0.0001
SWTD	17. 8(6.6)	14.6(6.2)	<0.0001
DOES	12.2(6.1)	11.4(5.9)	0.208
SHY	4.5(3.5)	3.6(3.1)	0.013
Total score	68.1(20.4)	57.3(18.2)	<0.0001

Abbreviations: Disorders of initiating and maintaining sleep (DIMS), sleep disordered-breathing (SDB), Disorders of arousal (DA), Sleep-wake transition disorder (SWTD), Disorders of excessive somnolence (DOES), and Sleep hyperhidrosis (SHY), P-value<0.05 was considered significant

Items in each subscale	Item mean (SD)	Coronbach's alpha if deleted	Corrected item-total correlation
Disorders of initiating and maintaining sleep (DIMS)			
Q1	4.1(.9)	.651	-.072
Q2	2.1(1.27)	.572	.418
Q3	4(2.7)	.575	.354
Q4	2.8(2.5)	.528	.460
Q5	3.3(2.5)	.606	.265
Q10	2.8(2.3)	.527	.467
Q11	1.9(1.9)	.563	.384
Sleep disordered-breathing (SDB)			
Q13	1.2(.87)	.335	.335
Q14	1.4(1.36)	.564	.564
Q15	2.5(1.3)	.706	.706
Disorders of arousal (DA)			
Q17	1.4(1.36)	.744	.247
Q21	1.9(1.92)	.493	.477
Q22	2.5(1.99)	.792	.625
sleep-wake transition disorder (SWTD)			
Q6	1.8(1.7)	.330	.410
Q7	1.6(1.7)	.416	.240
Q8	4.5(2.3)	.312	.387
Q12	3.8(2.9)	.254	.512
Q18	3.4(2.4)	.514	.084
Q20	1.4(1.36)	.248	.656
Disorders of excessive somnolence (DOES)			
Q23	2.4(1.4)	.782	.673
Q24	2.2(2.04)	.788	.639
Q25	1.9(1.7)	.823	.502
Q26	1.66(1.5)	.766	.733
Q19	2.09(2	.589	-.112
Sleep hyperhidrosis (SHY)			
Q9	2.14(2.1)	.83	.835
Q16	1.8(1.67)	.825	.835
Total	68.1(20.4)	.834	

Table 3: Cronbach's alpha and item-scale correlation in the sleep disturbance scale for children

P-value<0.05 was considered significant

Table 4: Interclass-correlation coefficient of various subscales of sleep disturbance scale for children

	Interclass correlation coefficient	Confidence interval (95%)	P-value
DIMS	.795	.482-.919	.01
SDB	.333	-.685-.736	.192
DA	.468	-.345-.789	.089
SWTD	.795	.483-.919	.001
DOES	.919	.795-.968	<.001
SHY	.746	.357-.899	0.002
Total	.680	.192-.873	.008

Abbreviations: Disorders of initiating and maintaining sleep (DIMS), Sleep disordered-breathing (SDB), Disorders of arousal (DA), Sleep-wake transition disorder (SWTD), Disorders of excessive somnolence (DOES), and Sleep hyperhidrosis (SHY), P-value<0.05 was considered significant.

Table 5: Pearson correlation coefficient among the subscales of sleep disturbance scale

	Cut off	Sensitivity	Specificity	AUC (95% CI)	P-value
DIMS	16	0.72	0.52	0.63(0.68-0.69)	<0.0001
SDB	6.5	0.25	0.84	0.56(0.50-0.62)	0.038
DA	4.5	0.38	0.76	0.58(0.53-0.64)	0.003
SWTD	14.5	0.66	0.53	0.63(0.57-0.68)	<0.0001
DOES	10.5	0.55	0.54	0.54(0.48-0.60)	0.17
SHY	3.5	0.39	0.75	0.56 (0.50-0.62)	0.027
Total	50.5	0.76	0.40	0.65 (0.59-0.71)	<0.0001

Abbreviations: Disorders of initiating and maintaining sleep (DIMS), sleep disordered-breathing (SDB), Disorders of

Table6: Results of sensitivity, specificity, and area under curve for sleep disturbance scale in children arousal (DA), Sleep-wake transition disorder (SWTD), Disorders of excessive somnolence (DOES), and Sleep hyperhidrosis (SHY), **P-value<0.01 was considered significant

	DIMS	SDB	DA	SWTD	DOES	SHY	Total
DIMS	1						
SDB	.213**	1					
DA	.410**	.278**	1				
SWTD	.412**	.192**	.414**	1			
DOES	.457**	.330**	.330**	.233**	1		
SHY	.275**	.269**	.253**	.205**	.182**	1	
Total	.796**	.492**	.650**	.690**	.686**	.478**	1