Original Article

Performance of the Activities and Participation component of International Classification of Functioning, Disability and Health Sleep Disorders Brief Core Set in patients with obstructive sleep apnea

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Background: Limitation of daily activities and impairment of working memory have received less attention in the clinical diagnosis and prognostic assessment of obstructive sleep apnea (OSA). In this study, the Activities and Participation component of the International Classification of Functioning, Disability and Health (ICF) Sleep Disorders Brief Core Set was evaluated for its performance in predicting impaired work ability in OSA patients.

Methods: A total of 221 subjects were recruited into this cross-sectional study. ICF Sleep Disorders Brief Core Set, polysomnography, and neuropsychological tests were applied for data acquisition. Data analysis was performed by regression analysis and receiver operating characteristic (ROC) construction.

Results: The scores for the component Activities and Participation were significantly different between the no OSA/OSA group, and were elevated as the severity of OSA increased. Scores were positively correlated with apnea-hypopnea index (AHI), trail making test (TMT), and negatively correlated with symbol digit modalities test (SDMT) correct. The component Activities and Participation performed better with the threshold of 4 in the prediction of impaired attention and work ability in severe OSA [AHI ≥30 events/h, bottom 10% of TMT part B (TMTb) scores as the diagnostic criteria], with area under the curve, sensitivity and specificity as 0.909, 71.43% and 96.72%, respectively.

Conclusions: The Activities and Participation component of the ICF Sleep Disorders Brief Core Set could have the potential to predict the impairment of attention and work ability in OSA patients. It provides a new perspective for the identification of OSA patients' disturbances in daily activities and improving the overall assessment level.

Keywords: Obstructive sleep apnea (OSA); International Classification of Functioning, Disability and Health Sleep Disorders Brief Core Set (ICF Sleep Disorders Brief Core Set); symbol digit modalities test (SDMT); trail making test (TMT); Montreal Cognitive Assessment (MoCA)

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Introduction

Obstructive sleep apnea (OSA) is a disorder characterized by recurrent upper airway collapse during sleep, which causes nocturnal apnea and/or hypopnea, with repeated nocturnal arousals, disturbed sleep architecture, nocturnal hypoxemia, lethargy, fatigue and other daytime symptoms (1). The prevalence of OSA is increasing constantly, causing a heavy burden of global public health (2). The systemic multi-organ damage caused by the long-term course of OSA is closely related to the increase of co-morbidities such as diabetes, cardiovascular disease, and neurocognitive impairment (3-6). Polysomnography (PSG) is currently the gold standard for the diagnosis of OSA, which focuses on monitoring the nocturnal apnea-hypopnea index (AHI) and oxygen desaturation index (7). In addition to the respiratory manifestation, OSA is often accompanied by many kinds of daytime symptoms, which received little attention in the past few decades. Excessive daytime sleepiness could injure quality of life and work performance in patients with OSA, including impaired cognitive function represented by attention and increased risk of motor vehicle traffic accidents (8). However, there is currently a lack of simple and efficient overall health assessment methods, which might result in incomplete diagnosis and treatment of OSA patients.

The International Classification of Functioning, Disability and Health (ICF) is endorsed by the World Health Organization, aimed to provide a scientific basis and a universal framework for understanding and investigating health-related conditions, including the consequences and potential environmental factors (9). Meanwhile, the application of ICF in neurology and psychiatry promotes research in clinical health services and practical care of patients, which will facilitate the promotion of vocational rehabilitation (10). Currently, ICF has been applied to multiple diseases as a unified model for rehabilitation strategies. The developed ICF core sets such as diabetes mellitus, stroke, and obstructive pulmonary diseases have proven their effectiveness in relevant studies (11-13). However, there is no specific OSA core set. We previously used the Body Functions component of the ICF Sleep Disorders Brief Core Set to assess function and health in patients with OSA and demonstrated its effectiveness (14). The ICF Sleep Disorders Brief Core Set contains fourteen categories that form four functional components, Body Functions, Body Structures, Activities and Participation, and Environment Factors, which helps to take a multidisciplinary consideration into clinical practice when evaluating the comprehensive health statues of patients (15).

Helping patients overcome limitations in daily activity and encouraging more participation to achieve vocational rehabilitation is one of the ultimate goals of the ICF (16). The Activities and Participation is a distinctive component of ICF. Therefore, this study focused on the Activities and Participation component of the ICF Sleep Disorders Brief Core Set, aiming to validate its role in assessing daily activity disorders such as impaired work ability in patients with OSA, and provide a better reference for clinical evaluation of OSA. We present the following article in accordance with the STARD reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1446/rc).

Highlight box

Key findings

- Activities and Participation of International Classification of Functioning, Disability and Health (ICF) Sleep Disorders Brief Core Set might have the potential to predict the impaired working performance in OSA patients.

What is known and what is new?

- ICF Sleep Disorders Brief Core Set might have the potential to diagnose OSA.
- The value of the component Activities and Participation of ICF Sleep Disorders Brief Core Set was evaluated.

What is the implication, and what should change now?

- This tool might help to get a more comprehensive understanding of OSA in the process of diagnosis and treatment while there is still a necessity to add more specific categories related to OSA when put it into clinical practice.

Methods

Clinical subjects and ethical review

This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of Zhongshan Hospital of Fudan University [No. B2018-216(2)R]. All informed consents were obtained from the participants before conducting PSG and questionnaires. Between September 2021 and July 2022, this 11-month cross-sectional study recruited adults over the age of 18 who presented to the respiratory clinic for OSA. The exclusion criteria were as follows: (I) diagnosed with OSA or received OSA treatment

previously; (II) patients in acute medical illness; (III) history of psychiatric, or neurological diseases, or psychiatric drug dependence; (IV) drug use that affect brain function before the test.

A total of 221 subjects were enrolled and completed PSG and questionnaires in this survey. PSG (Alice-5 Respironics, Pittsburgh, Pennsylvania, USA) were monitored in a room for sleep with the same setting. PSG tests were analyzed by the same two sleep medicine specialists according to American Academy of Sleep Medicine guidelines, and the relevant clinical characteristics of the subjects were blind at the time of assessment (17). AHI refers to the mean number of apneas and hypopnea per hour during sleep which is the current gold standard for OSA diagnosis. In this study, the severity of OSA was graded according to the AHI: AHI <5 events/h, no OSA group; 5≤ AHI <15 events/h, mild OSA group; 15≤ AHI <30 events/h, moderate OSA group; AHI ≥30 events/hour, severe OSA group.

Neuropsychological tests and ICF Sleep Disorders Brief Core Set

Neuropsychological tests of all subjects were conducted by two professional clinical psychologists. Epworth Sleepiness Scale (ESS) was used to evaluate the extent of daytime sleepiness. The Montreal Cognitive Assessment (MoCA) was performed to assess the overall cognitive level, including abilities of visuospatial and executive, naming, attention, language, abstraction, delayed recall, and orientation (18). Symbol digit modalities test (SDMT) and trail making test (TMT) were applied to assess subjects' attention, information processing speed, working memory, and executive ability (19,20).

The ICF Sleep Disorders Brief Core Set consists of four components and fourteen categories. In this study, a general five-point scale were performed, with each category divided into five levels according to the degree of functional impairment: no impairment [0], mild impairment [1], moderate impairment [2], severe impairment [3] and complete impairment [4]. Environment Factors were graded in three grades: facilitator [–1], no effect [0], or hindrance [+1]. Based on the principle of doubt-blind, all information related to ICF of patients was collected before they undergone the PSG and neuropsychological tests. Meanwhile, information integration and statistical analysis were conducted by different investigators and the group assignment won't be known until all works were completed.

Statistical analysis

Subject characteristics were shown as mean ± standard deviation or percentage. Student's *t*-test, Mann-Whitney rank-sum test and Chi-square test or Fisher's exact test were performed for comparison between two groups. Multiple-group comparisons were assessed by one-way analysis of variance followed by least significant difference (LSD) *post-hoc* analysis, Kruskal-Wallis test with the Bonferroni correction *post-hoc* analysis and Chi-square test or Fisher's exact test according to the feature of data. Univariate regression analysis was used to determine the relationship between neuropsychological tests, PSG parameters and the performance of ICF. MedCalc 20.1.0 (MedCal Software, Brussels, Belgium), SPSS 25.0 (SPSS Software, Chicago, USA) and GraphPad Prism version 8 (GraphPad Software, San Diego, USA) were applied for all statistical analyses and plots. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), area under the receiver operating characteristic (ROC) curve was calculated, including respective confidence intervals. Statistical significance level was set at $P<0.05$.

Results

Demographic and clinical characteristics of subjects

A total of 221 subjects (182 males, 39 females) were enrolled in the study. According to the results of PSG, patients were divided into four groups: AHI <5 events/h, no OSA group (n=53); 5≤ AHI <15 events/h, mild OSA group (n=52); 15≤ AHI <30 events/h, moderate OSA group (n=48); AHI ≥30 events/h, severe OSA group (n=68). The demographic and clinical characteristics of the four groups were shown in *Table 1*. There was no statistical difference in age (P=0.1466), gender (P=0.1081), and the years of education (P=0.7431). In addition, body mass index (BMI), AHI, max apnea time, the oxygen saturation (SaO_2) nadir, and the scores of ESS were significantly different among the four groups.

In terms of neuropsychological tests, there were differences in SDMT, TMT part B (TMTb) and MoCA scores among the four groups except for TMT part A (TMTa). MoCA mainly contains 7 aspects, in which attention and delayed recall differed among the four groups (P=0.0207, P=0.0407). Compared with the mild and the moderate OSA groups, the severe OSA group had significantly more impairments in SDMT, TMTb and MoCA scores than the no OSA group (*Table 2*).

Table 1 Demographic and clinical characteristics of the study group

Characteristics	No OSA (n=53)	Mild OSA (n=52)	Moderate OSA (n=48)	Severe OSA (n=68)	P value
Sex (M/F)	38/15	43/9	41/7	60/8	0.1081[c]
Age (years)	41.23±13.30	43.57±13.11	46.88±10.29	44.06±11.91	0.1466[a]
Education (years)	15.02±3.91	14.46±3.27	14.15±3.44	14.49±3.15	0.7431[b]
BMI (kg/m^2)	25.35±3.95	25.96±4.50	26.36±3.07	28.67±4.02$^{***\#\#\&}$	<0.0001[b]
Smoking	13 (24.53)	25 (48.08)	24 (50.00)	36 (52.94)	0.0098[c]
Short of breath	23 (43.40)	14 (26.92)	17 (35.42)	28 (41.18)	0.2645[c]
ESS (scores)	9.21±4.40	9.79±5.19	10.69±5.24	14.35±5.59$^{***\#\#\#\&\&\&}$	<0.0001[a]
AHI (events/h)	1.98±1.39	8.88±2.63***	21.86±4.30$^{***\#\#}$	52.88±15.31$^{***\#\#\#\&\&\&}$	<0.0001[b]
Max apnea time (s)	19.48±18.29	39.62±21.61**	57.12±20.00$^{***\#\#}$	70.16±25.40$^{***\#\#\#}$	<0.0001[b]
SaO_2 nadir (%)	88.45±4.21	83.38±7.83**	80.63±6.73***	70.65±9.19$^{***\#\#\#\&\&\&}$	<0.0001[b]
Hypertension	14 (26.42)	20 (38.46)	23 (47.92)	35 (51.47)	0.0327[c]
Diabetes mellitus	8 (15.09)	4 (7.69)	3 (6.25)	2 (2.94)	0.0940[c]
Rhinitis	15 (28.30)	19 (36.54)	11 (22.92)	17 (25.00)	0.4238[c]
Pharyngitis	14 (26.42)	15 (28.85)	17 (35.42)	36 (52.94)	0.0094[c]
Nasosinusitis	6 (11.32)	4 (7.69)	2 (4.17)	5 (7.35)	0.6076[c]
Nasal polyp	0 (0.00)	3 (5.77)	1 (2.08)	0 (0.00)	0.0773[c]
Polyp of vocal cord	2 (3.77)	0 (0.00)	1 (2.08)	1 (1.47)	0.5374[c]

Data are presented as mean ± standard deviation or n (%). [a], P value among four groups from the one-way analysis of variance followed by LSD *post-hoc* analysis; [b], P value among four groups from the Kruskal-Wallis test with the Bonferroni correction *post-hoc* analysis; [c], P value among four groups from Chi-square test. There was a significant difference compared to the no OSA group: **, P<0.01; ***, P<0.001; to mild OSA group: $^{\#\#}$, P<0.01, $^{\#\#\#}$, P<0.001; to moderate OSA group: $^{\&}$, P<0.05; $^{\&\&\&}$, P<0.001. Statistical significance level was set at P<0.05. AHI, apnea-hypopnea index; BMI, body mass index; ESS, Epworth Sleepiness Score; F, female; LSD, least significant difference; M, male; OSA, obstructive sleep apnea; SaO_2, oxygen saturation.

Subject's performance on the ICF Sleep Disorders Brief Core Set

The ICF Sleep Disorders Brief Core Set contains fourteen different categories that form four functional components. The scores for each category of each group were obtained and the total scores of each component were calculated (*Table 3*, Table S1). The final scores of Body Functions, Body Structures and Activities and Participation showed significant differences among the four groups. Compared with the mild OSA group and the moderate OSA group, the severe OSA group had higher scores, indicating that the higher the severity of OSA, the more severe the impairment of their respective functions. Among them, the scores of category d160 focusing attention of Activities and Participation were significantly different between the no OSA group and the severe OSA group. Meanwhile, the scores of category d240 handling stress and other psychological demands were significantly different in the no OSA/severe OSA group. Although the scores of category d475 driving were not statistically different between the four groups, there was still an increase trend in the impaired score with worsen OSA severity. As for the component Environmental Factors, almost all subjects who came to see the doctor received support from relatives and friends, health institutions and social security, and there was no difference between the four groups.

Correlation of participant parameters with Activities and Participation in the ICF Sleep Disorders Brief Core Set

SDMT and TMT are widely used as well-established neuropsychological tests to assess subjects' attention, information processing speed, working memory, and

Table 2 Neuropsychological tests of the study group

Characteristic	No OSA (n=53)	Mild OSA (n=52)	Moderate OSA (n=48)	Severe OSA (n=68)	P value
SDMTcorrect (number)	48.96±11.91	47.37±13.24	43.23±12.80	42.04±13.40*	0.0385[a]
SDMTrecall (number)	4.36±2.43	4.12±1.99	3.71±2.27	3.15±1.86*	0.0171[b]
TMTa (s)	47.15±18.48	49.37±24.93	53.35±21.93	58.29±29.67	0.0537[b]
TMTb (s)	105.51±45.11	108.42±50.38	116.75±41.12	121.18±41.02*	0.0103[b]
MoCA (scores)	26.96±2.98	26.33±2.78	25.90±3.47	25.74±2.54*	0.0119[b]
Visuospatial and executive	4.23±0.85	4.12±0.98	4.04±1.09	4.01±1.00	0.6826[b]
Naming	2.85±0.60	2.87±0.49	2.75±0.89	2.93±0.40	0.6304[b]
Attention	5.77±0.58	5.60±0.77	5.52±0.95	5.44±0.74*	0.0207[b]
Language	2.64±0.62	2.54±0.85	2.60±0.57	2.60±0.69	0.9385[b]
Abstraction	1.92±0.27	1.87±0.40	1.83±0.38	1.82±0.38	0.3783[b]
Delayed recall	3.43±1.54	3.12±1.50	2.85±1.40	2.74±1.33*	0.0407[b]
Orientation	5.77±0.87	5.96±0.19	5.98±0.14	5.91±0.33	0.1166[b]

Data are presented as mean ± standard deviation. [a], P value among four groups from the one-way analysis of variance followed by LSD *post-hoc* analysis; [b], P value among four groups from the Kruskal-Wallis test with the Bonferroni correction *post-hoc* analysis. Statistical significance level was set at P<0.05. There was a significant difference compared to the no OSA group: *, P<0.05. LSD, least significant difference; MoCA, Montreal Cognitive Assessment; OSA, obstructive sleep apnea; SDMT, symbol digit modalities test; TMT, trail making test; TMTa, TMT part A; TMTb, TMT part B.

Table 3 Scores of the ICF Sleep Disorders Brief Core Set in the study group

Category title	No OSA (n=53)	Mild OSA (n=52)	Moderate OSA (n=48)	Severe OSA (n=68)	P value
Body Functions	1.43±1.39	2.52±2.01	3.69±2.34***	4.43±3.17***##	<0.0001
Body Structures	0.47±0.80	0.40±0.63	0.58±0.85	0.93±1.11*#	0.0114
Activities and Participation	0.30±0.61	0.54±0.94	0.79±1.25	1.03±1.48*	0.0331
d160: focusing attention	0.11±0.42	0.17±0.47	0.27±0.54	0.37±0.62*	0.0165
d240: handling stress and other psychological demands	0.11±0.32	0.27±0.56	0.38±0.61	0.47±0.76*	0.0280
d475: driving	0.08±0.27	0.10±0.30	0.15±0.36	0.19±0.40	0.2386
Environmental Factors	–2.62±0.88	–2.67±0.79	–2.94±0.25	–2.71±0.75	0.2400

Data are presented as mean ± standard deviation. P value among four groups from the Kruskal-Wallis test with the Bonferroni correction *post-hoc* analysis. Statistical significance level was set at P<0.05. There was a significant difference compared to the no OSA group: *, P<0.05; ***, P<0.001; to mild OSA group: #, P<0.05, ##, P<0.01. ICF, International Classification of Functioning, Disability and Health; OSA, obstructive sleep apnea.

executive ability. We compared their correlations with the component Activities and Participation in the ICF Sleep Disorders Brief Core Set through regression analysis. Furthermore, given that the greater the severity of OSA, the higher the scores of the ICF functional components, the correlation analyses were performed on the component Activities and Participation in the ICF Sleep Disorders Brief Core Set with key parameters of OSA. The results shown that the scores of Activities and Participation were positively correlated with AHI and the scores of TMTa and TMTb, and negatively correlated with the correct numbers of SDMT (*Table 4*).

Table 4 Correlation of participants' different parameters with Activities and Participation in the ICF Sleep Disorders Brief Core Set

Category	β	95% CI	P value
AHI (events/h)	0.016	0.010, 0.023	<0.0001****
SaO_2 nadir (%)	−0.013	−0.028, 0.003	0.1043
BMI (Kg/m^2)	0.028	−0.009, 0.066	0.1407
SDMTcorrect (number)	−0.047	−0.057, −0.037	<0.0001****
TMTa (s)	0.013	0.007, 0.019	<0.0001****
TMTb (s)	0.017	0.014, 0.019	<0.0001****

****, P<0.0001. AHI, apnea-hypopnea index; BMI, body mass index; CI, confidence interval; ICF, International Classification of Functioning, Disability and Health; SaO_2, oxygen saturation; SDMT, symbol digit modalities test; TMT, trail making test; TMTa, TMT part A; TMTb, TMT part B.

Table 5 Predictive parameters for various Activities and Participation score cut-offs at different AHI levels according to SDMTcorrect

OSA diagnostic criteria	Cut-offs	AUC	95% CI	Sensitivity%	Specificity%	PPV%	NPV%
Bottom 25% of SDMTcorrect scores as the diagnostic criteria for impaired "activity and participation"							
AHI ≥5 events/h	ICFsleep-AP ≥1	0.795	0.726 to 0.854	78.57	73.02	49.30	91.10
AHI ≥15 events/h	ICFsleep-AP ≥1	0.826	0.745 to 0.890	82.76	72.41	50.00	92.60
AHI ≥30 events/h	ICFsleep-AP ≥1	0.834	0.725 to 0.914	88.24	70.59	50.00	94.70
Bottom 20% of SDMTcorrect scores as the diagnostic criteria for impaired "activity and participation"							
AHI ≥5 events/h	ICFsleep-AP ≥1	0.777	0.706 to 0.837	76.47	69.40	38.80	92.10
AHI ≥15 events/h	ICFsleep-AP ≥3	0.829	0.748 to 0.893	56.52	95.70	76.50	89.90
AHI ≥30 events/h	ICFsleep-AP ≥1	0.833	0.723 to 0.913	85.71	66.67	40.00	94.70
Bottom 10% of SDMTcorrect scores as the diagnostic criteria for impaired "activity and participation"							
AHI ≥5 events/h	ICFsleep-AP ≥3	0.777	0.707 to 0.838	52.94	93.38	47.40	94.60
AHI ≥15 events/h	ICFsleep-AP ≥3	0.866	0.790 to 0.922	66.67	91.35	47.10	96.00
AHI ≥30 events/h	ICFsleep-AP ≥4	0.900	0.804 to 0.960	71.43	96.72	71.40	96.70

AHI, apnea-hypopnea index; AP, Activity and Participation; AUC, the area under the curve; CI, confidence interval; ICF, International Classification of Functioning, Disability and Health; NPV, negative predictive value; OSA, obstructive sleep apnea; PPV, positive predictive value; SDMT, symbol digit modalities test.

Performance of the component Activities and Participation in the ICF Sleep Disorders Brief Core Set for predicting impaired ability to work of OSA patients

Considering that the subjects' SDMT and TMT scores were mostly within the normal range for the general population, the scores decreased only with the severity of OSA. Furthermore, there were significant differences in SDMTcorrect and TMTb between the severe group and the control group in this study. Therefore, we set the last 25%, 20% and 10% of the SDMTcorrect and TMTb as the diagnostic cut-off points for impaired attention and working memory. At the same time, AHI 5/h, 15/h and 30/h were performed as the critical points for OSA. Taking the last 10% of SDMTcorrect as the evaluation standard of attention impairment, when AHI ≥30 events/h, the area under the curve (AUC) was the highest of 0.900, and the specificity, sensitivity and specificity were 71.43% and 96.72%, respectively (*Table 5*, *Figure 1*). Taking the last 10% of TMTb as the evaluation standard of attention impairment, when AHI ≥30 events/h, the AUC was the highest of 0.909, and the specificity, sensitivity and specificity were 71.43% and 96.72%, respectively (*Table 6*, *Figure 1*).

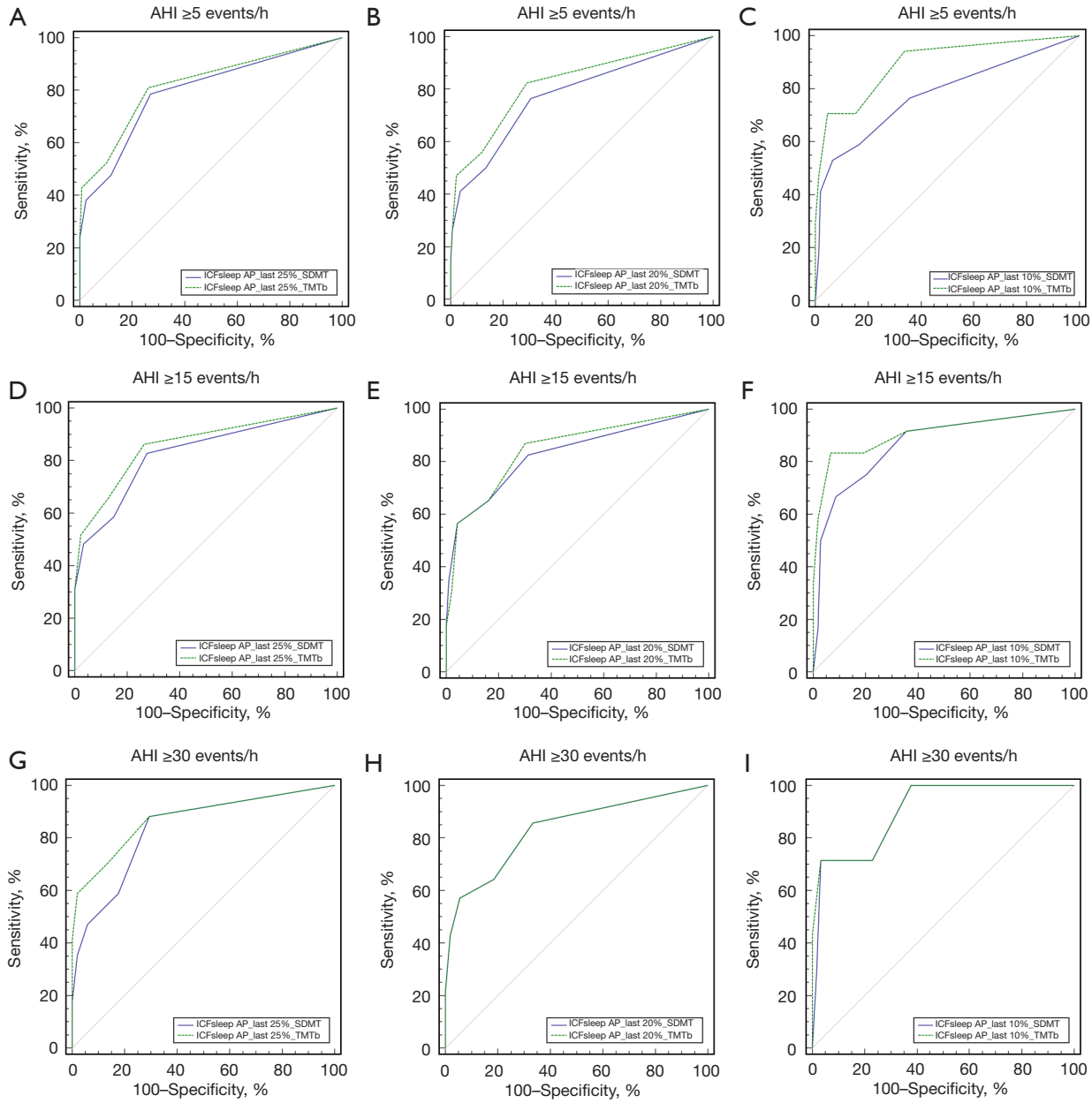

Figure 1 ROC curves for the Activities and Participation component of ICF Sleep Disorders Brief Core Set. (A-C) ROC for AHI cut-off ≥5 events/h; (D-F) ROC for AHI cut-off ≥15 events/h; (G-I) ROC for AHI cut-off ≥30 events/h. AHI, apnea-hypopnea index; AP, Activity and Participation; ICF, International Classification of Functioning, Disability and Health; ROC, receiver operating characteristic; SDMT, Symbol Digit Modalities Test; TMT, Trail Marking Test; TMTb, TMT part B.

It shown that with increasing AHI, the predictive ability, sensitivity, and specificity for impaired work performance of component Activities and Participation were increased and were within acceptable limits. Combining SDMT with TMTb as diagnostic cut-points for impaired attention and work ability, the component Activities and Participation of ICF Sleep Disorders Brief Core Set would applicable with the threshold of 4.

Table 6 Predictive parameters for various Activities and Participation score cut-offs at different AHI levels according to TMTb

OSA diagnostic criteria	Cut-offs	AUC	95% CI	Sensitivity%	Specificity%	PPV%	NPV%
Bottom 25% of TMTb scores as the diagnostic criteria for impaired "activity and participation"							
AHI ≥5 events/h	ICFsleep-AP ≥1	0.822	0.755 to 0.876	80.95	73.81	50.70	92.10
AHI ≥15 events/h	ICFsleep-AP ≥1	0.860	0.783 to 0.917	86.21	73.56	52.10	94.10
AHI ≥30 events/h	ICFsleep-AP ≥1	0.875	0.772 to 0.943	88.24	70.59	50.00	94.70
Bottom 20% of TMTb scores as the diagnostic criteria for impaired "activity and participation"							
AHI ≥5 events/h	ICFsleep-AP ≥1	0.822	0.756 to 0.877	82.35	70.90	41.80	94.10
AHI ≥15 events/h	ICFsleep-AP ≥1	0.846	0.767 to 0.906	86.96	69.89	41.70	95.60
AHI ≥30 events/h	ICFsleep-AP ≥1	0.833	0.723 to 0.913	85.71	66.67	40.00	94.70
Bottom 10% of TMTb scores as the diagnostic criteria for impaired "activity and participation"							
AHI ≥5 events/h	ICFsleep-AP ≥3	0.895	0.838 to 0.937	70.59	95.36	63.20	96.60
AHI ≥15 events/h	ICFsleep-AP ≥3	0.907	0.839 to 0.953	83.33	93.27	58.80	98.00
AHI ≥30 events/h	ICFsleep-AP ≥4	0.909	0.814 to 0.965	71.43	96.72	71.40	96.70

AHI, apnea-hypopnea index; AP, Activity and Participation; AUC, the area under the curve; CI, confidence interval; ICF, International Classification of Functioning, Disability and Health; NPV, negative predictive value; OSA, obstructive sleep apnea; PPV, positive predictive value; TMT, trail making test; TMTb, TMT part B.

Discussion

According to epidemiological statistics, nearly one billion adults aged 30–69 years may have OSA worldwide, and nearly 425 million people with moderate and severe OSA are generally recommended for treatment. Recently, China was estimated to have the largest number of patients with OSA (2). Traditional screening questionnaires and PSG are mostly aimed at clinical manifestations with airway obstruction and nocturnal respiratory dysfunction, while insufficient attention has been paid to the overall functional impairment of OSA patients including fatigue and excessive daytime sleepiness. As a disease syndrome, OSA causes sleep disturbance and repeated nocturnal hypoxemia, resulting in the decline of quality of life and psychological and spiritual imbalance which finally led to the worse performance during work or daily life (21).

According to the bio-psycho-social medical system, assessing the overall functional status of OSA patients is extremely important for clinical diagnosis, therapy and rehabilitation (22). Recent years, a numbers of system reviews have pointed that chronic intermittent hypoxia and the disturbed sleep at night can cause the deficits in attention, memory, executive function and language abilities (6,23). Therefore, it is necessary to develop appropriate tools to promptly identify various functional impairments and prevent patients from worse outcomes.

ICF, as a common framework for understanding and describing the overall functioning, health status, and disability, plays an enabling role in occupational rehabilitation efforts, and has been successfully applied to many kinds of physical and psychiatric disorders including multiple sclerosis and autism (24-27). Sleep disturbance is the most important dysfunction and disabling factor for OSA patients. Although the ICF brief core set has not been developed specificity for OSA, we previously demonstrated that the ICF Sleep Disorders Brief Core Set, especially its first component, Body Functions, could be used to assess physical dysfunction and health status in OSA patients and diagnosis (14).

However, the above study focused on the physical dysfunction of OSA, with insufficient attention paid to the psychological, mental, and occupational impairment of OSA. Additionally, the component Activities and Participation is also the most characteristic component of the ICF, which is another key goal of our attention and help to enrich the utilization of the Brief Core Set of Sleep Disorders. Each different categories of the component Activities and Participation in ICF Sleep Disorders Brief Core Set is typical, which could not only reflect the performance of working but also the ability of social participation. Therefore, identify the potential of

this component in predict the impaired function in daily working is our main aim in this study.

In order to comprehensively assess the cognitive level of OSA patients, especially the impairment of attention, working memory and executive function, we used the neuropsychological tests of MoCA, SDMT and TMT to evaluate all subjects. First of all, MoCA is the classic and the most commonly used test to identify the cognitive impairment, and the total score of MoCA and its sub-categories, attention and delayed recall, were statistically different. Consistent with the results of previous studies, the MoCA score of the OSA group was lower than that without OSA, especially in severe OSA group, suggesting that the degree of cognitive impairment in OSA is related to the severity of the disease (28,29). The sub-categories of MoCA, attention and delayed recall, were mostly influenced. To further evaluate these abilities, the SDMT and TMT tests were conducted. SDMT and TMT are professional neuropsychological scales for the assessment of attention, working memory and executive ability, which have higher sensitivity and accuracy than MoCA. The TMT consists of two parts. TMTa only contains numbers, while TMTb is more complicated with both numbers and symbols. Compared with TMTa, some scholars thought that the execution of TMTb requires higher-order cognitive ability and the synchronous coordination of the left and right brains (30). Despite the time expenditure of the four groups of subjects in this study increased with the severity of OSA in TMTa, there was no statistical difference. It was consistent with previous studies in which OSA attention was primarily manifested as mild impairment and severe dysfunction was uncommon (8). At the same time, the time spent by OSA patients in TMTb also increased, and significant differences were observed in the severe group, which also explained that cognitive impairment in the study subjects mainly occurred in the group of moderate to severe OSA. Therefore, although the degree of cognitive impairment varies greatly among individuals with OSA, the overall risk of impairment is steadily increasing.

Despite the center of this work is the part of Activities and Participation, we still evaluated other categories in the rest component. Through comparison of the fourteen categories of the ICF, we found some high-frequency categories, particularly category b130, b134, b440 and s330 in the functional and structural components of the body. As the initiating factors in the etiology of OSA and concomitant significant physical impairment, the statistical features of the outcomes closely matched the severity of OSA. It is also consistent with our previous findings indicating that the ICF Sleep Disorders Brief Core Set has good reproducibility in the assessment of OSA (14).

The Activities and Participation, as an important assessment component of ICF covering some main points of psychopsychiatry and disability, is consistent with SDMT, TMT, and MoCA. The performance of the two categories, d160 and d240, reflecting the abilities and motivations to work, showed significant statistical differences between the severe OSA group and the no OSA group, although its statistical significance was slightly weak when compared with body functions and structures. The performance of d475 in driving was not statistically different, but its impaired proportion was significantly higher in the severe OSA group.

For the treatment strategies of chronic diseases, except relieving the progress of the disease, how to improve the impaired performance in daily life and promote the occupational rehabilitation needs urgent attention. Accidents caused by impaired concentration and work ability are among the most prominent risk factors for the limitation of quality of life and activities in OSA patients, compared with death and disability of physical function. Therefore, assessing the impairment of activities and participation in OSA patients has important implications for their prognosis and recovery. Given the potential of the component Activities and Participation of ICF at the overall level of prognosis and rehabilitation, we investigated it in ICF Sleep Disorders Brief Core Set to predict impaired work ability in OSA patients. We compared their correlation with the component Activities and Participation of ICF Sleep Disorders Brief Core Set by regression analysis, and found that it was positively correlated with TMTa and TMTb, and negatively correlated with the correct number of SDMT. Since there was no statistical difference in TMTa among the four groups, we took the last 25%, the last 20% and the last 10% of SDMT and TMTb scores as the diagnostic cut-off points for impaired attention and work ability, and plotted the difference ROC curve by the different cut-off points. When the threshold of Activities and Participation was set as 4, its AUC, sensitivity and specificity in the prediction of impaired attention and work ability were more appropriate. In particular, the reliability of the component Activities and Participation in predicting effects was better in patients with moderate and severe OSA.

In addition to nocturnal hypoxemia, OSA's impact on cognitive and work ability impairments also include sleep

structure disorders, emotional imbalances, and abnormal brain metabolism, etc. Aseptic neuroinflammation and metabolic disturbances in the brain microenvironment caused by nocturnal hypoxemia result in neuronal apoptosis, gliosis, and synaptic dysfunction in cognitive-related brain regions. This is the basis for the abnormal physiological structure of brain cognition in patients with OSA (31). Daytime sleepiness combined with nocturnal sleep fragmentation and depressed mood caused by decreased energy affect the acquisition of short-term and long-term memory and the processing and storage of brain information during sleep (32,33). The accumulation of multiple organs and systems in the whole body and the additive effect of multiple comorbidities could directly or indirectly increase the risk of cognitive and work impairment in OSA (23,34). Therefore, paying attention to the impaired work ability of OSA patients is a difficult problem worthy of further exploration.

In this study, we identified the impaired performance of OSA patients by kinds of neuropsychological tests and validated the potential of ICF Sleep Disorders Brief Core Set in predicting firstly, especially the component of Activities and Participation. Same as the previous studies, our research also existed some limitations. Be limited to the size and characteristic of sample, the results from different researches were controversial (35,36). Besides, the component Activities and Participation of ICF Sleep Disorders Brief Core Set only contains three categories. Although representative and closely related to the most prominent functional impairments in OSA patients' activities and participation, it might not to some extent cover all aspects of work ability and activities. Therefore, our research is a preliminary exploration. Meanwhile, the mixed factors such as BMI, smoking, and hypertension were not excluded from the analysis of each neuropsychological test, as for we mainly focused on the overall performance status rather than identifying risk factors for impaired function. Therefore, the predictive ability of the ICF Sleep Disorder Brief Core Set should be further improved by incorporating relevant factors and adding categories to meet the needs of clinical practice.

Conclusions

This is the first study to identify the component Activities and Participation of ICF Sleep Disorders Brief Core Set in predicting impaired attention and work performance in OSA patients. It preliminarily evaluated that the categories in Activities and Participation component were closely related to the severity of hypoxia, impaired attention and working memory for OSA. Therefore, this tool performed the potential to predict the impaired attention and working performance of OSA, and further provided a new perspective on recognizing the dysfunction in daily life and improving the overall assessment efficiency for OSA patients.

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Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1446/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1446/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of Zhongshan Hospital of Fudan University (No. B2018-216(2)R). All informed consents were obtained from the participants before conducting sleep monitoring and questionnaires.

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