Original Research

Corresponding author:
Carlos Olivera-López;
Email: olivera168@comunidad.unam.mx

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Polysomnographic parameters associated with cognitive function in patients with major depression and insomnia

Carlos Olivera-López[1,4] , Alejandro Jiménez-Genchi[2] , David Ortega-Robles[2], Matilde Valencia-Flores[1], Selene Cansino[3] and Judith Salvador-Cruz[4]

[1]Laboratory of Sleep Disorders, Faculty of Psychology, National Autonomous University of Mexico, Mexico City, Mexico; [2]Clinical Services Unit, Sleep Clinic, National Institute of Psychiatry "Ramón de la Fuente Muñiz", Mexico City, Mexico; [3]Laboratory of NeuroCognition, Faculty of Psychology, National Autonomous University of Mexico, Mexico City, Mexico and [4]Faculty of Higher Studies Zaragoza, National Autonomous University of Mexico, Mexico City, Mexico

Abstract

Objective. To examine whether objective sleep parameters are associated with cognitive function (CF) in patients with major depressive disorder (MDD) with chronic insomnia (CI) and whether the severity of these disorders is related to CF.

Method. Thirty patients with MDD with CI attending a tertiary care institution underwent two consecutive nights of polysomnographic (PSG) recording and a battery of neuropsychological tests, which included episodic memory, sustained attention, working memory, and executive function. The severity of MDD and CI was assessed by clinical scales. We examined the relationship between PSG parameters and CF, as well as whether the severity of the disorders is related to CF.

Results. Linear regression analysis revealed that total sleep time (TST) was positively associated with higher learning and recall of episodic memory, as well as better attention. Slow-wave sleep (SWS) showed a positive association with better working memory. Furthermore, wake after sleep onset (WASO) was negatively associated with episodic memory and lower attention. No significant relationships were found between the severity of MDD or CI with CF.

Conclusion. Both sleep duration and depth are positively associated with several aspects of CF in patients with MDD with CI. Conversely, a lack of sleep maintenance is negatively related to CF in these patients. These findings could help identify modifiable therapeutic targets to reduce CF impairment.

Introduction

Major depressive disorder (MDD) is one of the most prevalent and severe mental illnesses worldwide, making it a significant public health issue.[1] Sleep disturbances are a common feature in MDD[2] patients, with chronic insomnia (CI) being the most prevalent.[3] It has been reported that as many as 90% of MDD patients experience CI concurrently,[4] and this comorbidity has been considered a distinct phenotype associated with greater dysfunction[5] and higher healthcare costs.[6] Cognitive function (CF) impairment is a frequently reported issue in both patient groups,[7,8] particularly difficulties in attention, memory, and executive functions.[9,10] Until now, the etiology of these impairments remains incompletely understood,[11] and it is believed that sleep may be a factor associated with CF in patients with this comorbidity.[12] This hypothesis is supported by the consistent association of objective sleep parameters, as determined through polysomnographic (PSG) data, with CF in healthy subjects.[13–19] However, it is important to consider that pharmacological treatment of MDD and CI may alter sleep patterns,[20] and the severity of these disorders could be related to CF.[21,22] For instance, it has been reported that in patients with a current episode of MDD[23] and in those with subclinical depression,[24] a decrease in subjective sleep quality is associated with worse performance on tasks of psychomotor speed, cognitive flexibility, and semantic fluency. Furthermore, both subjective sleep quality and depression severity independently predict self-reported cognitive impairment, but only sleep quality is associated with objectively measured cognitive impairment.[25] It has also been suggested that both shorter self-reported total sleep time (TST) and longer self-reported TST are associated with worse performance on attention and memory tasks (inverted U model).[26] Two studies that employed PSG found that shorter TST and increased wake after sleep onset (WASO) were linked to poorer performance on working memory and executive functioning tasks[27,28] in MDD patients. Research on insomnia patients, using PSG data and its relationship with CF, revealed a negative correlation between WASO and episodic memory recall.[29] Furthermore, a recent meta-analysis consistently reports that objectively short sleep duration (<6 hours) is

associated with impairments in attention, memory, and executive functions.[30] Until now, only one study has examined the relationship between sleep and CF in individuals with both MDD and CI using actigraphy. This study found that among men older than 50 years, poorer sleep efficiency (SE) was associated with reduced processing speed and executive function.[12] Interestingly, the severity of neither MDD nor CI was associated with CF. In terms of disorder severity, there is consistent evidence suggesting that the severity of CI is negatively related to CF in general, particularly in memory tests.[21] Meanwhile, the severity of MDD has shown negative correlations in some instances and no association with CF in others, as reported in recent reviews.[22] In summary, the available evidence indicates that sleep is associated with CF in both MDD and CI. However, the data have been limited due to subjective sleep assessments, insufficient control of sleep-related comorbidities requiring PSG assessment, and the monitoring of the effects of pharmacological treatment on sleep, as well as self-report-based assessments of CF.[11,12] To date, there are no studies that evaluate with PSG data the relationship between sleep and CF in individuals with both MDD and CI. In addition, the limited number of studies employing PSG has hindered the exploration of potential relationships involving sleep stages, including the role of slow-wave sleep (SWS), and its relationship on episodic memory[13–16] and working memory,[18] as observed in studies with healthy subjects. Therefore, it is essential to examine the association between objective sleep parameters and CF in patients with MDD and CI who do not have medical, psychiatric, or sleep-related comorbidities and are not taking medication. This analysis would enable us to examine whether sleep is a factor related to CF in this sample and could help identify modifiable factors that may contribute to reducing cognitive impairment in these patients.[12] Thus, the objectives of this investigation were as follows: 1) to examine the relationship between PSG parameters and CF in MDD patients with CI and 2) to assess whether the severity of MDD and CI is associated with CF. We hypothesize that both TST[26,27,28] and SWS will be positively associated with CF, as observed in healthy subjects[13–16,18] and patients with insomnia,[30] while WASO will have a negative association with CF.[27,28] Additionally, we expected that the severity of CI,[21] but not MDD, would be related to CF, primarily due to the persistence of cognitive impairments in remission of mood symptoms.[7]

Materials and methods

Participants

A total of 30 participants, aged between 19 and 59 years, were recruited from the National Institute of Psychiatry "Ramón de la Fuente Muñiz" (INPRFM), a tertiary care hospital in Mexico City, Mexico. Inclusion criteria required participants to have received a clinical diagnosis of MDD by a psychiatrist in accordance with the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V)[31] criteria, with concurrent CI as defined by the International Classification of Sleep Disorders, Third Edition (ICSD-3).[32] They were followed as outpatients and were not currently undergoing psychopharmacological treatment. No participant's medication was discontinued for inclusion in this study. Exclusion criteria included the presence of any other psychiatric disorder (DSM-V), substance abuse, suicidal risk, serious health conditions, chronic diseases, neurodegenerative disease, high risk of obstructive sleep apnea (OSA), and evidence of any sleep disturbance other than insomnia as confirmed by PSG (patient flow is

shown in Figure 1). The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The protocol was approved by the INPRFM Ethics and Research Committee (SC17070.0.), and all participants signed an informed consent form.

Assessments

Clinical assessments

Depressive symptoms: The validated Spanish version[33] of the Quick Inventory of Depressive Symptomatology—Self-Report (QIDS-SR) was applied,[34] with a higher score indicating greater severity of MDD. Additionally, specific cutoff points have been proposed, where <5 suggests the absence of depression, 6–10 indicates a mild disorder, 11–15 indicates a moderate level, and > 16 indicates a severe MDD.[35]

Insomnia symptoms: The Spanish validated version of the Insomnia Severity Index (ISI) was applied.[36] A higher ISI score suggests more severe insomnia, and specific cutoff points have been proposed that identify no insomnia (0–7); insomnia below the threshold (8–14); moderate insomnia (15–21); and severe insomnia (22–28).[37]
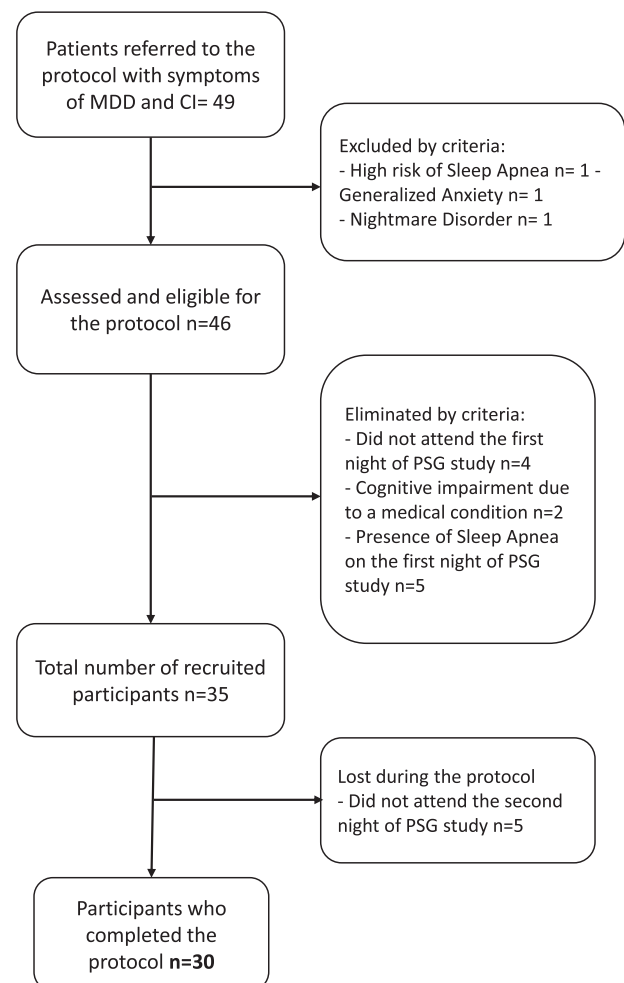

Figure 1. Patient flow. Abbreviations: MDD, major depressive disorder; CI, chronic insomnia; PSG, polysomnography.

Table 1. PSG and Nneuropsychological Characteristics of the Sample

PSG parameters	Mean (SD)
Total recording time $_{hr}$	8.0 (0.02)
Total sleep time $_{min}$	412.35 (39.02)
Latency to non–REM sleep $_{min}$	21.42 (30.85)
Latency to REM sleep $_{min}$	88.01 (34.33)
Awakenings (#)	20.59 (7.61)
Sleep efficiency (%)	86.83 (7.95)
WASO $_{min}$	41.77 (28.42)
Wake time $_{min}$	62.42 (37.61)
Sleep stages	
N1 $_{\% \text{ of TST}}$	8.29 (3.48)
N1 $_{min}$	33.90 (14.24)
N2 $_{\% \text{ of TST}}$	56.63 (7.26)
N2 $_{min}$	233.15 (35.46)
N3 $_{\% \text{ of TST}}$	13.58 (5.96)
N3 $_{min}$	56.56 (26.66)
REM $_{\% \text{ of TST}}$	21.50 (3.88)
REM $_{min}$	87.40 (21.77)
Arousal (#)	45.18 (13.09)
Cognitive functions[a]	
Episodic memory	
Learning[b]	7.18 (1.45)
Recall	8.03 (1.67)
Sustained attention	
Correct answer	170.7 (42.12)
Working memory	9.9 (2.20)
Trail Making Test	
Part A	42.31 (19.58)
Part B	92.59 (70.72)

Abbreviations: REM, rapid eye movements; TST, total sleep time; WASO, wake after sleep onset.
[a]Raw scores of the neuropsychological tests.
[b]For the learning section of the memory test, the average of the three trials was used.

Sleep assessment

Polysomnography (PSG): Two PSG studies were conducted following international standards (American Academy of Sleep Medicine (AASM)).[38] The first PSG aimed for habituation and to rule out any other sleep disturbances. For this study, electroencephalographic (EEG) variables with a full 10–20 montage, electrooculography (EOG), electrocardiography (EKG), electromyography (EMG) of the chin and anterior tibialis, and respiratory variables such as oronasal thermal flow, thoracoabdominal respiratory effort bands, and partial oxygen saturation were recorded. Data from the second night of recording were used for the analyses in this study to avoid the effect of the first night of sleep.[39] For this night, respiratory variables and EMG of the tibialis were omitted, and a 9-channel EEG montage was recorded (Fz-A1, Cz-A1, Pz-A1, F3-A2, C3-A2, O1-A2, F4-A1, C4-A1, and O2-A1). The following parameters were obtained: TST, latency to non-rapid eye movement (REM) and REM sleep; SE (TST/time in bed x 100); WASO;

number of awakenings and arousals; and the duration of each sleep stage: N1, N2, N3 (SWS), and REM. These variables are presented as descriptive data for the sample. However, only the parameters of TST (minutes), SE (%), WASO (minutes), and SWS (minutes) were included in the analysis as they have shown evidence of an association with cognitive functioning.[18, 26–30]

Neuropsychological assessment measures

Word List Memory Test: It is a measure of episodic memory consisting of the presentation of words in three trials to assess the memory curve (learning phase) and recall after 20 minutes. A higher score indicates a greater number of words recalled.[40]

Attention test D2: It is designed to measure the capacity for sustained and selective attention,[41] consisting of a selective search for relevant stimuli (letter "d" with two lines) within a matrix. The total number of correct answers was obtained as a score, which was used in subsequent analyses.

Letter–Number Sequencing Test: It is a subtest that is part of the Adult Intelligence Scale (Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV))[42] and is focused on the evaluation of working memory. It involves the verbal presentation of a series of mixed numbers and letters, where the subject must first repeat the numbers in increasing order and then the letters in alphabetical order. Scores on this test range from 0 to 30, with a higher score indicating better working memory performance.

Trail Making Test (TMT): The test is divided into two parts: Part A provides a measure of visual and attentional skills, psychomotor speed, and visual tracking; and Part B assesses complex attention, executive control, and cognitive flexibility.[43] The total time taken to complete the test was recorded, with higher scores indicating poorer performance in these functions.[44]

Procedures

Patients newly followed at the INPRFM with a diagnosis of MDD and comorbid CI were invited to participate in the study. Those who agreed were referred to the sleep clinic at the same institute, where they underwent a clinical interview conducted by a specialist in psychiatry and sleep. During this interview, the presence of neurodegenerative disease was ruled out, as well as comorbidity with any other psychiatric disorders using the Mini-International Neuropsychiatric Interview,[45] and the Berlin Questionnaire[46] was administered to identify individuals at high risk of OSA. Additionally, the QIDS-SR and ISI clinical scales were applied. Participants who met the inclusion criteria were scheduled for two consecutive nights of PSG recording, which took place 7 to 10 days after the initial evaluation. During this period, they underwent sleep monitoring (sleep diary) to ensure that they maintained their usual sleep schedules and were not sleep deprived. PSG recordings started between 22:00 and 23:00 hours and ended between 6:00 and 7:00 hours to coincide as closely as possible with their usual sleep schedules, which aligned with the average bedtimes of 80% of the participants, with each PSG recording lasting for 8 hours. At the end of the first night of recording, the participant left the laboratory and was instructed to go about their routine activities and return in the evening for the second PSG recording. Prior to the start of the second night, at approximately 19:00 hours, all participants underwent a neuropsychological test battery with an approximate duration of 60 minutes. All PSG recordings were scored according to the AASM manual for sleep staging and associated events[38] by an independent sleep specialist who was not involved in the research.

Table 2. Association between PSG Parameters and Cognitive Function

		B	B	90% CI	t	p
Learning	TST	0.016	0.437	0.005 to 0.027	2.882	0.008*
	SE	0.045	0.248	−0.016 to 0.106	1.506	0.144
	WASO	−0.012	−0.238	−0.031 to 0.007	−1.294	0.207
	SWS	0.010	0.197	−0.008 to 0.029	1.152	0.260
Recall	TST	0.021	0.509	0.007 to 0.034	3.139	0.004*
	SE	0.055	0.272	−0.020 to 0.130	1.513	0.142
	WASO	−0.027	−0.508	−0.046 to −0.008	−2.873	0.008*
	SWS	0.018	0.325	−0.002 to 0.038	1.827	0.080
Sustained attention	TST	0.383	0.367	0.076 to 0.690	2.566	0.016*
	SE	1.827	0.348	0.255 to 3.398	2.390	0.024*
	WASO	−0.541	−0.371	−1.013 to −0.069	−2.360	0.026*
	SWS	0.397	0.276	−0.107 to 0.900	1.623	0.117
Working memory	TST	0.005	0.109	−0.014 to 0.025	0.585	0.564
	SE	0.020	0.079	−0.078 to 0.117	0.418	0.680
	WASO	−0.020	−0.294	−0.050 to 0.009	−1.417	0.169
	SWS	0.028	0.403	0.003 to 0.052	2.330	0.028*
TMT A	TST	0.045	0.114	−0.115 to 0.204	0.577	0.569
	SE	0.294	0.150	−0.511 to 1.098	0.752	0.459
	WASO	−0.145	−0.265	−0.394 to 0.105	−1.193	0.244
	SWS	0.111	0.194	−0.120 to 0.343	0.991	0.331
TMT B[a]	TST	−0.001	−0.203	−0.003 to 0.001	−1.022	0.316
	SE	−0.005	−0.223	−0.013 to 0.004	−1.114	0.276
	WASO	0.0004	0.075	−0.002 to 0.003	0.323	0.750
	SWS	0.0002	−0.034	−0.003 to 0.002	−0.166	0.869

Note: All variables adjusted for age and schooling, *significant p values following the Benjamini–Hochberg procedure for controlling the false discovery rate.
Abbreviations: TMT, Trail Making Test; TST, total sleep time; SE, sleep efficiency; SWS, slow-wave sleep; WASO, wake after sleep onset.
[a]Log-transformed variable, B = unstandardized coefficients, B = standardized coefficients.

Data analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25. Percentages, means, and standard deviations of sociodemographic and clinical variables for the sample, as well as the PSG and CF variables, are reported. All variables underwent descriptive analysis, and those with skewness greater than ±2 were transformed into natural logarithms. We examined the relationship between PSG parameters and CF using multiple linear regression analysis for each PSG variable (TST, SE, WASO, and SWS) and each assessed cognitive variable. Due to the high multicollinearity among the PSG parameters, a multiple analysis would not have allowed us to identify the possible influence of each factor. We controlled for the effect of schooling and age by including them as covariates, considering their known relationship with CF.[47] Finally, we examined the association between the severity of MDD, CI, and CF using multiple linear regression controlling for age, schooling, and PSG variables that were significantly associated with CF in the previous analysis. For each pair of variables examined, we a priori assessed homoscedasticity and linearity with the dependent variable.[48] To control for multiple regressions, we applied the Benjamini–Hochberg procedure[49] (with a false discovery rate of 0.10).

Results

The sample consisted of 30 participants, 16 women and 14 men, with an average age of 37.5 (standard deviation) (13.2) years (range = 19–59) and a schooling age of 14.2 (3.6) years (range = 9–19). About 73.3% of the sample had undergraduate or graduate studies. With an average body mass index of 24.29 (3.59), participants reported consuming an average of 0.30 (0.55) alcoholic drinks per day and 0.52 (0.84) cups of coffee per day. The clinical scales indicated a high mean severity, both in the MDD (21.8 (5.4)) and in the CI (20.6 (3.8)). All variables exhibited skewness less than ±2, except for the TMT part B variable, which had a skewness = 3.83. This variable was transformed using natural logarithm (skewness = 1.19).

PSG and neuropsychological characteristics

All participants exhibited an apnea–hypopnea index (AHI) of 1.20 (1.26) and a periodic limb movement index (PLM) of 6.55 (7.90), within normal ranges on the first night.[32] Table 1 presents the PSG parameters of the second night as well as the scores of the cognitive variables. The percentage of the sample exhibiting CF difficulties
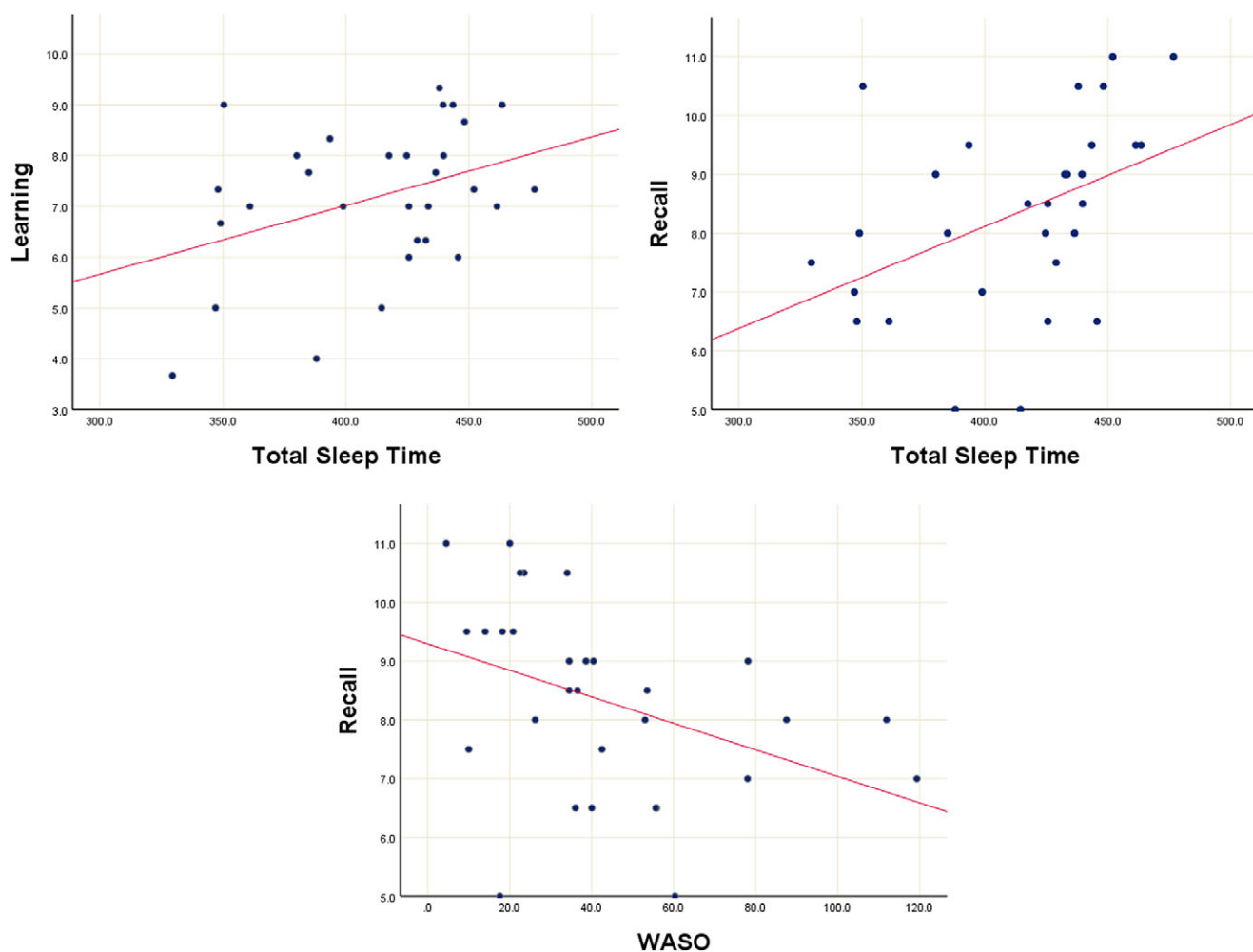
Figure 2. Dispersion of scores between PSG parameters and episodic memory. Abbreviations: WASO, wake after sleep onset.

falling below the first standard deviation was 20% for the word list memory test in the learning subtest and 16.6% in recall. Twenty percentage showed poor performance in the sustained and divided attention test (D2), while only 6.6% in the Letter–Number Sequencing Test, as well as 23.3% in the TMT-A and 16.6% in part B.

PSG factors associated with CF

Episodic memory
All the analyses between the PSG parameters and each of the cognitive variables are detailed in Table 2. In the learning subtest, it was observed that only TST showed a significant positive association with the number of words learned. Meanwhile, for the recall subtest, TST exhibited a positive association, while WASO showed a negative association with word recall. The dispersion of these associations is shown in Figure 2.

Sustained attention
In the sustained and divided attention test, a positive association was observed between better attention performance and an increase in TST and SE. Additionally, a negative relationship was found between WASO and attention (see Figure 3).

Working memory
A positive association was found between SWS and higher performance in working memory (see Figure 4).

TMT
No association was found between the PSG parameters and the scores obtained in both parts A and B of the TMT.

Association between severity of MDD and CI with CF

All the analyses between depression and insomnia severity and each of the CF variables are detailed in Table 3. No significant relationship was found between the severity of MDD or CI with CF (see Table 3). However, a trend was noted between CI severity and word recall, as well as working memory.

Discussion

To the best of our knowledge, this study is the first to utilize PSG data to examine the relationship between sleep and CF in patients with MDD comorbid with CI. Our findings suggest that TST, SE, and SWS are positively associated with CF, whereas WASO is negatively correlated. These results remained consistent after controlling for the age and schooling of the participants, as well as the
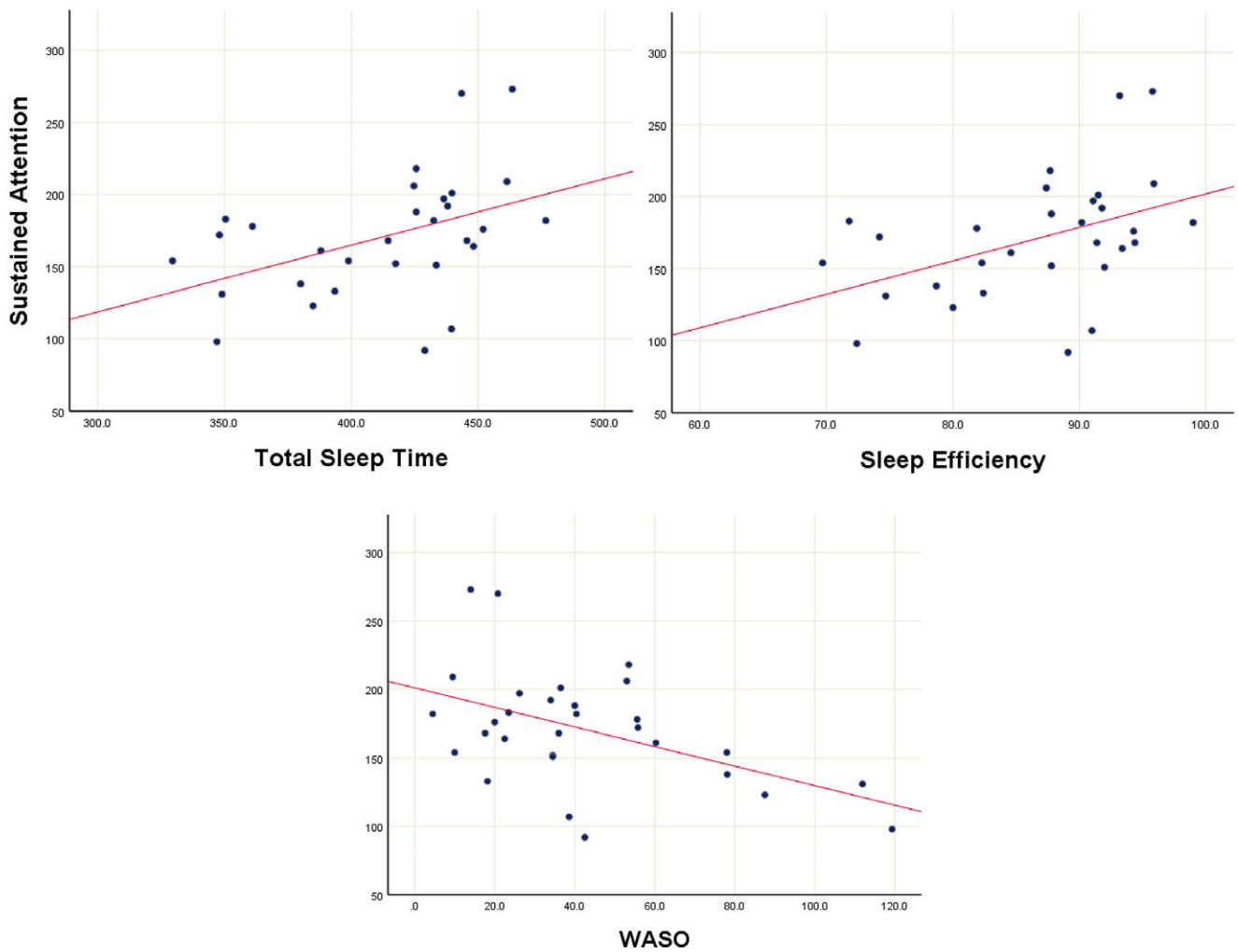
Figure 3. Dispersion of scores between PSG parameters and sustained attention. Abbreviations: WASO, wake after sleep onset.

Table 3. Association Between Depression Severity, Insomnia, and Cognitive Function

		B	*B*	90% CI	T	*p*
Learning	MDD[a]	0.044	0.151	−0.070 to 0.159	0.793	0.436
	CI[a]	0.029	0.077	−0.099 to 0.157	0.469	0.643
Recall	MDD[a]	−0.068	−0.228	−0.185 to 0.048	−1.212	0.237
	CI[a]	−0.151	−0.354	−0.286 to −0.016	−2.315	0.029
Sustained attention	MDD[a]	0.807	0.102	−2.453 to 4.067	0.511	0.614
	CI[a]	2.004	0.183	−1.297 to 5.305	1.250	0.223
Working memory	MDD[a]	−0.146	−0.353	−0.291 to −0.002	−2.086	0.048
	CI[a]	−0.190	−0.332	−0.367 to −0.013	−2.205	0.037
TMT A	MDD	0.343	0.109	−1.188 to 1.875	0.462	0.648
	CI	0.552	0.135	−1.103 to 2.207	0.687	0.498
TMT B[b]	MDD	2.504	0.393	−0.499 to 5.508	1.717	0.098
	CI	1.160	0.140	−2.256 to 4.575	0.699	0.491

Note: All variables adjusted for age and schooling, *significant *p* values following the Benjamini–Hochberg procedure for controlling the false discovery rate.
Abbreviations: CI, chronic insomnia; MDD, major depressive disorder; TMT, Trail Making Test.
[a]Adjusted for sleep variable.
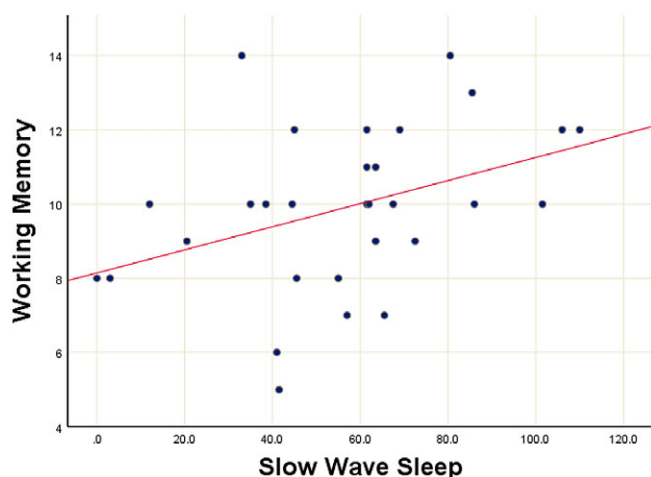[b]Log-transformed variable, B = unstandardized coefficients, *B* = standardized coefficients.

Figure 4. Dispersion of scores between PSG parameters and working memory.

absence of other sleep disorders or pharmacological treatments that could affect the results. Furthermore, we found no association between the severity of MDD or CI and CF in this sample of patients.

Specifically, TST is positively associated with word learning and recall in an episodic memory task, while WASO is negatively related to recall. These results are aligned with findings suggesting that TST is linked to memory task performance in patients with MDD[26] and in individuals with CI who have objectively short sleep duration.[30] Additionally, WASO has been reported to be negatively associated with episodic memory in both patient groups.[27,28,29] This association could be explained by the active role of sleep in memory consolidation,[13] which involves the reactivation of top-down networks between the cortex and the hippocampus during sleep.[13-14] In addition, it has been shown that sleep not only benefits memory consolidation but also enhances the encoding of new material.[50,51] There is strong evidence that SWS plays a crucial role in memory consolidation in healthy subjects.[13,14,15,16] However, our results did not reveal a significant relationship between SWS and episodic memory recall; we only observed a trend in that direction. This could be explained by the observed decrease in SWS in both patients with MDD and CI.[52,53] This trend is also present in our sample, potentially influencing the strength of this association.

Regarding attention, our findings indicate that TST is positively associated with better performance in a sustained and selective attention task, while WASO is negatively related to this function. This relationship has been extensively explored in sleep deprivation models,[17,19] and it is well established that reduced TST impairs daytime attention levels. This is related to the accumulation of homeostatic sleep pressure, where decreased sleep leads to an increased need for sleep, resulting in a cumulative decrease in alertness.[17] A striking finding is that, despite not observing a significant reduction in TST in our sample, which averaged around 7 hours, an increased WASO is associated with worse attention performance. This observation suggests that increased WASO, commonly reported in CI,[52] may itself be a risk factor related to the attention problems reported by these patients.[30-32] Therefore, not only the amount of sleep but also the maintenance of sleep throughout the night is an important factor for optimal attention levels.

Another notable finding was the improvement in TST and SE on the second night of PSG recording, showing higher values than expected for this population. However, not all patients exhibited

improvement, suggesting that there was no global sleep rebound. These changes are likely associated with the first-night sleep effect described in patients with insomnia.[39] This effect may arise from maladaptive associations between the insomniacs' sleep issues and their familiar sleep environment, which are disrupted by a new sleep setting in the laboratory where patients appear to fall asleep more readily.[54] Another plausible explanation is that the sample comprised newly followed ambulatory patients, possibly resulting in less objective sleep disturbance, as reported in MDD patients from the general population.[55]

Finally, we observed a positive association between the duration of SWS and higher working memory. Previous studies have not explored this association in patients with MDD or CI. Nevertheless, our findings are consistent with studies in healthy subjects, which have shown that increased SWS predicts better performance on working memory tasks.[18] In addition, an increase in slow-wave activity has been observed during sleep following training on a working memory task.[56] This could be related to the regulation of the homeostatic need for sleep by SWS,[57] which is associated with cortical plasticity and improved cognitive task performance.[58,59] This suggests that sleep depth may have a stronger relationship with higher CFs.[15] This finding is particularly relevant in our sample, as working memory impairment has been documented in patients with CI, especially with objective sleep assessments.[60] However, we failed to observe an association between SWS and other executive functions, such as those assessed in the TMT. Therefore, it is likely that more sensitive tests are needed to evaluate executive function in this group of patients and gain a better understanding of the influence of SWS on these functions.

Our results showed no significant association between the severity of MDD or CI and CF. We only observed a trend between CI severity and CF, which aligns with our initial hypothesis and with findings from other research.[21] However, these findings are likely limited by our sample size. On the other hand, we did not expect to find a relationship between MDD and CF, mainly due to inconsistent findings in the literature.[22] Furthermore, evidence suggests that a significant portion of cognitive impairments persist beyond acute episodes of depression,[7,61,62] and deficits in selective attention, working memory, and long-term memory have been reported to persist even during remission from a major depressive episode.[63] Therefore, it is important to consider that sleep may play a larger role in its association with the CF observed in this group of patients and to recognize the implications this has for their treatment. For instance, cognitive behavioral therapy for insomnia has demonstrated the potential to enhance cognition in patients with MDD and CI.[64,65] This therapy has also shown effectiveness in improving various sleep parameters, including TST and WASO.[66] Additionally, stimulating SWS in depressed patients could potentially improve CF.[67] In the future, these techniques and others that are developed should focus on promoting a more natural sleep that is reflected in objective sleep parameters.

Limitations, implications, and future directions

There are several limitations that should be considered when interpreting and generalizing our findings. One limitation is the relatively small sample size and potential referral bias, as our participants were from a tertiary care setting. Additionally, we did not control for activities performed between PSG studies; participants were only advised to carry out their routines, which could have influenced their sleep on the second night. Smoking history was also not considered in our analysis. For future studies, it

would be important to include a comparison group, comprising individuals with insomnia but without depressive symptoms or healthy controls matched for age and educational background. This would help to determine the association of each disorder with CF. Furthermore, including patients with a wider range of severity in both MDD and CI could provide a more comprehensive understanding of the potential moderating effect of disorder severity on the relationship between sleep and CF. Additionally, conducting neuropsychological tests both before and after a night of sleep could offer valuable insights into how prior sleep influences CF.

In conclusion, our findings highlight the importance of sleep and its relationship with CF in individuals presenting the MDD phenotype with CI. TST, SWS, and WASO are critical parameters linked to CF. Therefore, these parameters could serve as targets for therapeutic interventions aimed at addressing cognitive impairments in these patients. It is essential for mental health professionals to recognize the potential benefits of sleep-focused interventions within the context of mood disorders. Furthermore, future research should explore the connection between objective sleep parameters and various health outcomes, enabling the development of tailored treatments and even preventive strategies such as those currently recognized as sleep health.[68]

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