Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Effect of body mass index on selective attention and cognitive flexibility in resident physicians before and after an on-call shift

Luis Fernando Jácome-Suarez
Servicios de Salud del Instituto Mexicano del Seguro Social para el Bienestar
Jorge Iván Zurutuza-Lorméndez
Secretaria de Salud
Jaime Morales-Romero
Universidad Veracruzana
María del Sagrario Pérez-Callejas
Universidad Veracruzana
Felipe de Jesús Hernández-Castellanos
Mexican Social Security Institute
Juan Manuel Flores-Ayala
Universidad Nacional Autónoma de México
Juan Hernández-Domínguez
Mexican Social Security Institute
Leonel Efrén Rivera-Pinete
Secretaria de Salud
Liliana Ovando-Diego
liliana.ovando@imss.gob.mx

Mexican Social Security Institute

Research Article

Keywords: Attention, Sleep Quality, Cognitive Flexibility, Shift Work Schedule, Internship and Residency, Sleep Deprivation

Posted Date: November 20th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11513060/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Introduction:

Selective attention and cognitive flexibility are essential functions for complex professional activities, including medical practice. The objective was to analyze the correlation between body mass index, selective attention and cognitive flexibility, considering sleep deprivation. **Methods**: A prospective cohort study was conducted in 76 first-year resident physicians. Anthropometric measurements were obtained. Cognitive performance was measured before and after an on-call shift using the Stroop Test, the Symbol–Digit Test and the Trail Making Test (TMT-A and TMT-B). Statistical tests for related samples and correlation analyses were applied.

Results

Overall, 97.4% of participants obtained a score indicating poor sleep quality (> 5 points), and 60.5% had overweight or obesity. The ability to switch between tasks (Stroop Test) decreased after the on-call shift ($p < 0.05$). Processing speed (Symbol–Digit Test) improved, with a reduction in completion time ($p < 0.01$). In linear regression models for the post-shift assessments, BMI was associated with the scores on the TMT part A, Stroop Test page 2 and Symbol–Digit Test ($p < 0.05$). **Discussion**: Most physicians in training have poor sleep quality and chronic sleep deprivation, as well as overweight or obesity. This study shows a negative correlation of higher body mass index and sleep deprivation with cognitive flexibility and selective attention.

1. Introduction

In Mexico, overweight and obesity affect 74.5% of the population (prevalence of overweight 37.4% [95% CI 36.5–38.2] and of obesity 37.1% [95% CI 36.2–38.1]) (Rodríguez Barreto et al., 2016); it is therefore essential to measure the effect of this variable on all aspects of human life, particularly on the higher executive functions involved in decision-making. A higher body mass index is currently associated with poorer performance on instruments measuring attention, memory and higher executive functions in general (Costache et al., 2023; La Marra et al., 2022; Lentoor & Myburgh, 2022). The cause has not been established, but it is plausibly related to a chronic low-grade inflammatory process driven by visceral adipose tissue and its function as an endocrine organ (La Marra et al., 2022; Uranga & Keller, 2019). The changes that this inflammatory process may induce in the central nervous system include anatomical changes in grey and white matter volume across several regions, and physiological changes related to impaired metabolic processes and neuronal function (Uranga & Keller, 2019).

Sleep, in turn, is a fundamental biological process in all human beings. During rest, the brain consolidates memory, clears metabolites and reorganizes its synaptic networks, laying the foundations for cognitive performance and emotional balance on the following day (Ayala Servin et al., 2022). When this process is disrupted in a sustained manner, the consequences extend beyond sleepiness, leading to

systemic deterioration with physiological, immunological, metabolic and neurocognitive alterations(Khan & Al-Jahdali, 2023; Zurutuza et al., 2024). Chronic sleep deprivation directly promotes weight gain and reduces attention, processing speed and cognitive flexibility—capacities that enable individuals, especially healthcare personnel, to adapt to unforeseen situations and make decisions under pressure(Cooper et al., 2018; Khan & Al-Jahdali, 2023; Mota Albuquerque et al., 2023; Ramier et al., 2024; Shaik et al., 2022; Tan et al., 2026; Vidović et al., 2025; Zurutuza et al., 2024).

Resident physicians play a key role in healthcare delivery within the Mexican health system (Anuradha et al., 2022), particularly in public healthcare institutions such as the Mexican Social Security Institute (IMSS), since they provide continuous patient care. Throughout their training, resident physicians are exposed to continuous sleep deprivation (Binjabr et al., 2023; Vidović et al., 2025), which may reduce their capacity to perform clinical duties and directly affect the quality of the care they provide(Zurutuza et al., 2024) .

The type and duration of work shifts, residents' responsibilities and the stress arising from their professional activity have multiple repercussions on their health and decision-making capacity (Špiljak et al., 2022; Tan et al., 2026). These conditions vary(Shaik et al., 2022; Špiljak et al., 2022), but their negative effect has been documented as an increase in body mass index (BMI) and a decline in performance on neuropsychological tests of attention and processing speed (Daher et al., 2024) .

Furthermore, two higher executive functions have been reported to be impaired by both obesity and sleep deprivation: selective attention, defined as the ability to focus on relevant stimuli and filter out distractions, which is related to the capacity to adapt and alternate between different tasks or situations; and cognitive flexibility, the function that allows behavior to be adapted in response to a new demand from the work environment, enabling individuals to disengage from the current task and address a new one, thus providing the capacity to perform multiple consecutive tasks(Corbo et al., 2024). Both play a key role in optimal physician performance, as physicians must maintain attention on patients and adapt rapidly to changing clinical scenarios (Mota Albuquerque et al., 2023) .

This study arises from the need to generate context-specific evidence on the relationship between two higher executive functions (attention and cognitive flexibility), BMI and sleep in Mexican resident physicians. Its implications bear directly on patient safety, the well-being of physicians in training and the appropriateness of institutional policies governing the organization of medical work. Accordingly, the aim of this article is to analyze the relationship between selective attention, cognitive flexibility and body mass index, considering sleep deprivation and sleep quality, in first-year resident physicians.

2. Materials and Methods

2.1. Study design

A multicenter, correlational, prospective cohort study was conducted at three specialist physician training sites, including resident physicians in primary care (Family Medicine Unit No. 66 and Family

Medicine Unit No. 06) and specialized care (General Zone Hospital No. 11). Participants were recruited between November 2024 and February 2025. The study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) reporting guideline.

2.2. Study population

First-year resident physicians active during the 2024–2025 academic year, assigned to the participating sites and who signed informed consent, were included. The primary care specialty was family medicine, whereas the specialized care specialties were anesthesiology, general surgery, obstetrics and gynecology, internal medicine, pediatrics, orthopedics and traumatology, and emergency medicine

The inclusion criteria were as follows: resident physicians who had completed 10 to 11 months of the first-year program, in order to ensure exposure to the clinical activities of their specialty; no vacation period in the previous 3 months; and no prior diagnosis of anxiety, depression or neurodivergence (autism, attention-deficit/hyperactivity disorder [ADHD]), nor any history of neurological disease, brain injury or profound sensory loss (severe blindness or hearing loss). Residents who reported frequent, high-intensity exercise as high-performance athletes; who reported use of medications affecting the sleep–wake cycle or alertness; who had an external rotation outside their training site during the month immediately preceding the assessment; and who reported use of drugs such as amphetamines, cocaine or hallucinogens such as lysergic acid diethylamide (LSD) or psilocybin mushrooms were excluded. All resident physicians who met the selection criteria agreed to participate in the study. The final sample comprised 76 participants

2.3. Data collection and processing

Demographic data were collected on sex, specialty, training site, marital status, body mass index, alcohol, tobacco and cannabis use, chronic non-communicable diseases, physical activity and number of children. The survey was administered in person in a classroom specifically prepared for testing, either individually or in groups of up to 3 participants, so that questions could be easily resolved.

The data collection form, together with the PSQI, the Stroop Test, the TMT and the Symbol–Digit Test, was administered before the start of the working day (between 07:00 and 08:00 h), prior to a 24-h on-call shift and after a meal (light breakfast provided by the hospital). The second assessment comprised only the Stroop Test, the TMT and the Symbol–Digit Test, and was administered between 13:00 and 14:00 h, after the on-call shift.

2.4. Anthropometry

Weight and height were measured during the first assessment, before breakfast. Measurements were obtained using the same calibrated scale and the same flexible medical tape for all study participants; each measurement was taken three times per participant, and the mean value was recorded.

2.5. Sleep quality

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a 19-item instrument covering seven components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction), with a global score ranging from 0 to 21. Scores > 5 indicate poor sleep quality. The PSQI has been validated in the Mexican population*(*Royuela Rico & Macías Fernández, 1997*)* .

2.6. Selective attention, cognitive flexibility and processing speed

To assess cognitive performance, the Stroop Test was used to evaluate selective attention and inhibitory control by quantifying the number of items correctly named in 45 seconds per page. The Symbol–Digit Test records the number of correct responses in 90 seconds, reflecting processing speed and sustained attention Meyer(Meyer et al., 2024; Zheng et al., 2024). Cognitive flexibility was assessed using the Trail Making Test (TMT), parts A (numerical sequencing from 1 to 25) and B (number–letter alternation), recording completion time and number of errors, which allows processing speed and cognitive flexibility to be measured. All instruments have been validated in Spanish-speaking and Mexican populations (Camacho Ruíz et al., 2010; Ramos-Galarza et al., 2018; Rodríguez Barreto et al., 2016). These tests are examiner-administered, easy to explain and quick to complete.

2.7. Statistical analysis

Descriptive statistics were calculated, including measures of central tendency and dispersion for continuous variables, and frequencies and percentages for categorical variables. The normality assumption for continuous variables was assessed using the Kolmogorov–Smirnov test with Lilliefors correction, and homoscedasticity using Levene's test. For pre- versus post-shift comparisons, statistical tests for related samples were used (paired Student's t-test or Wilcoxon signed-rank test, according to the distribution of each variable). Spearman's rank correlation coefficient (ρ) was used to determine the correlation between PSQI scores and cognitive scores (owing to the data distribution). Statistical significance was set at $p < 0.05$.

Simple linear regression models were constructed to estimate the effect size of the variables of interest on the scores obtained on the instruments, both pre- and post-shift. In this modelling, the dependent variables were each of the scores obtained on the instruments administered after the on-call shift, whereas the independent variables tested were the residents' characteristics; the best-fitting models were selected. For regression modelling, independence was assessed by plotting standardized residuals against the fitted values of the response variable and against the predictor variable separately. The linearity assumption was tested using the lack-of-fit test with a specific F statistic. Outliers in the regression models were identified by calculating Cook's distance; once identified, justified removal (data entry error, implausible case) was evaluated, and conditional imputation using the sample median was not required. The use of Huber robust regression algorithms was not required.

Statistical analyses were performed using IBM SPSS Statistics for macOS version 30.0.2 and Epidat version 4.2; figures were generated using GraphPad Prism 11.1.0.

2.8. Ethics approval

The study protocol was approved by the Research Committee and the Research Ethics Committee of the Mexican Social Security Institute (registration number R-2024-785-053). All resident physicians were informed of the purpose of the study and provided written informed consent.

3. Results

3.1. Sociodemographic characteristics

A total of 76 first-year resident physicians from different specialties at three IMSS training sites were included. The median age was 28 years (25th percentile [P25] 27, 75th percentile [P75] 30.5); 53.9% were women (41 cases). The most frequent specialties were family medicine (26.3%; 20 residents), emergency medicine (18.4%; 14 residents) and pediatrics (17.1%; 13 residents). The vast majority were single (94.7%). These data are shown in Table 1.

Table 1
Descriptive characteristics of the surveyed resident physicians

Variable	Categories	Statistic	
Age, years, *Mdn* (P_{25}, P_{75})		28 (27, 30.5)	
Sex *(n, %)*	Female	41	53.9
	Male	35	46.1
Training site *(n, %)*	Secondary care hospital	56	73.7
	Primary care unit	20	26.3
Specialty *(n, %)*	Anesthesiology	10	13.2
	General surgery	5	6.6
	Obstetrics and gynecology	4	5.3
	Family medicine	20	26.3
	Internal medicine	6	7.9
	Pediatrics	13	17.1
	Orthopedics and traumatology	4	5.3
	Emergency medicine	14	18.4
Marital status *(n, %)*	Single or divorced	72	94.7
	Married	4	5.3
BMI category *(n, %)*	Normal weight	30	39.5
	Overweight	31	40.8
	Obesity class I	14	18.4
	Obesity class II	1	1.3
Frequent alcohol use *(n, %)*	Yes	47	61.8
	No	29	38.2
Frequent tobacco use *(n, %)*	Yes	14	18.4
	No	62	81.6
Cannabis use *(n, %)*	Yes	2	2.6
	No	74	97.4

Abbreviations: Mdn = median, P25 = 25th percentile, P75 = 75th percentile.

Variable	Categories	Statistic	
Diabetes mellitus *(n, %)*	Yes	2	2.6
	No	74	97.4
Coffee intake, cups/day, *Mdn (P_{25}, P_{75})*		2 (1, 2.8)	
Body mass index, kg/m², *Mdn (P_{25}, P_{75})*		26.4 (23.7, 28.7)	
Number of children, *Mdn (P_{25}, P_{75})*		0 (0, 0)	
Physical activity, hours/week, *Mdn (P_{25}, P_{75})*		1.8 (0, 3)	
Abbreviations: Mdn = median, P25 = 25th percentile, P75 = 75th percentile.			

3.2. Clinical characteristics and medical history

Regarding body mass index (BMI), 39.5% of residents had normal weight (30 residents); however, the median BMI was 26.4 kg/m² (P25–P75 23.7, 28.7). Residents reported a median of 5 hours of sleep per night (P25–P75 4.5, 6) and a median coffee intake of 2 cups per day (P25–P75 1, 2.8). Alcohol use was reported by 61.8% (47 residents), tobacco use by 18.4% (14 residents) and cannabis use by 2.6% (2 residents). Median weekly physical activity was 1.8 hours (P25–P75 0, 3). These data are shown in Table 1

3.3. Sleep quality (PSQI)

The median sleep duration was 5 hours (P25–P75 4.5, 6), and the median global PSQI score was 12 points (P25–P75 8.5, 14). Overall, 97.4% of participants (74 residents) obtained a score consistent with poor sleep quality (> 5 points). When classified by severity, 22.4% had a severe disturbance (17 residents), 57.9% a moderate disturbance (44 residents) and 17.1% a mild disturbance (13 residents). Only 2 residents (2.6%) showed no significant disturbance. Subjective sleep quality was rated as very bad by 7.9% (6 residents) and as bad by 59.2% (45 residents). Daytime sleepiness while driving, eating or engaging in educational or clinical activities affected 34.2% (26 residents) three or more times a week and 43.4% (33 residents) once or twice a week. Maintaining enthusiasm to carry out these activities was a very big problem for 6.6% of residents (5 residents) and somewhat of a problem for 35.5% (27 residents). A total of 6 residents (7.9%) reported taking sleeping medication three or more times a week, and another 7.9% (6 residents) reported taking sleeping medication at least once a week. Fifty-six resident physicians (73.7%) slept alone. *These data are shown in Supplementary Table 2.*

3.4. Correlation between variables: BMI, sleep quality and cognitive performance instruments

The relationships between the PSQI score, body mass index and the instruments used to measure selective attention and cognitive flexibility before and after the 24-h on-call shift were analysed using Spearman's correlation test. The results are presented in the correlation heat map in *Supplementary*

Fig. 1, and the complete correlation table is provided in *Supplementary Table 2 and Supplementary Table 3.*

Among the statistically significant correlations ($p < 0.05$), the most relevant were the negative correlation between the PSQI and BMI (ρ − 0.193) and the correlation with the post-shift Symbol–Digit Test (ρ − 0.193). Regarding the resident's age, several correlations were observed: before the on-call shift, with the number of errors on the Trail Making Test Part A (ρ 0.255) and with Stroop Test page 1 (ρ − 0.22); and after the on-call shift, with the number of errors on the Trail Making Test Part A (ρ 0.287).

A relevant finding was the correlation between BMI and several instruments: in the pre-shift assessment, with Trail Making Test part A time (ρ − 0.248), with Trail Making Test Part B for both time (ρ − 0.226) and number of errors (ρ − 0.218), and with Stroop Test page 2 (ρ 0.238); and in the post-shift assessment, with Trail Making Test part A time (ρ − 0.210), Stroop Test page 2 (ρ 0.218) and the Symbol–Digit Test (ρ 0.245).

3.5. Changes in cognitive performance before and after a 24-h on-call shift

As described in the Methods section, the selective attention and cognitive flexibility instruments were administered at two time points (before and after a 24-h on-call shift); the results are shown in Table 2 *and Supplementary Fig. 2*. For the Trail Making Test part A, the median completion time increased by 2.9 seconds, whereas the number of errors did not increase; neither difference was statistically significant. For the Trail Making Test part B, the median completion time decreased by 3.3 seconds; however, the interquartile range (25th–75th percentile) widened. Likewise, there was no difference in the number of errors, and no differences were statistically significant. Performance on all three pages of the Stroop Test decreased significantly after the on-call shift (all $p < 0.05$), with a reduction in mean time of 3.6 seconds for page 1, a reduction in median time of 1 second for page 2 and a reduction in median time of 2.4 seconds for page 3. Finally, the Symbol–Digit Test showed a statistically significant reduction in median time of 1.5 seconds ($p < 0.01$).

Table 2
Differences in neuropsychological test performance before and after a 24-h on-call shift.

Instrument	Pre-shift	Post-shift	*p value*
Trail Making Test part A (time, seconds) *Mdn (P_{25}, P_{75})*	22.6 (19.4, 32.5)	25.5 (20.8, 31.5)	0.08[a]
Trail Making Test part A (number of errors) *Mdn (P_{25}, P_{75})*	0 (0, 0)	0 (0, 0)	0.59[a]
Trail Making Test part B (time, seconds) *Mdn (P_{25}, P_{75})*	59.5 (44.9, 72.5)	56.2 (47.9, 78.5)	0.82[a]
Trail Making Test part B (number of errors) *Mdn (P_{25}, P_{75})*	0 (0, 1)	0 (0, 1)	0.77[a]
Stroop Test, page 1 *mean (SD)*	106.6 (16.6)	103 (18.8)	< 0.01[b*]
Stroop Test, page 2 *Mdn (P_{25}, P_{75})*	74 (68, 80.5)	73 (62.3, 80.5)	0.03[a*]
Stroop Test, page 3 *mean (SD)*	52.2 (11.1)	49.8 (11.5)	0.02[b*]
Symbol–Digit Test *Mdn (P_{25}, P_{75})*	56 (50, 61)	54.5 (48, 58)	< 0.01[a*]

Abbreviations: Mdn = median, P25 = 25th percentile, P75 = 75th percentile, SD = standard deviation.
Tests used: [a] Wilcoxon signed-rank test for related samples, [b] One tailed paired Student's t-test.
*Statistically significant value

Notably, the instruments administered were correlated with each other, both between their pre- and post-shift administrations and across the different instruments, irrespective of the time of administration.

3.6. BMI and its effect on cognitive performance

Instrument scores were compared between residents with normal weight and those with obesity; a summary of this analysis is presented in Table 3 and *Supplementary Fig. 3* (statistically significant results only). Differences were identified in TMT part A time both before and after the on-call shift, in TMT part B time and errors before the on-call shift, in Stroop Test page 2 before and after the on-call shift, and in the Symbol–Digit Test before the on-call shift, all with $p < 0.05$. A possible association between BMI and sleep quality was explored; although there was no statistically significant difference, one resident had good sleep quality and belonged to the normal-weight group, whereas none in the obesity group had good sleep quality.

Table 3
Differences in neuropsychological test performance according to BMI

Instrument	Normal weight	Obesity	*p value*
Trail Making Test part A (time, seconds), pre-shift *Mdn (P_{25}, P_{75})*	26.8 (20.2, 35.2)	20.6 (17.9, 25)	0.03[a]*
Trail Making Test part A (number of errors), pre-shift *Mdn (P_{25}, P_{75})*	0 (0, 0)	0 (0, 0)	0.72[a]
Trail Making Test part A (time, seconds), post-shift *Mdn (P_{25}, P_{75})*	28.9 (22.9, 35.2)	22.4 (19.6, 25.4)	0.04[a]*
Trail Making Test part A (number of errors), post-shift *Mdn (P_{25}, P_{75})*	0 (0, 0)	0 (0, 0)	0.71[a]
Trail Making Test part B (time, seconds), pre-shift *Mdn (P_{25}, P_{75})*	55.9 (47.9, 81.8)	52.9 (43, 58.8)	0.03[a]*
Trail Making Test part B (number of errors), pre-shift *Mdn (P_{25}, P_{75})*	0 (0, 1)	0 (0, 0)	0.04[a]*
Trail Making Test part B (time, seconds), post-shift *Mdn (P_{25}, P_{75})*	71 (48.5, 80.8)	49.2 (40.4, 66)	0.15[a]
Trail Making Test part B (number of errors), post-shift *Mdn (P_{25}, P_{75})*	0 (0, 1)	0 (0, 0)	0.23[a]
Stroop Test, page 1, pre-shift *mean (SD)*	104 (16.2)	108.6 (11.9)	0.17[b]
Stroop Test, page 1, post-shift *Mdn (P_{25}, P_{75})*	104 (87, 112.3)	100 (94, 118)	0.16[b]
Stroop Test, page 2, pre-shift *mean (SD)*	71.7 (11.2)	80.4 (10.8)	0.01[b]*
Stroop Test, page 2, post-shift *Mdn (P_{25}, P_{75})*	71.5 (64.8, 77.5)	79 (68, 88)	0.04[a]*
Stroop Test, page 3, pre-shift *mean (SD)*	50.9 (11.6)	53.7 (12.4)	0.24[b]
Stroop Test, page 3, post-shift *mean (SD)*	49.2 (11.8)	52.8 (14.2)	0.18[b]
Symbol–Digit Test, pre-shift *Mdn (P_{25}, P_{75})*	56.5 (50, 59.5)	61 (55, 66)	0.04[a]*
Symbol–Digit Test, post-shift *Mdn (P_{25}, P_{75})*	52.5 (45, 58.5)	58 (51, 63)	0.18[a]
Sleep quality score (PSQI) *mean (SD)*	12.1 (4.5)	10.4 (3.2)	0.09[b]

Abbreviations: Mdn = median, P25 = 25th percentile, P75 = 75th percentile, SD = standard deviation, PSQI = Pittsburgh Sleep Quality Index. Tests used: [a] Mann–Whitney U test, [b] one-tailed Student's t-test for independent samples. *Statistically significant value

Separate linear regression models were constructed for each of the scores obtained on the instruments administered before and after an on-call shift, with the resident's body mass index as the predictor; only residents with normal weight and those with obesity were included in this analysis. Statistically significant models are shown in Table 4; the remaining models are provided in the in *Supplementary Table 4 and Supplementary Table 5*. and the plots are shown in Fig. 1.

Table 4
Linear regression models constructed for each of the instrument scores, by body mass index (without overweight residents) and age.

Dependent variable	Assessment	F test	Standardized β coefficient	R^2	*p value*
Body mass index (all resident physicians)					
Stroop Test, page 2	Pre-shift	4.95	0.25	0.06	0.03*
	Post-shift	5.15	0.26	0.07	0.03*
Symbol–Digit Test	Pre-shift	4.87	0.25	0.06	0.03*
	Post-shift	6.72	0.29	0.07	0.01*
Age (all resident physicians)					
TMT-A errors	Pre-shift	5.64	0.27	0.07	0.02*
	Post-shift	6.69	0.29	0.08	0.01*
TMT-B time	Pre-shift	12.2	0.38	0.14	<0.01*
	Post-shift	11.4	0.37	0.13	<0.01*
Body mass index (only resident physicians with overweight and obesity)					
TMT-A time	Pre-shift	4.34	-0.30	0.09	0.04*
	Post-shift	3.14	-0.26	0.07	0.08
Stroop Test, page 2	Pre-shift	4.92	0.32	0.1	0.03*
	Post-shift	4.42	0.31	0.09	0.04*
Symbol–Digit Test	Pre-shift	6.02	0.35	0.12	0.02*
	Post-shift	5.9	0.34	0.12	0.02*

All models use calculated BMI; only participants with normal weight and obesity are included, excluding those with overweight. The sample size was reduced to 45 resident physicians.
*Statistically significant value. The remaining models are provided in Supplementary Tables 3, 4 and 5.

Models were also constructed with the Pittsburgh instrument score, sleep efficiency and hours of sleep using data from all resident physicians; however, none reached statistical significance. Age was associated with the number of errors on TMT part A and with TMT part B time (non-significant models in *Supplementary Table 5*). When all resident physicians were included (including those with overweight), an effect was identified on Stroop Test page 2 and the Symbol–Digit Test (non-significant models in Supplementary Tables 3 and 4).

4. Discussion

Regarding sleep quality, the median PSQI score was 12 points (P25–P75 8.5, 14); only 2.6% (2 cases) of resident physicians had good sleep quality, whereas 22.4% (17 cases) had a severe sleep disturbance, with more than 15 points on the instrument. This proportion is higher than that reported among attending physicians at the same institution, in whom the prevalence is 43.2%, with a mean PSQI score of 7.37 ± 4.9 (Zurutuza et al., 2024) ; this indicates that the current medical education system places greater demands on physicians in training.

Poor sleep quality among resident physicians is not homogeneous worldwide and varies according to the country and the characteristics of the healthcare facility where residents are trained. The PSQI score was lower among Chinese resident physicians at a tertiary care hospital (5.9 ± 2.4)(Shi et al., 2023), and a large cohort of residents in Singapore showed a prevalence of 27.59% (Lee et al., 2022), implying better sleep quality, whereas the prevalence was 48% among Iranian resident physicians(Shafiee, Teymouri Athar, et al., 2024) and 86.1% among Egyptian resident physicians(El-Zoghby et al., 2022), the latter being closer to the present study. The factors identified for this higher prevalence were marital status, on-call shift duration, clinically suspected anxiety and variables related to workplace violence(El-Zoghby et al., 2022; Lee et al., 2022; Shafiee, Teymouri Athar, et al., 2024). Within IMSS itself, among permanent staff, poor sleep quality was associated with alcohol use, clinically suspected depression, type of healthcare worker and burnout syndrome(Zurutuza et al., 2024) ; however, the direction of causality among these variables remains unclear.

It is important to clarify that sleep deprivation refers to the inability to sleep—in the case of resident physicians, owing to their training activities—and may be acute or chronic, whereas sleep quality is a much broader concept involving different sleep components: efficiency, disturbances, latency, duration and wake time after sleep onset; these differences must therefore be considered when drawing conclusions(Nelson et al., 2022) .

Accordingly, sleep quality showed no effect in the linear regression models on the scores obtained on the instruments, either as the PSQI score or as the presence or absence of good sleep quality. This may reflect adaptation on the part of healthcare personnel. Conversely, when sleep deprivation is considered, the pre- versus post-shift analysis shows that the Stroop Test required more time to complete on all pages, implying a longer time between the identification of a simple visual stimulus and access to the verbal response without the interference of cross-reading (processing speed and selective attention); a

similar pattern was observed for the Symbol–Digit Test, which is related to reduced cognitive processing speed, selective attention and cognitive flexibility. It can therefore be inferred that fatigue and sleep deprivation have a negative effect on these functions in resident physicians.

The effect of chronic sleep deprivation on cognitive functions in healthcare personnel has been associated with greater difficulty performing clinical duties and a higher risk of error (Abdalla et al., 2022; AL-hrinat et al., 2024; Thompson et al., 2022) ; the findings of the present study therefore constitute a relevant contribution to the field of mental health assessment and represent an important opportunity to improve the environments in which resident physicians work. To improve sleep quality, multiple strategies have been developed focusing on the educational policies of training sites, and even on pharmacological interventions, always considering the predominant cause on an individual basis according to the needs of each resident physician. Those with the strongest evidence and greatest benefit include duty-hour limits, strategically planned schedules, scheduled naps during on-call shifts, efficient handling of consultation requests and sleep hygiene education campaigns (Redinger et al., 2022).

In addition, the prevalence of overweight and obesity among resident physicians was 60.5% (overweight 40.8%, obesity 19.7%), somewhat below the national average (74.5%). However, the proportion of resident physicians with obesity varies across studies, with a pooled prevalence of obesity of 9% (95% CI 7%–11%) but a highly variable range (1% to 74%), mostly lower than the national prevalence of the respective countries yet with an increasing annual trend (Shafiee, Nakhaee, et al., 2024) .

In this regard, response times on TMT parts A and B improved after the on-call shift in participants with obesity, and a positive correlation was observed between BMI and the scores on these instruments, whereas in the regression models only post-shift TMT part A time retained a statistically significant effect. Important additional factors must be considered, such as the learning or practice effect (resident physicians had completed the instrument before the same on-call shift) and the fact that they were about to finish their clinical duties, so many were more relaxed and less anxious despite possible fatigue. These factors may be reflected in the linear regression models, in which the resident's age and specialty influenced these same instruments.

In the pre-shift assessment, resident physicians with obesity showed longer response times on Stroop Test page 2 and the Symbol–Digit Test, and for Stroop Test page 2, the difference persisted after the on-call shift. In the regression models, BMI was a significant component of the pre-shift models for Stroop Test page 2 and the Symbol–Digit Test, with an increase in the time required to complete the test, and the effect persisted in the post-shift models. This negative effect of obesity on executive functions has been documented from birth, through exposure to maternal obesity during pregnancy, and during childhood in children with obesity, and it persists into adulthood, where it increases the risk of cognitive impairment (Krzeczkowski et al., 2026; La Marra et al., 2022; Reinert et al., 2013).

In this context, obesity-related dysregulation of the neuroimmunoendocrine axis with direct involvement of the central nervous system (CNS) has been identified; the most extensively studied mechanisms are

chronic low-grade inflammation, vascular abnormalities (due to endothelial dysfunction) and impaired neuronal energy homeostasis (due to mitochondrial dysfunction or to adipose tissue interference with CNS signaling)(Costache et al., 2023). The mediators and biological mechanisms with the greatest production and chronic inflammatory effect identified to date are interleukin-1β (IL-1β), tumor necrosis factor α, brain-derived neurotrophic factor, interferon γ and monocyte chemoattractant protein-1, and altered amyloid-β metabolism has also been observed (Cao et al., 2025; La Marra et al., 2022; Ma et al., 2025; Pesoli et al., 2022; Tai et al., 2022).

Studies in other populations using the same instruments have identified a strong, direct positive correlation between higher BMI and longer time to complete the instruments, even without considering sleep deprivation (Grandner et al., 2015). The present study takes sleep loss into account and identifies reduced processing speed and selective attention before and after the on-call shift in physicians with obesity, suggesting that the effect of a higher BMI may be persistent and may even intensify the effect of sleep deprivation.

The resident's age influenced instrument results, a factor that has been identified as contributing to better or poorer test performance (Ramier et al., 2024; Shaik et al., 2022; Špiljak et al., 2022; Tan et al., 2026). Several variables warrant in-depth exploration, such as type of specialty and training site, since they reflect the lack of homogeneity across medical training programs. Despite the existence of general operating guidelines, academic and clinical workloads are not comparable; therefore, clearer and more comprehensive regulation of the time allocated to different activities should be considered. Likewise, improving the health of physicians in training is of paramount importance, particularly with regard to obesity and sleep quality, by promoting healthy changes in dietary and physical activity habits while reducing exposure to sleep deprivation through clear evidence-based strategies, bearing in mind that full health is fundamental to improving the teaching–learning process and, as noted above, reduces the number of errors and therefore has a positive effect on the quality of patient care.

This study is a first attempt to explore the combined effect of obesity and sleep deprivation on higher cognitive functions in resident physicians and requires further analysis, particularly measuring change from the beginning to the end of residency, since a cumulative reduction in cognitive abilities may occur over time with chronic sleep deprivation, which could not be verified in the present study. As with any observational design, causality cannot be clearly established, particularly given the short follow-up period; nevertheless, the study opens opportunities for generating hypotheses and new lines of research. The strengths of the study reflect the authors' efforts to establish exploratory associations: the inclusion of multiple sites and the pre- and post-shift assessments performed around a scheduled on-call shift under the same conditions

5. Conclusions

This study provides evidence that sleep deprivation, body mass index and executive functions of the central nervous system are interrelated. This may increase the likelihood of error and difficulty in clinical

decision-making.

Many physicians in training have poor sleep quality and chronic sleep deprivation, as well as overweight or obesity. It is therefore a priority to generate further evidence on the effects of these variables on the care provided by resident physicians—evidence that can support the establishment of protocols aimed at improving the health of this workforce and promoting healthy habits.

Declarations

Accordance Statement

This study was approved by the Research Committee and the Research Ethics Committee of the Mexican Social Security Institute in accordance with the guidelines and regulations set forth by Mexico's Ministry of Health, National Bioethics Commission and Federal Commission for the Protection Against Sanitary Risks. The protocol number for this approval is R-2024-785-053. The project was conducted in accordance with the criteria of the Declaration of Helsinki and complied with all regulations currently in force in Mexico regarding the protection of participants in research projects. All resident physicians were informed of the purpose of the study and provided written informed consent. Written informed consent has been obtained from the patients to publish this paper.

Ethics approval:

The study protocol was approved by the Research Committee and the Research Ethics Committee of the Mexican Social Security Institute (registration number R-2024-785-053). All resident physicians were informed of the purpose of the study and provided written informed consent. Written informed consent has been obtained from the patients to publish this paper.

Specific consent for publication

N/A

Funding:

This research received no external funding.

Conflicts of interest/competing interests: The authors declare no conflicts of interest.

Author Contribution

Author Contributions: Conceptualization, J.I.Z.L. and L.O.D.; data curation, J.M.R., M.S.P.C. and L.F.J.S.; formal analysis, J.I.Z.L. and M.S.P.C.; investigation, L.F.J.S., J.M.F.A., J.H.D. and L.E.R.P.; methodology,

F.J.H.C., J.I.Z.L. and L.O.D.; project administration, L.F.J.S., J.M.F.A. and J.H.D.; resources, M.S.P.C. and F.J.H.C.; software, J.I.Z.L. and J.M.R.; supervision, J.I.Z.L. and L.O.D.; validation, J.I.Z.L., L.O.D., L.F.J.S., J.M.F.A., J.H.D. and L.E.R.P.; visualization, J.I.Z.L; writing—original draft, J.I.Z.L. and L.O.D.; writing—review and editing, L.F.J.S., M.S.P.C., L.F.J.S., J.M.F.A., J.H.D. and L.E.R.P. All authors have read and agreed to the published version of the manuscript.

Acknowledgement

Acknowledgments: During the preparation of this manuscript, the authors used Claude (An-thropic; Claude Opus 5.5; accessed September–October 2026) for the purposes of text translation. The authors have reviewed and edited the output and take full responsibility for the content of this publication.

Data Availability

Data availability statement: The anonymized dataset and the analysis scripts supporting the findings of this study are available from the corresponding author upon reasonable request; they will be deposited in a public repository upon acceptance. The data are not publicly available at present because they were collected from a clinical population under a consent procedure that did not include open publication of individual records.

References

1. Abdalla RN, Ansari SA, Hurley MC, Attarian H, Fargen KM, Hirsch JA, Cantrell DR, Curl PK, Daves PR, Shaibani A. Correlation of Call Burden and Sleep Deprivation with Physician Burnout, Driving Crashes, and Medical Errors among US Neurointerventionalists. Am J Neuroradiol. 2022;43(9):1286–91. https://doi.org/10.3174/ajnr.A7606.
2. AL-hrinat J, Al-Ansi AM, Hendi A, Adwan G, Hazaimeh M. The impact of night shift stress and sleep disturbance on nurses quality of life: case in Palestine Red Crescent and Al-Ahli Hospital. BMC Nurs. 2024;23(1):24. https://doi.org/10.1186/s12912-023-01673-3.
3. Anuradha R, Hemachandran S, Patil AB. (2022). Sleep Quality and Daytime Sleepiness among Medical Undergraduate Students in Tamil Nadu: A Cross-sectional Study. *JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH*. https://doi.org/10.7860/JCDR/2022/57499.16552
4. Ayala Servin N, Samaniego Ríos M, Distefano Martínez J. Calidad del sueño y satisfacción laboral en médicos residentes. Med Clínica y Social. 2022;6(1):26–32. https://doi.org/10.52379/mcs.v6i1.235.
5. Binjabr MA, Alalawi IS, Alzahrani RA, Albalawi OS, Hamzah RH, Ibrahim YS, Buali F, Husni M, BaHammam AS, Vitiello MV, Jahrami H. The Worldwide Prevalence of Sleep Problems Among Medical Students by Problem, Country, and COVID-19 Status: a Systematic Review, Meta-analysis, and Meta-regression of 109 Studies Involving 59427 Participants. Curr Sleep Med Rep. 2023;9(3):161–79. https://doi.org/10.1007/s40675-023-00258-5.

6. Camacho Ruíz EJ, Mancilla JM, Escoto Ponce de León MDC, Yáñez Tellez MG. Diseño y validación de una tarea computarizada tipo stroop para evaluar sesgos de la atención en bulimia nerviosa. Revista Mexicana de Análisis de La Conducta. 2010;35(2). https://doi.org/10.5514/rmac.v35.i2.16109.
7. Cao Y, Xie T, Ma N. The impairments of sleep loss on core executive functions: General and task-specific effects. Sleep Med Rev. 2025;84:102163. https://doi.org/10.1016/j.smrv.2025.102163.
8. Cooper CB, Neufeld EV, Dolezal BA, Martin JL. Sleep deprivation and obesity in adults: a brief narrative review. BMJ Open Sport Exerc Med. 2018;4(1):e000392. https://doi.org/10.1136/bmjsem-2018-000392.
9. Corbo I, Troisi G, Marselli G, Casagrande M. The role of cognitive flexibility on higher level executive functions in mild cognitive impairment and healthy older adults. BMC Psychol. 2024;12(1):317. https://doi.org/10.1186/s40359-024-01807-5.
10. Costache AD, Ignat BE, Grosu C, Mastaleru A, Abdulan I, Oancea A, Roca M, Leon MM, Badescu MC, Luca S, Jigoranu AR, Chetran A, Mitu O, Costache II, Mitu F. Inflammatory Pathways in Overweight and Obese Persons as a Potential Mechanism for Cognitive Impairment and Earlier Onset Alzeihmer's Dementia in the General Population: A Narrative Review. Biomedicines. 2023;11(12):3233. https://doi.org/10.3390/biomedicines11123233.
11. Daher AM, Burud I, Subair M, Mushahar L, Xin LJ. The prevalence of sleep deprivation and its impact among medical officers in a tertiary hospital, a cross-sectional study from Malaysia. PLoS ONE. 2024;19(8):e0306574. https://doi.org/10.1371/journal.pone.0306574.
12. El-Zoghby SM, Ibrahim ME, Zaghloul NM, Shehata SA, Farghaly RM. Impact of workplace violence on anxiety and sleep disturbances among Egyptian medical residents: a cross-sectional study. Hum Resour Health. 2022;20(1):84. https://doi.org/10.1186/s12960-022-00786-1.
13. Grandner MA, Schopfer EA, Sands-Lincoln M, Jackson N, Malhotra A. Relationship between sleep duration and body mass index depends on age. Obesity. 2015;23(12):2491–8. https://doi.org/10.1002/oby.21247.
14. Khan MA, Al-Jahdali H. The consequences of sleep deprivation on cognitive performance. Neurosciences. 2023;28(2):91–9. https://doi.org/10.17712/nsj.2023.2.20220108.
15. Krzeczkowski JE, Mortaji N, Van Lieshout RJ. Obesity During Pregnancy and Deficits in Offspring Neurobehavioral Flexibility: The CONFINE Model. Biol Psychiatry. 2026;99(6):446–56. https://doi.org/10.1016/j.biopsych.2025.06.032.
16. La Marra M, Ilardi CR, Villano I, Carosella M, Staiano M, Iavarone A, Chieffi S, Messina G, Polito R, Scarinci A, Monda V, Di Maio G, Messina A. Functional Relationship between Inhibitory Control, Cognitive Flexibility, Psychomotor Speed and Obesity. Brain Sci. 2022;12(8):1080. https://doi.org/10.3390/brainsci12081080.
17. Lee YY, Lau JH, Vaingankar JA, Sambasivam R, Shafie S, Chua BY, Chow WL, Abdin E, Subramaniam M. Sleep quality of Singapore residents: findings from the 2016 Singapore mental health study. Sleep Medicine: X. 2022;4:100043. https://doi.org/10.1016/j.sleepx.2022.100043.

18. Lentoor AG, Myburgh L. (2022). Correlation between Body Mass Index (BMI) and Performance on the Montreal Cognitive Assessment (MoCA) in a Cohort of Adult Women in South Africa. *Behavioural Neurology*, *2022*, 1–7. https://doi.org/10.1155/2022/8994793
19. Ma T, Feng L, Li G-H, Sun X-Y, Chu Y, Zhao W-H, Feng S, Zhang H, Wang W. The impact of 24-hour sleep deprivation on cognition and inflammatory response in anesthesiologists and nurses in operating rooms. Saudi J Anaesth. 2025;19(3):353–62. https://doi.org/10.4103/sja.sja_772_24.
20. Meyer N, Lok R, Schmidt C, Kyle SD, McClung CA, Cajochen C, Scheer FAJL, Jones MW, Chellappa SL. (2024). The sleep–circadian interface: A window into mental disorders. *Proceedings of the National Academy of Sciences*, *121*(9). https://doi.org/10.1073/pnas.2214756121
21. Mota Albuquerque P, Ribeiro Franco CM, Sampaio Rocha-Filho PA. Assessing the impact of sleep restriction on the attention and executive functions of medical students: a prospective cohort study. Acta Neurol Belgica. 2023;123(4):1421–7. https://doi.org/10.1007/s13760-023-02250-w.
22. Nelson KL, Davis JE, Corbett CF. Sleep quality: An evolutionary concept analysis. Nurs Forum. 2022;57(1):144–51. https://doi.org/10.1111/nuf.12659.
23. Pesoli M, Rucco R, Liparoti M, Lardone A, D'Aurizio G, Minino R, Lopez T, Paccone E, Granata A, Curcio C, Sorrentino G, Mandolesi G, L., Sorrentino P. A night of sleep deprivation alters brain connectivity and affects specific executive functions. Neurol Sci. 2022;43(2):1025–34. https://doi.org/10.1007/s10072-021-05437-2.
24. Ramier M, Clavier T, Allard E, Lambert M, Dureuil B, Compère V. Examining the impact of sleep deprivation on medical reasoning's performance among anaesthesiology residents and doctors: a prospective study. BMC Anesthesiol. 2024;24(1):356. https://doi.org/10.1186/s12871-024-02712-5.
25. Ramos-Galarza C, Acosta-Rodas P, Jadán-Guerrero J, Guevara-Maldonado CB, Zapata-Rodríguez M, Apolo-Buenaño D. (2018). Neuropsychological assessment of attention: Symbols and digits test. Revista Ecuatoriana de Neurologia, *27*(1).
26. Redinger J, Kabil E, Forkin KT, Kleiman AM, Dunn LK. Resting and Recharging: A Narrative Review of Strategies to Improve Sleep During Residency Training. J Graduate Med Educ. 2022;14(4):420–30. https://doi.org/10.4300/JGME-D-21-01035.1.
27. Reinert KRS, Po'e EK, Barkin SL. (2013). The Relationship between Executive Function and Obesity in Children and Adolescents: A Systematic Literature Review. *Journal of Obesity*, *2013*, 1–10. https://doi.org/10.1155/2013/820956
28. Rodríguez Barreto LC, Roa P, C. A., Pulido NDC. Propiedades psicométricas del Stroop, test de colores y palabras en población colombiana no patológica. Universitas Physiol. 2016;15(2):255. https://doi.org/10.11144/Javeriana.upsy15-2.ppst.
29. Royuela Rico A, Macías Fernández JA. (1997). Propiedades clinimétricas de la versión castellana del Cuestionario de Pittsburgh. Vigilia-Sueño, *9*(2).
30. Shafiee A, Nakhaee Z, Bahri RA, Amini MJ, Salehi A, Jafarabady K, Seighali N, Rashidian P, Fathi H, Abianeh E, Omran F, Bakhtiyari SP, M., Alirezaei A. Global prevalence of obesity and overweight

among medical students: a systematic review and meta-analysis. BMC Public Health. 2024;24(1):1673. https://doi.org/10.1186/s12889-024-19184-4.

31. Shafiee A, Teymouri Athar MM, Seighali N, Amini MJ, Hajishah H, Bahri A, Akhoundi R, Beiky A, Sarvipour M, Maleki N, Zandifar S, A., Bakhtiyari M. The prevalence of depression, anxiety, and sleep disturbances among medical students and resident physicians in Iran: A systematic review and meta-analysis. PLoS ONE. 2024;19(8):e0307117. https://doi.org/10.1371/journal.pone.0307117.
32. Shaik L, Cheema MS, Subramanian S, Kashyap R, Surani SR. Sleep and Safety among Healthcare Workers: The Effect of Obstructive Sleep Apnea and Sleep Deprivation on Safety. Medicina. 2022;58(12):1723. https://doi.org/10.3390/medicina58121723.
33. Shi C, Luo J, Xiao Y. The association of sleep quality and burnout among Chinese medical residents under standardized residency training in a tertiary hospital. Sleep Breath. 2023;27(1):379–86. https://doi.org/10.1007/s11325-022-02621-2.
34. Špiljak B, Vilibić M, Glavina A, Crnković M, Šešerko A, Lugović-Mihić L. A Review of Psychological Stress among Students and Its Assessment Using Salivary Biomarkers. Behav Sci. 2022;12(10):400. https://doi.org/10.3390/bs12100400.
35. Tai XY, Chen C, Manohar S, Husain M. Impact of sleep duration on executive function and brain structure. Commun Biology. 2022;5(1):201. https://doi.org/10.1038/s42003-022-03123-3.
36. Tan SF, Siddiqui H, Pinto A, Paur B, Chen G, Elfenbein DM, Minichiello V, Barrett B, Davidson RJ, Goldberg SB. Work Hours, Stress, and Burnout Among Resident Physicians. JAMA Netw Open. 2026;9(1):e2553974. https://doi.org/10.1001/jamanetworkopen.2025.53974.
37. Thompson KI, Chau M, Lorenzetti MS, Hill LD, Fins AI, Tartar JL. (2022). Acute sleep deprivation disrupts emotion, cognition, inflammation, and cortisol in young healthy adults. *Frontiers in Behavioral Neuroscience*, *16*. https://doi.org/10.3389/fnbeh.2022.945661
38. Uranga RM, Keller JN. (2019). The Complex Interactions Between Obesity, Metabolism and the Brain. *Frontiers in Neuroscience*, *13*. https://doi.org/10.3389/fnins.2019.00513
39. Vidović S, Rakić N, Kraštek S, Pešikan A, Degmečić D, Zibar L, Labak I, Heffer M, Pogorelić Z. Sleep Quality and Mental Health Among Medical Students: A Cross-Sectional Study. J Clin Med. 2025;14(7):2274. https://doi.org/10.3390/jcm14072274.
40. Zheng NS, Annis J, Master H, Han L, Gleichauf K, Ching JH, Nasser M, Coleman P, Desine S, Ruderfer DM, Hernandez J, Schneider LD, Brittain EL. Sleep patterns and risk of chronic disease as measured by long-term monitoring with commercial wearable devices in the All of Us Research Program. Nat Med. 2024;30(9):2648–56. https://doi.org/10.1038/s41591-024-03155-8.
41. Zurutuza JI, Ovando-Diego L, Lezama-Prieto MA, Morales-Romero J, Melgarejo-Gutierrez MA, Ortiz-Chacha CS. Factors Associated With Poor Sleep Quality Among Primary Healthcare Workers During the SARS-CoV-2 Pandemic. Cureus. 2024. https://doi.org/10.7759/cureus.56502.

Figures

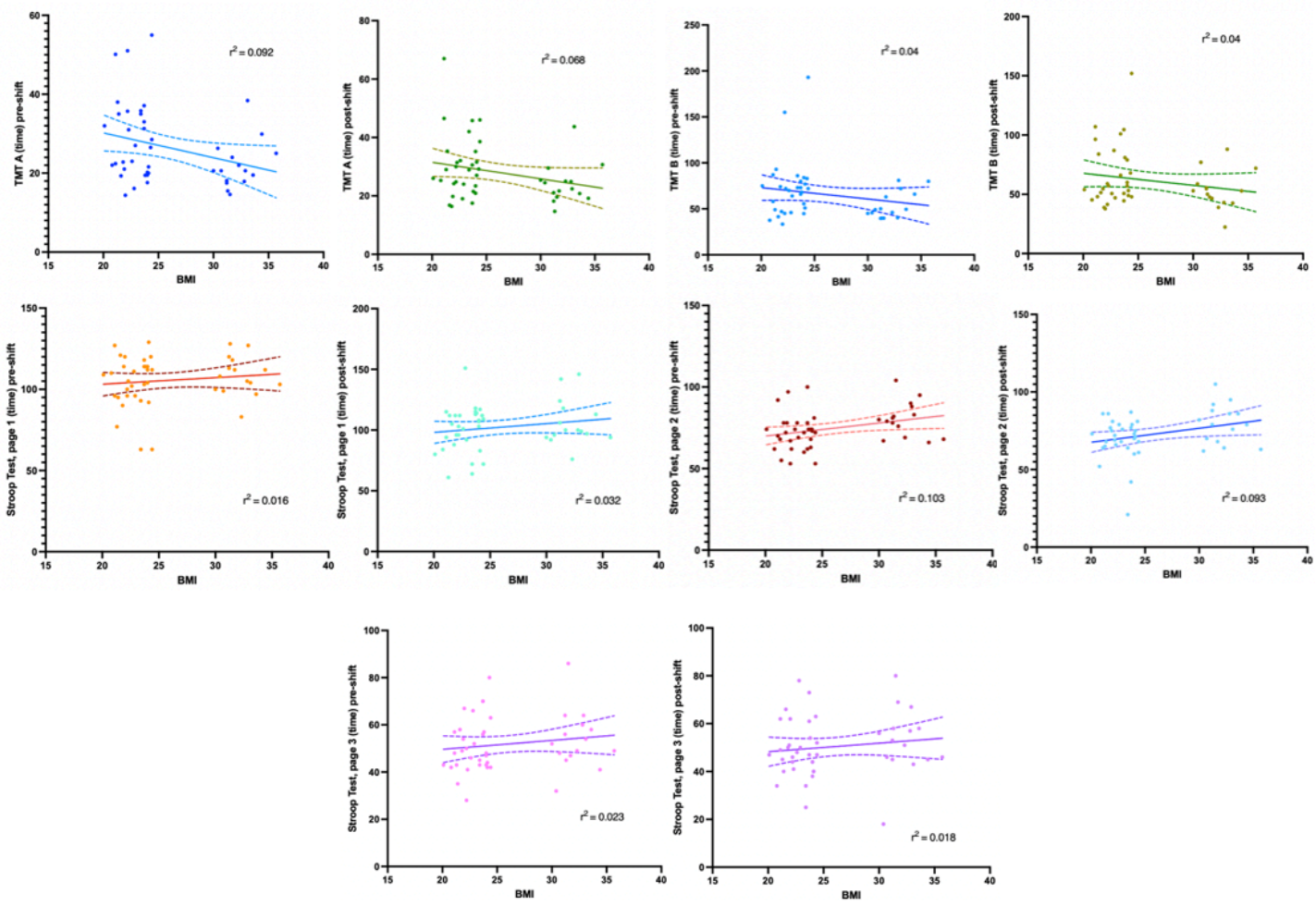


Figure 1

Time in seconds Scatter plots of instrument completion time (seconds) versus BMI of the resident physicians. Only residents with normal weight and obesity (any class) are included. The regression R2 is shown; the solid line represents the fitted regression line, the dashed lines represent the 95% confidence bands, and the dots represent individual observations.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarymaterial.docx