

## The Effects of Chronic Partial Sleep Deprivation on Cognitive Functions of Medical Residents

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**Objective:** Because of on-call responsibilities, many medical residents are subjected to chronic partial sleep deprivation, a form of sleep restriction whereby individuals have chronic patterns of insufficient sleep. It is unclear whether deterioration in cognitive processing skills due to chronic partial sleep deprivation among medical residents would influence educational exposure or patient safety.

**Method:** Twenty-six medical residents were recruited to participate in the study. Participants wore an Actigraph over a period of 5 consecutive days and nights so their sleep pattern could be recorded. Thirteen participants worked on services that forced chronic partial sleep deprivation (<6 hours of sleep per 24h for 5 consecutive days and nights). The other thirteen residents worked on services that permitted regular and adequate sleep patterns. Following the 5-day sleep monitoring period, the participants completed the three following cognitive tasks: (a) the Wisconsin Card Sorting Test (WCST) to assess abstract reasoning and prefrontal cortex performance; (b) the Time Perception Task (TPT) to assess time estimation and time reproduction skills; and (c) the Iowa Gambling Task (IGT) to assess decision-making ability.

**Results:** The results of independent samples t-tests found no significant differences between the group who was chronically sleep deprived and the group who rested adequately (all  $ps > .05$ ).

**Conclusion:** These results may have emerged for several possible reasons: (a) chronic partial sleep deprivation may have a lesser impact on prefrontal cortex function than on other cognitive functions; (b) fairly modest chronic sleep restriction may be less harmful than acute and more significant sleep restriction; or (c) our research may have suffered from poor statistical power. Future research is recommended.

**Keywords:** Cognition, Executive function, Internship and residency, Sleep deprivation

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Medical residents are subjected to regular sleep restriction due to their on-call responsibilities. There has been significant concern about whether sleep restriction among medical residents could threaten their educational exposure or, more critically, patient safety (1). For example, some reports indicate that residents working frequent 12-hour overnight emergency room shifts show significant deterioration in visual memory and psychomotor vigilance from the beginning to the end of their duty (2-5). Kahol et al suggested that surgical proficiency, as assessed among junior- and senior-level residents, is significantly impeded when they are fatigued. This effect is manifested by an increased number of cognitive errors and decreased psychomotor efficiency and overall task performance. Cognitive skills are more affected than psychomotor

skills; however, impeded cognitive performance may also lead to limited psychomotor proficiency. The decrement is significant in surgeons at all residency levels, and it must be considered when house officers are assigned post-call duties (2).

Barger et al also reported that extended-duration work shifts were associated with an increased risk of significant medical errors, adverse events, and attentional failures in interns across the United States. These results have important public policy implications for postgraduate medical education (5).

There are limited data examining the effects of chronic partial sleep deprivation (CPSD) on cognitive function of medical residents (1). This study examined whether medical residents' prefrontal cortex performance was affected by CPSD.

### Materials and Methods

A convenience sample of 26 medical residents of Kermanshah University of Medical Sciences (KUMS) was recruited to participate in the study. Exclusion criteria included acute or chronic medical or psychiatric illness, use of any medications, and pregnancy. All participants provided informed consent to participate in the research, and the study protocol was approved by the Ethics Committee of Kermanshah University of Medical School (KUMS).

The participants wore an Actigraph (Ambulatory Monitoring, Inc.) over a 5 consecutive day and night period so that their sleep pattern could be recorded. An actigraph is a portable device (like a wristwatch) that records movement and enables researcher to identify times of sleep and wakefulness.

Thirteen residents worked on services that required chronic partial sleep deprivation, defined as less than 6 hours of sleep per day for 5 consecutive days (1). The other thirteen residents worked on services that permitted regular and adequate sleep patterns.

Following the 5 consecutive days and nights sleep monitoring period, all the participants completed three tasks on a computer screen: (a) the Wisconsin Card Sorting Test (WCST) to assess abstract reasoning and prefrontal cortex performance; (b) the Time Perception Task (TPT) to assess time estimation and time reproduction skills; and (c) the Iowa Gambling Task (IGT) to assess decision-making ability.

The WCST requires participants to match geometrical shapes on a target card to four standard cards with different geometrical shapes. The subject has to find a rule on the basis of positive or negative feedback upon the response. When the rule has been found, application of this rule provides positive feedback until (after 10 trials) the rule is suddenly changed. From this point on, the sequence of rule search followed by rule application is repeated. Preservative responses occur when a subject is unable to switch to a new rule, but continues to apply the old rule (5,6).

The TPT requires participants to complete two sets of trials: one for time estimation and the other for time reproduction (7). Time estimation trials require participants to estimate the length of time that has passed. Distractors are present. The time reproduction trials require the participant to reproduce the time periods presented during the time estimation task. In both cases, the temporal latencies vary across trials (7 trials are presented for each of the 2 series).

The IGT gives four identical decks of cards to participants, who instructed to try to win as much money as possible by selecting cards from one of the four decks. They were permitted to choose 100 cards in total. Unknown to the participants, two of the decks contained cards that either offered large financial gains (more common) or extremely large penalties (less common). These two decks actually were detrimental to participants' winnings. The other two decks tended to have lower positive rewards, but also much lower decks for the participants to choose from. The

participants had been informed that some decks were better than others, but they were not otherwise given any indication of which decks to select (8).

Data analyses proceeded in two steps. First, descriptive data were considered, and the means of the CPSD group were listed adjacent to the means of the group who had adequate sleep. Second, independent sample *t*-tests were computed using SPSS software (version 15, Chicago, IL, USA) to compare the two groups using inferential statistics.

Analyses were conducted first on the demographic characteristics to ensure that the two groups were similar, and on sleep history to ensure the groups varied on that critical variable. Next, the analyses were conducted on the results of each of the three neuropsychological tests. A *p*-value of <0.05 was considered statistically significant.

### Results

The two groups were demographically similar. The mean age in the CPSD group was  $30.77 \pm 2.1$  years; the mean age in the control group was  $32.00 \pm 4.6$  years.

The CPSD group was 53.8% male and the control group was 69.2% male. As expected, there were significant differences between the groups on the mean total sleep time. The CPSD group obtained a mean of 5 hours, 28 minutes per night ( $\pm 25$  min); and the control group obtained 8 hours and 37 minutes ( $\pm 90$  min) ( $p < 0.05$ ).

The results of the primary hypotheses are summarized in Table 1. As shown, no significant differences emerged on performance of the two groups for any part of the WCST, TPT or IGT.

### Discussion

Cognitive and motor functions are impaired with acute and chronic sleep deprivation. Medical residents, who often face sleep deprivation because of their occupational duties, are negatively influenced by fatigue. Previous work indicates sleep deprivation has a negative impact on cognitive function, working memory, vigilance, fine motor skills and mood (1,2,5). The present study was designed to investigate the influence of CPSD on prefrontal cortex function. Results of our analyses demonstrated no significant effect.

There are several possible explanations for our null results. One primary possibility is that our research suffered from poor statistical power. The trend of our results was as expected for several tests, including the perseveration and non-perseveration results of the WCST, the longer time estimation and reproduction trials on the TPT, and the IGT results.

This possibility is supported by the broader literature, which tends to suggest that fatigued medical residents have reduced performance in a number of domains (2-5,9).

Table1. Means and *p* values of WCST results between the CPSD and control groups

Cognitive Test Results		CPSD Mean ± SD	Control Mean ± SD	<i>p</i> -value
WCST Achieved Category		6.69±0.75	6.92±0.28	0.31
WCST Total Error		16.31±7.96	18.08±8.66	0.59
WCST Perseveration		6.38±3.28	5.08±2.13	0.24
WCST Non-Perseveration		9.92±6.66	13±90	0.33
TPT Estimation trials	5 sec	6.15±2.7	7.38±6.7	0.55
	8 sec	8.08±4.6	9.85±6.7	0.44
	11 sec	9.77±4.8	10.92±4.7	0.54
	14 sec	10.46±5.0	12.77±5.3	0.26
	17 sec	13.54±5.2	15.46±4.9	0.34
	21 sec	15.92±5.7	18.92±7.3	0.25
	23 sec	17.46±4.9	19.31±6.0	0.40
TPT Reproduction trials	5 sec	4.15±1.5	4.81±1.4	0.27
	8 sec	5.76±2.2	6.80±2.2	0.24
	11 sec	7.55±2.4	9.23±1.7	0.06
	14 sec	10.73±2.9	11.90±3.9	0.39
	17 sec	10.24±4.3	13.69±2.6	0.06
	21 sec	12.99±5.4	15.75±3.1	0.12
	23 sec	14.44±6.2	17.90±5.9	0.16
TPT Estimation errors		3.08±1.60	2.46±1.19	0.27
TPT Reproduction errors		3.46±1.76	2.31±1.25	0.06
IGT score		-5.17±24.95	6.17±26.00	0.31

As an example, Saxena and George studied penalties as well. They were the more advantageous residents who were required to complete lengthy overnight on-call shifts for several nights per month versus a control group. They found that those who completed the overnight on-call shifts had slower reaction times and reduced vigilance compared to the control group, even after time was permitted for sleep recovery.

A second possible explanation for our null results is that CPSD has a lesser impact on prefrontal cortex function than on other cognitive functioning. Most previous research has studied other aspects of cognitive functioning. A third possibility is that fairly modest chronic sleep restriction is less harmful than more significant sleep restriction observed in some other research samples.

In summary, we can conclude that we found trends for differences in most cognitive tasks during CPSD. In doing so, we acknowledge limitations to our study. There may have been selection bias in our sample. Further, our sample size was small. We also were limited by recruitment from a single hospital, and the use of only three neuropsychological tests that may not sample all the relevant cognitive processing skills. We recommend future research to evaluate the effect of

sleep restriction on medical residents' cognition and performance.

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