The influence of shift work on the psychomotor capabilities of emergency medicine residents

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Abstract
Objective: Shift work affects health status of healthcare providers and patients. We assessed the effect of shift work on psychomotor activities of emergency medicine residents of 3 university hospitals.

Methods: The participants were enrolled to perform selected psychomotor tests via the Vienna test system (VTS) after written consent. They passed 4 episodes of test performance before and after 2 consecutive day and night clinical shifts of 12 hours. The status of general health, circadian rhythm, sleepiness, smoking habits, and the scores of the cognition test (COG), the determination test (DT), and the visual pursuit test of emergency medicine residents were compared before and after morning and night shifts.

Results: Overall, 23 residents (34.8% were male) performed tests. The mean (SD) age was 35.7 ± 8.5 years. The mean general health and circadian scores before and after day/night shifts were not different. The Stanford sleepiness scale showed higher scores after night shifts. In the cognition test, the sum of correct rejections was higher after day shifts. Moreover, in the DT results, correct responses were more prevalent, the omitted responses were fewer accompanied by better median reaction time after day shifts. The sum of correct rejections of the COG test showed difference in terms of improved results in night tests compared to day-shift tests. The mean reaction time of the DT showed significant difference with shorter reaction time in night-shift tests. The visual pursuit test results were not different between day and night shifts.

Conclusions: Sleepiness was higher after night shifts. The results of selected psychomotor tests showed that the psychomotor function of the residents was not delayed or worse after night shifts in comparison to the day shifts.

Keywords
determination test, psychomotor performance, Vienna test system, visual pursuit test
1 | INTRODUCTION

1.1 | Background

The utilization of shiftwork alternating programs is a common type of work schedule for healthcare workers although definite effects are not yet known. The emergency department (ED) requires 24-hour service that may be covered by emergency medicine residents in day and night shifts in some university hospitals. There is a growing concern that long shifts with high workloads could cause a decline in emergency medicine residents’ performance, concerned by educational stakeholders. Neuro-cognitive dysfunction, sleepiness, and fatigue are gradual effects of shift-rotational careers that can hamper general health. It is well-known that changes in circadian rhythm influence the cognitive and psychomotor abilities of affected people including medical workers. Sleep deprivation during night/rotational shifts as well as the healthcare workload affect psychomotor abilities in every-day practice.

Despite some evidence about further tolerance to sleep deprivation by means of individualized solutions among healthcare staff, the observed effects are concerning, especially on clinical decision-making that is linked to patient healthcare under special clinical consideration. Sleep deprivation is also a major contributor to decline and delay cognition and judgment. Some effects may be similar to other vocational activities after short or long periods of sleep deprivation. The tasks routinely performed by healthcare staff are not only related to themselves but also may affect the health status of patients. Any delayed or decreased cognitive and psychomotor capabilities of emergency medicine specialists could potentially be dangerous in patient management and lead to an increase in preventable errors.

1.2 | Importance

Applying appropriate tests for the assessment of the psychomotor function and sleep deprivation can develop possible solutions for improving the intellectual status in healthcare workers, especially ED workers. Amado et al. used and evaluated the validity of the Vienna test system (VTS) as a psychological assessment system and found it beneficial for evaluating attention, visual memory, and reasoning. Bartolacci et al. also used VTS for evaluating the influence of sleep quality and sleepiness on the psychomotor abilities of adult populations.

1.3 | Goals of this investigation

Considering the great importance of such potential decline in performance, our study aimed at evaluating the possible relationship between night and day shifts and cognitive and psychomotor capabilities of the emergency medicine residents by VTS system. This study compared physiologic and circadian rhythm, sleepiness scores, current cigarette smoking, and general health to assess the status of emergency medicine postgraduate residents before and after day and night shifts.

2 | METHODS

2.1 | Study design and setting

In this cross-sectional study, we have assessed the psychomotor performance of PGY-1 to 3 emergency medicine residents of 3 university hospitals, affiliated with the Tehran University of Medical Sciences. The hospitals are multidisciplinary referral centers with overall 65,000 mean annual visits where medical residents of various disciplines are trained.

2.2 | Selection of participants

Emergency medicine residents entered the study after giving consent. Exclusion criteria include previous known psychiatric disorder, past history of epilepsy, use of antidepressants or anxiolytic medications, and participants who did not give consent to perform the tests. Therefore, we included all of the emergency medicine residents who agreed to enter the study and excluded the ones who had any previous psychomotor disorders or did not complete the whole study. In addition, residents were directly supervised before and after shifts and during test performance and were not clinically intoxicated by alcohol or substances.

Emergency medicine residents have 2 consecutive day shifts followed by 2 consecutive night shifts of 12 hours from 7 am to 7 pm and vice versa. There is an interval of 24 hours between the second day and the first night shift. Shift difficulty was considered to be similar for all emergency medicine residents, because they have the same educational curriculum (ie, PGY-1, PGT-2, and PGY-3 residents have 20, 18, and 16 clinical shifts per month in the ED with the night shifts comprising 50% of the shifts). Emergency medicine residents had 2 days off from shifts after night shifts and before the following day shifts that are consistently planned among 3 hospitals.

2.3 | Interventions

The VTS was used to perform the cognition test (COG), determination test (DT), and visual pursuit test (LVT).
The emergency medicine residents participated in the tests for 4-time episodes, 1 hour each, before and after the second day shift, and the first night shift. They completed tests before the second day shift at 6 am and then passed the same tests at the end of the second day shift at 8 pm. Afterward, they ran the tests before the first night shift at 6 pm and after that in the following morning at 7:30 am before returning home. The test status was standardized for all the study participants. In this test, participants confronted a number of disordered lines and are asked to identify the end of one line as quickly as possible. The main variables of this test were scores based on working and viewing time episodes. The validity and reliability of these tests have been reported in several studies.

The participants received a financial reward of $20 if they tried their best to complete the tests after test analysis. They were trained before the test to be able to play with the VTS system, and 1 observer was present during the tests if they needed to ask for help. They were advised not to consume theine, caffeine, or any medications from 24 hours before and during the experiment by their own as most of them had reported coffee consumption commonly before shifts. Before each test episode, residents received a cup of a similar brand of coffee and were advised not to smoke, if possible.

2.4 Measurements

The emergency medicine residents participated in the tests for 4-time episodes, 1 hour each, before and after the second day shift, and the first night shift. They completed tests before the second day shift at 6 am and then passed the same tests at the end of the second day shift at 8 pm. Afterward, they ran the tests before the first night shift at 6 pm and after that in the following morning at 7:30 am before returning home. The test status was standardized for all the study participants.

They filled out questionnaires on circadian rhythm, sleepiness, fatigue, general health, and smoking habits by valid and reliable questionnaires. Sleepiness was defined as an urge to sleep and assessed by Stanford sleepiness scale. Fatigue was described as a subjective feeling of tiredness and assessed by the Swedish occupational fatigue inventory (SOFI) questionnaire, consisting of 20 questions in 5 subscales of physical exertion/discomfort, lack of energy/motivation, and somnolence. The values of responses were between 0 (not at all) to 10 (a very high degree of fatigue). The circadian type inventory questionnaire was used to evaluate the amplitude (languid vs vigorous) and stability (flexible vs rigid) of the circadian rhythm. Vigorous types are more alert during the day and necessitate less sleep than languid types who usually cannot tolerate lack of sleep, whereas rigid types cannot sleep at irregular times.

2.5 | Outcomes

The selected psychomotor tests were conducted via the VTS including cognition test, determination test, and visual pursuit by emergency medicine residents before and after 2 consecutive morning and night clinical shifts. These tests, along with the status of general health, circadian rhythm, sleepiness, and smoking habits, were compared before and after shifts as well as between day and night shifts.

2.6 | Analysis

Data was analyzed with SPSS version 24, and quantitative data was reported by mean and SD and assessed by paired t test. To compare differences of performance among clinical shifts, mixed model was used. Considering the mean incorrect responses in the DT and SD of 7.5, the power of 80%, and P value < 0.05, the sample size of 21 participants was calculated. To better understand the results, we compared the scores obtained before and after each shift. Moreover, we compared the scores between day and night shifts.

The ethics of this research have been approved by the University of Medical Sciences institutional review board. Written consent was obtained from the participants.

3 | RESULTS

Overall, 22 residents performed 4 test episodes (88 episodes) of which 8 (36.4%) were male. One resident completed only the day 1 tests and could not continue because of an ankle sprain. The mean ± SD (range) of age was 35.7 ± 8.5 (26-52) years. A total of 2 (9.1%), 17 (77.2%), and 4 (18.2%) residents were PGY-1, PGY-2, and PGY-3, respectively. Moreover, 12 (54.5%) residents were married and others were single. 9 (40.1%) residents had 1 to 2 children, and all residents were of Persian ethnicity. Regarding currently used medications, 2 residents reported acetaminophen, 1 mentioned propranolol (20 mg), and 1 consumed zinc during the past month.

The mean (SD) of the general health, circadian, and the Stanford sleepiness scale scores are shown in Table 1. There was not a significant difference between the status of current cigarette smoking or general health before and after day and night shifts. The Stanford sleepiness scale showed more sleepiness after night shifts in comparison with day shifts, 2.95 (1.09) 2.5–3.4 versus 1.81 (0.75), 1.5–2.1, respectively, P value = 0.000. Furthermore, the SOFI questionnaire showed higher extents of fatigue, somnolence, lack of motivation, and lack of energy after night shifts (Table 1).
Table 1 exhibits the results of tests completed by the emergency medicine residents in 4 time episodes. The sum of correct rejections and the mean time of correct rejection are reported for the COG test before and after day and night shifts in Table 2. Regarding the DT test, the sum of correct, incorrect, and omitted responses and also median reaction time are presented in Table 2. The LVT scores are also reported based on the viewing and working times (Table 2). The sum of correct rejections of the COG test was higher after day shifts and showed differences between day and night shifts. In the DT, correct responses were more prevalent after the day shifts and were more commonly observed in night shifts. The omitted responses were also fewer after day shifts compared with the test results before day shifts, 8.1 (3.25), 6.7–9.4 versus 12.1 (5.35), 9.9–14.3, respectively, \( P \) value = 0.000. The mean reaction time of the DT showed significant difference before and after day shifts and also between day and night shifts. The LVT test results were not different between day and night shifts. Figure 1 shows the scores of general health, the total circadian score, and fatigue before and after day and night shifts. Figure 2 represents the sum hits of the cognition test, the median reaction time of the DT, and the visual pursuit working time before and after day and night shifts.

3.1 Limitations

All the emergency medicine residents who could fulfill 4 test episodes of this study were limited and a larger sample of residents is needed to perform subgroup analysis considering different years of residency training, gender, marital status, and parenthood. The influence of personality traits on psychomotor function of the participants can also be assessed in future research. The various sums of working hours and shift duration should be considered along with day/night shifts to assess psychomotor function. Alcohol consumption is socially stigmatized in our settings and the participants were supervised during shifts and test performance to be clinically normal. Furthermore, as the majority of residents reported that they drink coffee before each shift, we tried to unify and control the volume and the type of coffee used by offering them a cup of coffee of a similar brand before tests.

4 DISCUSSION

According to our findings on 12-hour shifts of the emergency medicine residents, night shifts were significantly correlated with sleepiness...
### TABLE 2  Detailed scores of the psychomotor test results of emergency medicine residents

| Variable                        | Time of shift | Before the shift mean (SD) | 95% CI          | After the shift mean (SD) | 95% CI          | P value before and after shift | P value day/night shifts |
|---------------------------------|---------------|-----------------------------|-----------------|---------------------------|-----------------|------------------------------|--------------------------|
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 22.1 (1.76)                 | 21.4–22.8       | 22.6 (1.24)               | 22.1–23.1       | 0.268                        | 0.811                    |
|                                 | Night         | 22.9 (1.14)                 | 22.4–23.4       | 23.2 (0.95)               | 22.8–23.6       | 0.236                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 33.9 (1.4)                  | 33.3–34.5       | 35.0 (0.9)                | 34.6–35.4       | 0.001                        | 0.034                    |
|                                 | Night         | 34.9 (1.3)                  | 34.4–35.4       | 35.0 (0.8)                | 34.7–35.3       | 0.770                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 2.47 (0.56)                 | 2.2–2.7         | 2.45 (0.57)               | 2.2–2.7         | 0.840                        | 0.917                    |
|                                 | Night         | 2.24 (0.56)                 | 2.0–2.5         | 2.19 (0.62)               | 1.9–2.4         | 0.280                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 223.6 (30.3)                | 211.0–236.2     | 260.2 (30.3)              | 247.6–272.8     | 0.000                        | 0.003                    |
|                                 | Night         | 272.7 (25.8)                | 262.0–283.5     | 273.2 (26.3)              | 262.2–284.2     | 0.851                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 13.0 (6.2)                  | 10.4–15.6       | 11.9 (7.0)                | 9.0–14.8        | 0.439                        | 0.963                    |
|                                 | Night         | 13.4 (5.7)                  | 11.0–15.8       | 12.5 (7.5)                | 9.4–15.6        | 0.358                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 12.09 (5.35)                | 9.9–14.3        | 8.09 (3.25)               | 6.9–9.4         | 0.000                        | 0.036                    |
|                                 | Night         | 7.48 (3.70)                 | 5.9–9.0         | 7.26 (7.43)               | 4.2–10.4        | 0.739                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 0.85 (0.08)                 | 0.8–0.9         | 0.79 (0.08)               | 0.8–0.8         | 0.000                        | 0.077                    |
|                                 | Night         | 0.75 (0.07)                 | 0.7–0.8         | 0.75 (0.08)               | 0.7–0.8         | 1.000                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 14.48 (3.36)                | 13.1–15.9       | 13.26 (3.51)              | 11.8–14.7       | 0.101                        | 0.684                    |
|                                 | Night         | 14.52 (3.15)                | 13.2–15.8       | 13.91 (4.20)              | 12.2–15.7       | 0.293                        |                          |
|                                 |               |                             |                 |                           |                 |                              |                          |
|                                 | Day           | 15.87 (2.87)                | 14.7–17.1       | 15.17 (2.10)              | 14.3–16.3       | 0.201                        | 0.698                    |
|                                 | Night         | 16.04 (2.42)                | 15.0–17.0       | 15.78 (3.19)              | 14.5–17.1       | 0.560                        |                          |

Abbreviations: SD, standard deviation; CI, confidence interval; COG, cognition test; DT, determination test; LVT, visual pursuit test.

**FIGURE 1**  (A–C) The participants’ scores of general health questionnaire (GHQ), their circadian rhythm status, and fatigue before and after day and night shifts

**FIGURE 2**  (A–C) The participants’ scores of the cognition test (COG) sum hit variable, the determination test (DT) median reaction time, and visual pursuit test (LVT) working time scores before and after day and night shifts
after the shift in comparison with day shifts. Both day and night shifts were correlated with fatigue, although these issues were worse after their first night shifts. Although sleepiness may be logically increased after shifts, the corresponding psychomotor performance may not necessarily be the same. Our findings are congruent with the findings of Boivin et al. who also reported that sleepiness and fatigue occur more commonly in night shifts probably because of changes in circadian rhythms of medical workers. Patterson et al. showed that increased fatigue and poor sleep could lead to safety-compromising behaviors in emergency medical service (EMS) providers. Basner et al. reported that the mean weekly working hours for residents were less than 60 hours in the United States in 2010.

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AUTHOR CONTRIBUTIONS

SS, PP, MB, FA, MAZ, and MS conducted the research and designed the study. MAZ, MB, and MS performed data collection. MB, MAZ, MS, FA,
SS, and PP drafted the manuscript. MB, MAZ, MS, FA, SS, and PP contributed to the final version of the manuscript.

CONFLICTS OF INTEREST
The authors declare no conflicts of interest.

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