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Authors
Zahraie, Mehrnoosh Aligholi
Alaedini, Farshid
Payandemehr, Pooya
et al.

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ORIGINAL RESEARCH

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

Mehrnoosh Aligholi Zahraie MD[1] | Farshid Alaedini[2] | Pooya Payandemehr MD[3] | Soheil Saadat[4] | Mehran Sotoodehnia MD[3] | Maryam Bahreini MD[5]

[1] Department of Emergency Medicine, Tehran University of Medical Sciences, Tehran, Iran

[2] Research Center for Health Management in Mass Gathering, Red Crescent Society of Iran, Tehran, Iran

[3] Department of Emergency Medicine, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran

[4] University of California, Irvine, California, USA

[5] Department of Emergency Medicine, Tehran University of Medical Sciences, Tehran, Iran

Correspondence
Maryam Bahreini, MD, Department of Emergency Medicine, Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran.
Email: bahreinimaryam@gmail.com

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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

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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.[1,2] 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.[3] Neuro-cognitive dysfunction, sleepiness, and fatigue are gradual effects of shift-rotational careers that can hamper general health.[4] It is well-known that changes in circadian rhythm influence the cognitive and psychomotor capabilities of affected people including medical workers.[5,6] Sleep deprivation during night/rotational shifts as well as the healthcare workload affect psychomotor abilities in every-day practice.[7]

Despite some evidence about further tolerance to sleep deprivation by means of individualized solutions among healthcare staff,[8] the observed effects are concerning, especially on clinical decision-making that is linked to patient healthcare under special clinical consideration.[9,10] Sleep deprivation is also a major contributor to decline and delay cognition and judgment.[1] Some effects may be similar to other vocational activities after short or long periods of sleep deprivation.[11] The tasks routinely performed by healthcare staff are not only related to themselves but also may affect the health status of patients.[12–14] 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.[15]

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.[16,17] Amado et al[18] 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[19] 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.

The Bottom Line

Shift work is an integral part of the practice of emergency medicine. This study examined the effect of shift work on psychomotor activities of 23 emergency medicine residents in Iran. Although sleepiness was more common after night shifts, psychomotor function was not affected by night shift compared to day shift.

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).[20]

The COG evaluates selective attention and concentration comparing a geometric figure with others and determining whether the figure is identical to one of the other figures. The main variables of this test were sum hits (selective attention), the sum of correct rejections, and mean time correct rejections that measure the precision of the attention control. Concentration has a great influence on every-day performance and challenging activities.

The DT examines complex choice reaction time and stress tolerance by distinguishing various colors and sounds to select reactions. Participants react quickly under complex stimulus conditions to an optical or acoustic stimulus by pressing a button. The main variables of this test in this study were median reaction time and correct/incorrect/omitted responses. This test assesses reactive stress tolerance to investigate the behavior under different levels of stress.

The LVT assesses visual orientation performance and visual perception. This test is especially used in the field of safety assessment and is related to quick and accurate assessment of detailed visual stimuli. In this test, participants confront a number of disordered lines and are asked to identify the end of one line as quickly as possible.[21] 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.[22]

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[23] by valid and reliable questionnaires. Sleepiness was defined as an urge to sleep and assessed by Stanford sleepiness scale.[24] 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).[25] The standardized 12-item general health questionnaire (GHQ-12) was administered to assess the general health status of the participants.[26] 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.[27]

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 $\pm$ SD (range) of age was 35.7 $\pm$ 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 Results of general health, circadian, and sleepiness 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 shifts	*P* value day/night shifts
GHQ	Day	10.8 (4.6)	8.9–12.7	9.5 (4.3)	7.7–11.3	0.091	0.082
	Night	10.1 (5.9)	7.6–12.6	12.4 (4.7)	10.4–14.4	0.094	
Circadian total	Day	6.6 (2.6)	5.5–7.7	6.3 (2.9)	5.1–7.5	1.000	0.866
	Night	5.9 (2.8)	4.7–7.1	5.9 (2.7)	4.8–7.0	1.000	
Languid circadian	Day	4.1 (2.1)	3.2–5.0	4.4 (2.1)	3.5–5.3	0.135	0.811
	Night	3.9 (2.4)	2.9–4.9	3.9 (2.4)	2.9–4.9	0.219	
Flexible circadian	Day	2.3 (1.6)	1.6–3.0	2.0 (1.6)	1.3–2.7	0.229	0.612
	Night	2.3 (1.6)	1.6–3.0	2.3 (1.7)	1.6–3.0	1.000	
Stanford Sleepiness Scale scores	Day	1.96 (1.33)	1.4–2.5	1.81 (0.75)	1.5–2.1	0.576	0.000
	Night	1.74 (1.01)	1.3–2.2	2.95 (1.09)	2.5–3.4	0.000	
SOFI: total score	Day	0.92 (0.74)	0.6–1.2	1.61 (1.45)	1.0–2.2	0.055	0.469
	Night	0.93 (0.89)	0.6–1.3	2.04 (1.64)	1.4–2.7	0.011	
Physical exertion (SOFI)	Day	0.49 (0.70)	0.2–0.8	0.76 (1.19)	0.3–1.3	0.422	0.701
	Night	0.79 (1.20)	0.3–1.3	0.86 (1.40)	0.3–1.4	0.567	
Lack of motivation (SOFI)	Day	1.32 (1.04)	0.9–1.8	1.43 (1.21)	0.9–1.9	0.682	0.360
	Night	1.27 (1.16)	0.8–1.8	1.91 (1.64)	1.2–2.6	0.080	
Lack of energy (SOFI)	Day	1.15 (1.05)	0.7–1.6	2.75 (2.34)	1.8–3.7	0.008	0.574
	Night	0.98 (1.34)	0.4 1.0	3.03 (2.07)	2.2–3.9	0.001	
Physical discomfort (SOFI)	Day	0.67 (0.73)	0.4–1.0	1.44 (1.91)	0.6–2.2	0.081	0.987
	Night	0.86 (1.19)	0.4–1.4	1.61 (1.97)	0.8–2.4	0.104	
Somnolence (SOFI)	Day	1.07 (1.08)	0.6–1.5	1.83 (1.72)	1.1–2.5	0.101	0.107
	Night	0.75 (1.29)	0.2–1.3	2.59 (1.79)	1.8–3.3	0.002	

Abbreviations: SD, Standard deviation; CI, confidence interval; GHQ, general health questionnaire; SOFI, Swedish occupational fatigue inventory.

Table 2 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
COG: sum hits	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	
COG: sum of correct rejections	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	
COG: mean time correct rejection (ms)	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	
DT: correct responses	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	
DT: incorrect responses	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	
DT: omitted responses	Day	12.09 (5.35)	9.9–14.3	8.09 (3.25)	6.–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	
DT: median reaction time (ms)	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	
LVT: score (based on viewing time episodes)	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	
LVT: score (based on working time episodes)	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.

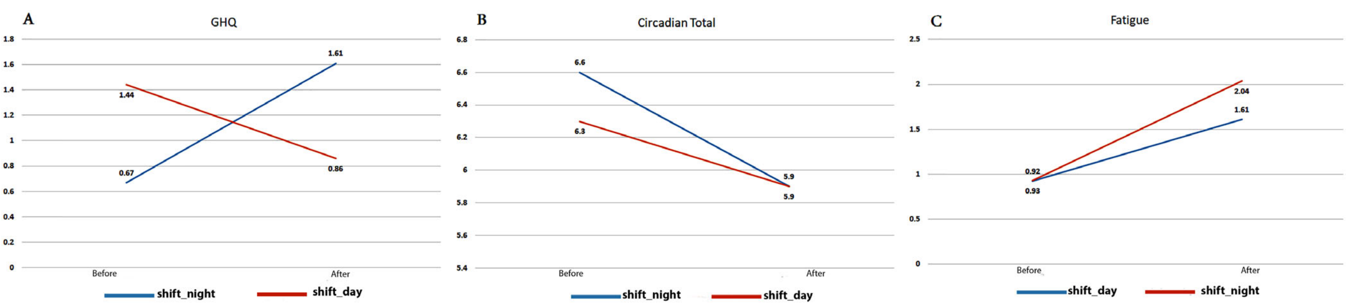

FIGURE 1 (A–C) The participants' scores of general health questionnaire (GHQ), their circadian rhythm status, and fatigue before and after day and night shifts

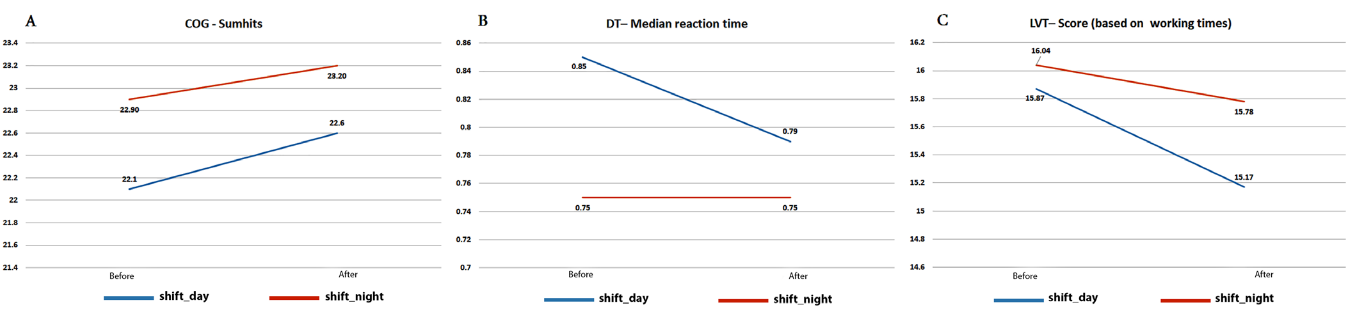

FIGURE 2 (A–C) The participants' scores of the cognition test (COG) sum hit variable, the determination test (DT) median reaction time, and visual pursuit test (LVT) working time scores before and after day and night shifts

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[28] 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[29] showed that increased fatigue and poor sleep could lead to safety-compromising behaviors in emergency medical service (EMS) providers. Basner et al[30] reported that long work shifts resulted in a larger decline in residents' alertness.

Other researchers showed that first day shifts could be correlated with similar sleep restriction to night shifts, especially immediately after an evening shift in rotating shift workers. Alertness and performance became impaired during night shifts because of the lack of circadian adaptation to night work. Although healthcare personnel felt less alert on the first night shift, objective performance was equally impaired compared to subsequent night shifts. However, they noted that the first night shift in a sequence was associated with higher wakefulness before the shift. Although a similar degree of performance impairment was observed in objective measures for the first and final night shifts, subjective ratings of concentration, task difficulty, sleepiness, and motivation were more impaired on the first night shift.[17]

Overall, we did not detect a significant difference between the COG sum hit scores, addressing selective attention, and LVT scores, a representative of psychomotor performance of emergency medicine residents before and after the day/night shifts. We could not show hampered psychomotor performance in the night shifts compared to day shifts according to these tests. Some other researchers evaluated the psychomotor capabilities of 9 surgery residents and similarly found no difference in this regard before and after shifts. These results are found despite workload difference among residents of other disciplines and settings.[31] However, after the termination of day shifts, we found a higher sum of correct rejections of the COG test. In addition, the correct responses of DT were more prevalent, the omitted responses were also fewer with better median reaction time after day shifts. These findings demonstrate that selective attention in their performance and reactive stress tolerance were not worse after night shifts and probably improved after day shifts. This may be because of sleep inertia, defined as a deficit of motor skills directly after rapidly waking up in the beginning of day shifts.[32]

Regarding various shift durations, some authors found that longer work shifts causes more decline in residents' alertness.[30] Sadeghi et al[3] estimated weekly working hours of 90.1 and 74.7 for surgery and non-surgery residents, respectively, in Iran in 2020, whereas Staiger et al[33] reported that the mean weekly working hours for residents were less than 60 hours in the United States in 2010.

The sum of correct rejections of the COG test showed significant difference with improved results in night tests compared to day-shift tests. The mean reaction time of DT showed significant difference with shorter reaction time in night-shift tests. Our results suggested that passing 12-hour clinical shifts did not cause the participants to omit more questions and did not increase their reaction time to respond in comparison to their basic performance before the shifts in DT. In this context, Bjorvatn et al[34] showed that the performance of medical workers, including reaction time, gradually improved during night shifts. This issue could be an explanation for our similar findings, however, further investigation is required.

Some studies suggested that fatigue and sleep deprivation are correlated with longer reaction time.[35,36] Westbrook et al[37] reported that task errors in emergency medicine specialists are associated with their level of fatigue and working memory capacities. Sadeghi et al[38] showed that the majority of residents suffer from high workload which can cause more decline in their psychomotor and cognitive capabilities. The psychomotor impairment could be explained by multiple-resource theory of cognition according to which humans merge various cognitive resources such as attention, memory, and reasoning to solve problems.[39] In multi-task situations, individuals usually shift resources from one to another. However, the performance on the other tasks declines if the difficulty of a task increases.[40]

It is crucial to note that the extent of probable dysfunction experienced by healthcare workers is related to their professional level.[41] The senior resident may be logically more affected by sleep deprivation versus a junior resident[42] because of more complicated responsibilities and the need to make more critical decisions despite fewer clinical shifts. Not only are the years of experience or the vocational level contributing factors in this issue. The type of affected function in healthcare staff can be indirectly related to the professional dysfunction and subsequent outcomes.[43,44] Recognition of such impacts on psychomotor performance can help better manage subsequent shortcomings for both students and their patients in emergency wards in other countries.[45] Even an insignificant decline in psychomotor capabilities of emergency medicine residents should be further addressed considering the critical roles they have. Although mandatory shift-rotational night work and sleep deprivation effects are inevitable,[46] some preferences can be applied (eg, family support or childcare measures for parents or taking pregnant women off from night shifts during the third trimester). Furthermore, the educational aspect of clinical shifts shall be the primary endpoint of residency training other than therapeutic management of an overcrowded ED.

Sleepiness and lack of energy were higher after shifts. The psychomotor function of emergency medicine residents was not delayed or worse after night shifts in comparison to day shifts. The ability to react rapidly and properly in the extended orders of reaction tasks did not decrease after the shifts.

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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.

ORCID

Maryam Bahreini MD https://orcid.org/0000-0002-7655-0987

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