ORIGINAL ARTICLE

EVALUATING THE EFFECTS OF NIGHT SHIFTS ON ATTENTION AND EXECUTIVE FUNCTION OF TRAKYA UNIVERSITY RESIDENTS USING THE TOWER OF HANOI TEST

Irmak İrem Özyiğit[1], Alperen Taha Certel[1], Begüm Söyleyici[1], Sezgin Kehaya[2]

[1] Trakya University School of Medicine, Edirne, TURKEY
[2] Department of Neurology, Trakya University School of Medicine, Edirne, TURKEY

ABSTRACT

Aims: This study aims to evaluate the effects of night shifts on attention and executive function among residents working at Trakya University Hospital. ***Methods:*** This prospective study was performed between November 2019 – January 2020 on 83 residents working at Trakya University Hospital. The Tower of Hanoi test was used to measure the attention and function level of two different groups of residents. The first group being residents working with night shifts and the other group being residents with regular working hours. After the participants finished solving the puzzle, the number of moves and the finishing time were recorded. The demographic data about smoking, coffee intake, sleep hours, departments, and hand dominance were also recorded. ***Results:*** The participants were composed of 36 (43.4 %) female and 47 (56.6 %) male residents. The difference in smoking rate and sleep time between the two groups were found to be statistically significant whereas the difference between the completion time and moves was not statistically significant. ***Conclusion:*** Smoking and duration of sleep may affect the Tower of Hanoi puzzle performance. Although residents working with night shifts did not under-perform, the importance of sleep for cognitive skills such as attention and coordination cannot be underestimated. Stress caused by night shifts may affect reaction time for problem-solving, but further studies are needed. ***Keywords:*** Nightshift, attention, Tower of Hanoi test

INTRODUCTION

Nightshift is an irregular work schedule which is extended beyond the usual 08:00-17:00 working hours (1). This irregularity affects residents' lifestyles. Employees working with nightshifts, for instance, residents are more subjected to loss of sleep time, difficulties with sleep onset, drowsy driving, and difficulties with concentration (1). Furthermore, night shift work abolishes melatonin levels and causes repair decrement of oxidative DNA lesions which is suggesting a role for oxidative stress (1). Poor sleep quality was significantly associated with anxiety and depression (1). As the anxiety and depression levels increase, back problems, eyesight difficulties, ulcers, and migraine headaches may start to occur. Thus, the longer the residents work the more prone they become to under-performing in their daily tasks (2).

Night shifts are recognized as a burden that affects doctors' behavior and attitude (2). Night shift does not only affect the residents' stress levels, but it also affects their sleep cycles. Doctors usually have many duties during the night shifts and those duties interrupt their sleep cycles (1). Thus, residents working with night shifts experience desynchronosis. This is usually a result of disruption to the circadian rhythm which is a biological cycle to coordinate various behavioral and physiological activities (1).

The workload during the night shifts also leads to sleep deprivation which has a high incidence among doctors (3). The danger of sleep-deprived medical mistakes by health care professionals has been recognized (3). Gülser et al. (4) suggested that sleep disorders can be caused by night shifts since they cause interruption of the circadian rhythm. On the other hand, a study conducted by Baldwin et al. (2) states that longer or

Address for Correspondence: Irmak İrem Özyiğit, Trakya University School of Medicine, Edirne, TURKEY
e-mail: iiozyigit@gmail.com ORCID: orcid.org/0000-0003-2443-0155
Received: 05.01.2020 Accepted: 15.01.2020 • DOI:10.4274/tmsj.galenos.2020.07.01.04 Available at: tmsj.trakya.edu.tr

Cite this article as: Özyiğit İİ, Certel AT, Söyleyici B et al. Evaluating the effects of night shifts on attention and executive function of Trakya University residents using the tower of hanoi test. Turkish Med Stud J 2020;7(1):20-5.

shorter sleep hours do not correlate with general health knowledge and attention. However short sleep periods relate the somatic symptoms such as "feeling run down" or "pain in the head" (2). For this reason, the necessity of sleep is very crucial for residents who need a lot of attention and coordination for their daily work.

"Tower of Hanoi" is used to measure the dysfunction and executive function levels. This measurement method is validated by a study on neuropsychology by Welsh et al (5). It is considered to be an exemplary measure of the executive function of the prefrontal cortex (5, 6). Solving the puzzle requires the coping ability with novel situations and means-end analysis (5). The puzzle also has an acceptable level of internal consistency (alpha=0.70) (5).

The aim of this study is to evaluate the effects of the night shift on attention and executive function among residents working at Trakya University Hospital using the Tower of Hanoi.

MATERIAL AND METHODS

This prospective study was approved by the Scientific Research Ethics Committee of Trakya University (Protocol Code: TÜTF-BAEK 2019-360). After obtaining informed consent from all participants, the study was performed between November 2019 and January 2020. The study population was composed of 83 residents who work at internal (cardiology, endocrinology, family medicine, gastroenterology, hematology, infectious diseases, internal medicine intensive care, nephrology, neurology, pediatrics, pulmonology, rheumatology) and surgical (anesthesiology, cardiovascular surgery, general surgery, gynecology, neurosurgery, ophthalmology, orthopedics and traumatology, otolaryngology, pediatric surgery, plastic surgery, urology) departments at Trakya University Hospital.

The trial was composed of two days. On the first and second days of trial, the residents were asked to solve the Tower of Hanoi puzzle and after they completed the puzzle, the number of moves and the completion time were recorded. The results from two different days with at least a 24-hour interval were evaluated to compare their performances. The puzzle trials were conducted in between 13:30-17:00 for each resident. On the second day of trial, data about their smoking habit, coffee intake, sleep duration, age, gender, department, shift status and hand dominance were recorded. Data on sleep duration, smoking habits, and coffee intakes are from the last 24-hours.

The participants were composed of two groups: residents with a night shift (continuously working for 36 hours) and residents with regular working hours (total of 9 hours). The first day of trial for the residents working on a night shift was before their night shift duty, and after they completed their night shift, they solved the puzzle again on their working hours. Residents on their regular working hours solved the puzzle in two different days with the same procedure.

"Tower of Hanoi" is a puzzle consisting of 3 bars (right, middle and left bars) and 5 different sized disks. The puzzle starts with all the disks being placed on the left bar. The aim of the puzzle is to take disks from the left bar and place them to the right bar. The person must build the tower on the right by following the three rules: only one disk can be moved at a time, a disk may not be placed on the table or held in the hand while another disk was being removed, a larger disk may not be placed on top of smaller disks (5). The mobile version of the puzzle has been used in this study.

For statistical analysis, SPSS 23.0.0.0 was used. The Kolmogorov-Smirnov test was used to check whether the variables distributed normally or non-normally. T-test was used for parametric variables whereas Mann-Whitney U test was used for non-parametric variables. Wilcoxon signed-rank test was used for evaluating the difference within the groups. The Chi-Square test was used for categorical descriptive data. Categorical variables were expressed as numbers and percentages. Normally distributed variables were summarized as mean and standard deviation, while non-normally distributed variables were summarized as median and interquartile range. In all statistical analyses, the significance level was determined as 0.05.

RESULTS

In this prospective study, the Tower of Hanoi test was performed on 83 residents and they were later divided into two groups; residents working on a night shift (n=40) and residents on their regular working hours (n=43). All steps in the puzzle and questionnaire were completed precisely. The total group was composed of 36 (43.4 %) female and 47 (56.6 %) male residents. The mean age of all participants was 27.9 ± 2.39 years. Comprehensive demographic data of the population can be observed in Table 1. Statistically significant difference was found in the smoking rate, and sleep time between groups (p=0.001).

Evaluation of the number of moves given by the digital Tower of Hanoi puzzle application and manu-

Table 1: Distribution of the residents according to their descriptive characteristics.

		Night shifts (n= 40)	Regular working (n= 43)	P value
Age (years)		27.83±2.1	28.05±2.6	0.952
Gender (n)	Female	14(35%)	22(51.2%)	0.136
	Male	26(65%)	21(48.8%)	
Smoking (n)	Yes	22	9	0.001
	No	18	34	
Coffee (n of cups)	Yes	33	39	0.269
	No	7	4	
Sleep time (hours)		4.88±1.42	6.62±1.45	0.001
Department (n)	Surgical	27	17	0.150
	Medical	13	26	
Hand dominance (n)	Right	38	39	0.677
	Left	2	4	

As descriptive statistics, quantitative data are expressed as mean ± standard deviation and qualitative data are expressed as numbers (percentages).

Table 2: Evaluation of moves and completion time.

		Night shifts (n= 40)	Regular working (n= 43)	P value
Moves (median (IQR))	1st	66 (44)*	69 (35)**	0.128
	2nd	70 (57)*	73 (44)**	0.538
Completion time, sec (median (IQR))	1st	153 (186)***	164 (197)****	0.307
	2nd	142.5 (93)***	142 (126) ****	0.841

*p=0.551: the difference between night shift groups in 1st and 2nd day.
**p=0.983: the difference between regular working groups in 1st and 2nd day.
***p=0.501: the difference between night shift groups in 1st and 2nd day.
****p=0.091: the difference between regular working groups in 1st and 2nd day.

Data are presented as median (interquartile range).

ally recorded completion time are presented in Table 2. Both of the groups, working with shifts and with regular hours, finished the puzzle with more moves on their second day of trial (p=0.551, and p=0.983, respectively). On the contrary, completion time records show a decrease on the second day of trial. Although there was no significant difference, residents working with shifts solved the puzzle with fewer moves on both of the days, and their completion time was also shorter on the first day of trial (p=0.128, p=0.583, and p=0.307, respectively).

DISCUSSION

Night shifts, especially in a demanding area like medicine, can be detrimental to physiological and psychological health. Healthcare professionals' attention and level of sleepiness may vary after shifts due to their working conditions. According to the literature, the Tower of Hanoi puzzle can be helpful to evaluate executive function which is of vital importance for doctors (5, 6). Their anticipation and problem-solving abilities were tested through the puzzle. Residents working with night shifts made fewer moves than residents working with regular hours. However, residents working with night shifts completed the task with more moves compared to their first trial when the test was performed after their night shifts. Residents who were working in regular hours also completed the task with more moves in their second trial. Besides, the completion time scores of both groups were quite close even though residents working with night shifts had a lesser time of sleep. This may be explained by a study conducted on mammals by Reser (7), stating that living in a stressful environment can cause changes in the body, notably in the neuroendocrine system. Humans and other mammals need to be more time-intensive and quick on information processing while under stress. This basic struggle for survival can be observed among residents. Poulton et al. (8) claimed that the lack of sleep and working conditions can cause stress, but it is not valid for every doctor.

The data obtained from this study shows that residents working with night shifts and residents working with regular hours completed the puzzle with more moves on their second day. However, Goel et al. (9) claimed that the Tower of Hanoi puzzle does not require planning abilities, therefore figuring out the trick of the puzzle is sufficient to complete the task. Both of the groups played and understood how to solve the puzzle on their first trial. On the second day of the study, two of the groups completed the puzzle with more moves. This data suggests that knowing how to solve the puzzle cannot be enough by itself, some external or internal factors may affect the results.

In our study, mean sleep time while working with a night shift was 4.88±1.42 hours, whereas the sleep time while working with regular hours was 6.62±1.45 hours for residents. Gülser et al. (4) confirms that restless legs syndrome which disrupts the circadian rhythm and night shift related sleep disorders can be seen among the health care workers. Our study does not include any scale to identify sleep disorders, but our results show a deficiency of sleep among the residents with night shifts. According to the literature, lack of sleep can cause stress which could increase vigilance, also lead to minor mistakes, tiredness, impaired decision-making, and poor performance on tasks (3, 7, 10, 11). In our study, the residents working on a night shift had fewer hours of sleep, and this situation might have affected the performance in a positive way which may be relevant to the stress caused by working conditions.

In addition to total sleep time, the smoking rate was also high among the residents with night shifts. Sleep time and smoking were confounding variables that may affect the number of moves and the completion time of the puzzle. According to the literature, nicotine influences the human brain in many ways including developed cognitive productivity, attention and memory in acute use (12). This cognitive development might lead the residents to solve the puzzle with fewer moves and time because of their accelerated information processing. Getting less sleep during the night shifts may be associated with not only the working conditions but also with smoking since nicotine alerts the brain in sensorial and motor aspects (12, 13). Although there was no significant difference found in regard to the residents' coffee consumption between the groups, caffeine may reduce reaction time and enhance performance. Buchvold et al. (14) states that on night shift duties, consumption of caffeine increases because of its stimulant effect. Our findings must be interpreted with caution because the number of cigarettes and the amount of coffee consumed daily were not included in the study. The amount of nicotine per cigarette varies for each brand. In addition, the amount of caffeine also varies regarding the cup size and coffee type. Amount and half-life of caffeine may affect attention span, therefore recording the time of the last coffee intake is recommended in future studies (13). According to the previous studies, although both caffeine and smoking have an impact on mental alertness, the effect that smoking has on cognitive skills should be evaluated with pre/post and acute/

chronic categories (12, 13). While acute smoking increases cognitive skills, long-term smoking is related to cognitive impairment (12).

The residents were chosen from two different departments: internal medicine and surgery. Within the groups, there was no significant difference in the number of residents between internal medicine physicians and surgeons. This data suggests that internal medicine physicians and surgeons might be distributed randomly in both of the groups. Wilkinson et al. (10) suggested that specialties with longer working hours are the ones who admitted low efficiency, but there was no distinctive analysis to compare surgery to internal medicine in our study.

In this study, there was no significant difference found in hand dominance between the night shift and regular working groups. Previous studies show that dominant hand preference affects attention (14,15). The relation of attention and right hemisphere dominance was shown by Weintraub et al. (15). A study conducted on the left and right-handed subjects by Chaudhary et al. (16) confirms that cognitive skills are related to hand dominance. The performances on attention and memory were found to be better in left-handed subjects (16). In our study, there were 2 left-handed subjects within residents working with night shifts and 4 left-handed subjects within residents working with regular hours. Since there were not many left-handed subjects involved in our study, it can be hard to establish extensive conclusions that evaluate the effect of hand dominance on the Tower of Hanoi performance. Additionally, we encourage conducting future studies that include one group of residents that are asked to solve the puzzle with their non-dominant hands, and another group of residents that are asked to solve the puzzle with their dominant hands. This selective use of hands may reveal varied results.

The Tower of Hanoi puzzle can determine whether a resident can solve problems quickly and if he/she has an advanced memory (17). There was no significant difference in the number of moves for the first and second days of residents working with night shifts and residents working with regular hours for both of the days. Both of the groups performed better on their first day of solving the puzzle which suggests that knowing how to solve the puzzle might not contribute to the subjects' performances on their second time of solving the puzzle. On the contrary, we found that the completion time was shorter when they performed the test for the second time. Residents working with night shifts completed the puzzle in 153 seconds on their first day and in 142.5 seconds on their second day. Residents working with regular hours completed the puzzle in 164 and 142 seconds on their first and second day, respectively. However, the difference between the completion times was not statistically significant. The stress factor or conditioning for doing no mistake in residents working with night shifts might be the reason for shorter completion time on the first day of the test. Completion time has shortened for both of the groups on the second day of the test. The completion time decreased by 11.5 seconds for the residents working with night shifts and 22 seconds for the residents working with regular hours. The reason behind a shorter completion time within the residents working with regular hours may be attributed to the difference in their sleeping hours. A smaller decrease in completion time was seen among the residents with night shifts which might be due to the elimination of the stress factor after finishing their night shift duty.

This study does not provide information about the impact of medications, and medical history on attention and sleepiness levels. Since the questionnaire was conducted participants' in their working space during office hours, they were not willing to answer personal and time-requiring questions, therefore we could not obtain enough data to analyze them. The subjects were chosen from the departments of surgery and internal medicine, but out of all residents, four of them were working on a shift in a different field rather than their expertise. Working in a different department and taking responsibility during the shifts may increase their level of stress which by implication can change the results. With more subjects, future studies evaluating the presented case are needed. Further studies with more subjects to determine if the Tower of Hanoi puzzle is reliable on measuring problem-solving speed on repetitive tests are recommended.

As a conclusion, smoking and duration of sleep were found to be different between the residents with night shifts and residents with regular working hours. This difference may have an impact on the number of moves and the time of completion. Even though residents working with night shifts did not perform worse than residents working with regular hours, the effects of night shifts on cognitive skills such as attention and executive function cannot be underestimated. Being exposed to stress during the night shift can decrease reaction time for problem-solving but further extensive studies are needed.

Ethics Committee Approval: This study was approved by the Scientific Research Ethics Committee of Trakya University School of Medicine (Protocol Code: TÜTF-BAEK 2019-360).
Informed Consent: Informed consent was obtained from the participants of this study.
Conflict of Interest: The authors declared no conflict of interest.
Author contributions: Concept: İİÖ, ATC, BS, SK Design: İİÖ, ATC, BS, SK Supervision: İİÖ, ATC, BS, SK Resources: İİÖ, ATC, BS, SK Materials: İİÖ, ATC, BS, SK Data collection and/or processing: İİÖ, ATC, BS Analysis and/or Interpretation: İİÖ, ATC, BS, SK Literature Search: İİÖ, ATC, BS, SK Writing Manuscript: İİÖ, ATC, BS Critical Review: İİÖ, ATC, BS, SK
Financial disclosure: The authors declared that this study received no financial support.
Editor-in-chief's note: Three authors of this article, Irmak İrem Özyiğit, Alperen Taha Certel and Begüm Söyleyici are members of the editorial board of Turkish Medical Student Journal. However, they did not take place in any stage on the editorial decision of the manuscript. The editors who evaluated this manuscript are from other institutions.

REFERENCES

1. Jaradat R, Lahlouh A, Mustafa M. Sleep quality and health related problems of shift work among resident physicians: a cross-sectional study. Sleep Med 2019;66:201-66.
2. Baldwin PJ, Dodd M, Wrate RW. Young doctors' health-I. How do working conditions affect attitudes, health, and performance? Soc Sci Med 1997;45(1):35-40.
3. Beecham L. Unanimous support for reduction in juniors' hours. Brit Med J 1989;298:121-3.
4. Gülser N, Öztürk L, Top MŞ et al. The relationship between restless legs syndrome and insomnia for the staff in shift. Archives of Neuropsychiatry 2012;49(4):281-5.
5. Welsh MC, Huizinga M. The development and preliminary validation of the Tower of Hanoi – revised. Assessment 2001;8(2):167-76.
6. Patsenko EG, Altmann EM. How planful is routine behavior? A selective-attention model of performance in the Tower of Hanoi. J Exp Psychol Gen 2010;139(1):95–116.
7. Reser JE. Chronic stress, cortical plasticity and neurocology. Behavioural Processes 2016;129:105-15.
8. Poulton EC, Hunt GM, Carpenter A et al. The performance of junior hospital doctors following reduced sleep and long hours of work. Ergonomics 1978;21(4):279-95.
9. Goel V, Grafman J. Are the frontal lobes implicated in "planning" functions? Interpreting data form the Tower of Hanoi. Neuropsychologia 1995;33(5):623-42.
10. Wilkinson RT, Tyler PD, Varey CA. Duty hours of young hospital doctors: Effects on the quality of work. J Occup Psychol 1975;48:219-29.
11. Lingenfelser TH, Kaschel R, Weber A et al. Young hospital doctors after night duty: their task-specific cognitive status and emotional condition. Medical Education 1994;28:566-72.
12. Campos MW, Serebrisky D, Castaldelli-Maia JM. Smoking and cognition. Curr Drug Abuse Rev 2016;9(2):76-9.
13. Ullrich S, de Vries YC, Kühn S et al. Feeling smart: effects of caffeine and glucose on cognition, mood and self-judgment. Physiol Behav 2015;151:629-37.
14. Buchvold HV, Pallesen S, Øyane NMF et al. Associations between night work and BMI, alcohol, smoking, caffeine and exercise – a cross sectional study. BMC Public Health 2015;15:1112.
15. Weintraub S, Mesulam M. Right cerebral dominance in spatial attention: Further evidence based on ipsilateral neglect. Arch Neurol 1987;44(6):621-5.
16. Chaudhary S, Narkeesh A, Gupta N. A study of cognition in relation with hand dominance. Journal of Exercise Science and Physiotherapy 2009;5(1):20-3.
17. Leana MZ. Üstün zekalı ve normal çocuklarda yönetsel fonksiyonlar: Londra Kulesi testi (dissertation). Istanbul: Istanbul Univ. 2005.