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RESEARCH ARTICLE

Effect of sleep deprivation on finger dexterity in resident doctors

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ABSTRACT

Background: Prolonged resident duty hours may affect patient care. There are no restrictions to the amount of hours a resident can work which may lead to medical errors and lapses in patient care. **Aims and Objectives:** The purpose of this study was to prospectively evaluate the effect of sleep deprivation (SD) on finger dexterity at different intervals of SD during the residents' on-call period and to identify the duration after which these effects begin. We further tested if this decline correlated with the subjective assessment of sleepiness. **Materials and Methods:** The finger dexterity was measured by the O'Connor dexterity apparatus, and subjective sleepiness assessment was carried out using pictorial sleepiness scale in 30 resident doctors at 6 h intervals during their on-call period which lasted for 24 h. **Results:** The finger dexterity was significantly decreased at the end of the 24 h duty period as compared to the baseline. This deterioration began after being on-call for 12 h and progressed thereafter. The changes in finger dexterity correlated negatively with the subjective sleepiness assessment. **Conclusion:** 24 h of SD during on-call duty significantly decreases the finger dexterity in resident doctors. This might be a major cause of medical errors and hamper patient safety.

KEY WORDS: Sleep deprivation; Finger dexterity, Psychomotor performance

INTRODUCTION

Sleep duration is one of the parameters to measure sleep health. On an average, an adult requires 8 h of sleep on a daily basis.[1] Doctors are known to work for long hours, and the work schedule of the resident in the postgraduate training program is especially intense. This decreased duration of sleep on a daily basis leads to chronic sleep deprivation (SD). Resident doctors undergo short periods of total SD ranging from 24 to 48 h while being on-call. SD has a detrimental effect on various aspects of one's health. It has a negative effect on cognitive, psychomotor and judgemental abilities. Common symptoms associated with SD include increased sleepiness, decreased psychomotor performance as evidenced by longer reaction time,[2] distractedness, disturbances in attention and concentration, forgetting known facts, difficulty in memorizing new information, and mistakes of commission and omissions[3] along with degraded mood.[4] SD is one of the major causes of accidents and catastrophic failures in real-world situations.[5]

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Along with cognitive skills medical work also involves precise, coordinated, fine motor activities often involving the deft use of many delicate instruments. These dexterities though helpful throughout medicine, are especially important in surgical branches. Decreased dexterity has also been proposed to be a cause for needle stick injuries and other medical errors.[6]

Many studies have shown a detrimental effect of SD on dexterity in medical doctors at the end of a 24 h call period,

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but they haven't defined the average time period after which this decrease occurs.[7,8] We sought to determine the progressive effect of a 24 h call on fine motor coordination in resident doctors at a tertiary care institute.

Our first hypothesis was that call related SD has no effect on finger dexterity. We further proposed to test the hypothesis that duration of SD has no relation with finger dexterity.

Sensation of sleepiness is the physiological drive that promotes the onset of sleep and can be measured objectively by multiple sleep latency test or subjectively using psychometric instruments.[9] We also aimed to test our third hypothesis that subjective assessment of sleepiness does not correlate with finger dexterity.

MATERIALS AND METHODS

Study Design

A time series design was used, with progressive SD as the independent variable. Repeated measures of finger dexterity and sleepiness were done at fixed intervals of 0, 6, 12, 18, and 24 h of SD.

Ethics

Research procedure was approved by the Institutional Review Board. Informed, written consent was obtained from all participants before the study.

All residents in the Medicine and Surgery Departments at our institute were invited for the study. They were enrolled if they had irregular sleeping habits and did not report any history of

i. Sleep disorders, mental or nervous system diseases
ii. Smoking, drinking alcohol, consuming tea or coffee more than 4-5 cups a day or ingesting any other central stimulant or suppressive drugs
iii. SD due to pain, drugs, medical diseases (central nervous system disorder, diabetes, etc.).

The 30 resident doctors (15 male and 15 female) who volunteered belonged to the age group 25-30 years.

The residents' on-call duty period began from 8.00 a.m in the morning and continued for the next 24 h. Sleepiness was self-reported using the pictorial sleepiness scale[9] at intervals of 6 h, which is 0, 6, 12, 18, and 24 h of SD. Subjects were instructed to select the face that best represented their current sleepiness state. The responses were rated on a scale of 0-4 (sleepiness score) indicating increasing sleepiness. This pictorial scale is very quick and easy to use and correlates well with other standard sleepiness scales.

Finger dexterity of the participants was measured by O' Connor finger dexterity apparatus containing one metal tray (for keeping the pins), one metal plate and around 300 metal pins. The metal plate consists of 100 holes of depth 0.75 inch made with No. 9 drill. The diameter of each hole is 0.196 inch and is 0.5 inch apart. The metal pins are made of brass of 1 inch in length. The diameter of each pin is 0.072 inch. The participants were made to sit comfortably on a chair with the height adjusted so that he/she is relaxed while performing the test. They were asked to fill the holes in the metal plate with pins in a particular direction using only dominant hand. The participants were instructed to pick only three pins at a time and fill them in one hole using only the dominant hand. Video of the same is available at https://youtu.be/C7Ciu2b0ApQ. The number of pins placed in 1 min was noted as the finger dexterity score. Friedman test was used to analyze the effect of SD on finger dexterity. Unpaired *t*-test was used to analyze if the finger dexterity scores differed significantly between male and female participants. Spearman correlation test was used to find if there is any correlation between the degree of sleepiness and finger dexterity score. The level of significance was set at $P < 0.05$, the power of study was at 80%, and α-error was at 5%. For statistical analysis, software Graphpad In stat DTCG (version 3.1) was used.

RESULTS

A total of 30 participants were studied. Their ages ranged between 26 and 31 years with the mean age being 27.83 ± 1.206 years. For the 15 male participants, the mean age was 27.8 ± 1.207 years and that of the 15 female participants was 27.86 ± 1.246 years.

Analysis of the finger dexterity scores showed a progressive decline in the mean scores as the duration of SD increases. The decrease in finger dexterity score after 6 h of SD was not significant ($P > 0.05$). At 12, 18 and 24 h of SD the decrease in finger dexterity score, compared to the baseline was highly significant ($P < 0.001$) (Table 1).

There is no significant difference in finger dexterity score between male and female participants at every interval of SD in this study, as evidenced by $P > 0.05$ (Table 2).

Spearman correlation coefficient $r = -0.7262$, showing a negative correlation between sleepiness score and finger dexterity score. It shows worsening of dexterity as sleepiness increases.

DISCUSSION

This study evaluated the effect of 24 h of SD on the finger dexterity and subjective sleepiness.

On analysis of the finger dexterity score, we found that the decrease in the score at the end of the 24 h period of SD

Table 1: Finger dexterity and sleepiness scores during the 24 h SD period

Duration of SD (h)	Finger dexterity score		Sleepiness score	
	Mean±SD	SEM	Mean±SD	SEM
0	45.77±0.68	0.124	1.033±0.18	0.033
6	42.59±1.93	0.354	1.433±0.5	0.092
12	38.2±1.83	0.335	1.566±0.72	0.132
18	34.38±2.07	0.378	2.5±0.82	0.149
24	31.09±1.24	0.228	3.76±1.13	0.207

SD: Standard deviation, SEM: Standard error of the mean

Table 2: Comparison of finger dexterity score at different time of 24 h SD period between male and female participants

Duration of SD	Finger dexterity scores				
	Male		Female		*P*-value
	Mean±SD	SEM	Mean±SD	SEM	
0	45.58±0.71	0.18	45.96±0.61	0.16	0.138
6	42.04±1.93	0.50	43.14±1.83	0.47	0.120
12	38.02±1.75	0.45	38.38±1.96	0.50	0.600
18	33.68±1.49	0.38	35.08±2.37	0.61	0.065
24	31.05±1.45	0.37	31.13±1.06	0.27	0.864

SD: Standard deviation, SEM: Standard error of the mean

was highly significant as compared to the baseline scores. The change in finger dexterity scores after 6 h of SD is not significant ($P > 0.05$). After 12 and 18 h of SD, the finger dexterity score decreases significantly ($P < 0.001$).

There is no statistically significant difference in finger dexterity score between males and females at any duration of SD ($P > 0.05$) as shown in Table 2. Thus, SD affects finger dexterity similarly in male and female.

Jakubowicz et al. studied the effect of SD on 8 surgery residents through the use of an endoscopic sinus surgical simulator.[10] They found no influence of fatigue in their study, which was limited by the small sample size. In this study, residents performed faster post-call but with more errors. They demonstrated continued learning of the tasks despite apparent fatigue.

Reznick and Folse studied the performance of a total of 21 residents in 4 different surgical training programs.[11] They evaluated cognitive and dexterity performance before and after a 24 h shift, and utilized the Purdue pegboard as well as simulated wound-closure exercises for dexterity testing. The effect of SD was only observed in the Purdue task using the dominant hand; no other statistically significant findings in operative or cognitive tasks were recorded.

Eastridge et al. evaluated 35 surgical residents pre- and post-call using a minimally invasive surgery trainer to test laparoscopic skills.[12] They reported that following SD, more surgical errors were made in all of the 6 tasks studied, and there was a slight, but not significant, prolongation of time required to complete the tasks. Taffinder et al. also used a laparoscopy simulator and evaluated 6 residents and response to SD; they also found decreased dexterity using the simulator following SD.[13] Similar findings were reported by Grantcharov et al. in their study of 11 surgical trainees.[14]

A significant decrease in the dexterity occurs after 12 h of SD and it progressively deteriorates with increasing duration of SD.

The previous studies show that SD causes mental fatigue which is a functional state that can lead either to sleep or to a relaxed, restful state, both of which are likely to reduce attention and alertness.[15] In this study, we had correlated the duration of SD with subjective sensation of sleepiness using the pictorial sleepiness scale.[9]

There is no significant effect of SD on sleepiness score after 6 h of SD ($P > 0.05$) as shown in Table 1. After 12 h of SD, sleepiness score starts to increase significantly as compared to the baseline in all subjects ($P < 0.001$). There is a highly significant increase in sleepiness score as the duration of SD increases from 12 to 24 h indicating progressive effects of SD. The difference in sleepiness score between males and females was not statistically significant at any time duration of SD ($P > 0.05$) as shown in Table 2.

We had also correlated the finger dexterity scores with individuals sleepiness score. There was a positive correlation between sleepiness score. There is a negative correlation between sleepiness score and finger dexterity score ($r = -0.7262$). It means as degree of sleepiness increases finger dexterity worsens in all subjects. This simple test could be an indicator of onset of detrimental effects of SD.

The combination of the subjective sleepiness scores together with the objective tests for finger dexterity indicate that the participants show effects of sustained wakefulness beginning as early as 12 h.

The effects of sleepiness on cognitive performance varies with age[16,17] with the deterioration being less in older age group after 24 h of SD. Ayalon and Friedman studied the effect of SD on fine motor skills in 28 obstetrics and gynecology residents. They concluded that the effect of SD is different in residents during different periods of their training on account of the duties required to be performed and a degree of adaptation to the fatigued state.[7] A further study of the various factors modifying the effect of SD is required before we can suggest some remedial measures or policy changes limiting work hours to improve both patient safety and help us fulfill one of the promises within the Hippocratic oath- “primum non nocere” the Latin phrase meaning first do no harm.

CONCLUSION

We conclude that SD significantly decreases the finger dexterity as measured by the O' Connor finger dexterity test, a validated tool which allowed us to compare the subjects to each other as well as to themselves. Both genders seem to be equally affected. Measurable decline in finger dexterity was noted after 12 h of SD. The decline in dexterity correlated well with the increase in subjective sleepiness scores. This provides us with a quick and easy way to measure the onset of effects of SD for routine use.

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