Original Research Article

Effect of Sleep Deprivation on Postural Control in Resident Doctors

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Abstract

Background: Resident doctors experience chronic as well as acute sleep deprivation (SD). Sleep deprivation is known to cause multiple physiological effects which can be neurological, autonomic, immune, biochemical or even altered gene expression**. Objectives:**1) To evaluate the effect of sleep deprivation on postural control at different durations of SD,2) to identify the duration of SD after which Postural control is affected, 3) to correlate the subjective assessment of sleepiness and postural control in resident doctors during the 24 h duty period. **Methods:**One leg stand test was used to measure Postural Control and Pictorial Sleepiness Scale measured the degree of sleepiness 6 hourly in 30 resident doctors during their 24 h duty. **Results**:Mean one leg stand test score increased with increasing duration of SD. The scores were significantly reduced at SD of 18 h ($p< 0.001$)., There was positive correlation between pictorial sleepiness scale and one leg stand test score ($r = 0.6619$). **Interpretation & conclusion:** Postural control deteriorates in SD, significantly so after 18 h. This might cause medical errors and compromise patient safety.

Keywords: One leg stand test, Postural control, Pictorial sleepiness Scale, Sleep deprivation

Introduction

Resident Doctors duty period is very exhaustive and stressful. Friedman et al found that residents who had been on call the night before made more errors in reading an electrocardiogram than their rested colleagues [1].Resident doctors suffer from intense mental fatigue due to stress full duty period with sleep deprivation. The 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 continuous duty. The reduction in performance after 24 hours of SD has been equated to the effect of a 0.1% blood alcohol concentration [2]. This comparison has received much attention because a physician with a blood alcohol level of 0.1% would be considered unfit for duty [3].Sleep deprivation 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[4].

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Mental fatigue is believed to be a gradual and cumulative process associated with a disinclination to exert any effort, reduced efficiency, alertness and impaired mental performance[5]. The body's Postural Control depends on co-ordination of the central nervous system (CNS) with visual sense, proprioceptive sense and vestibular information and regulation of the CNS to exercise the effector organs[6-8]. Any change in these processes will influence Postural Control. The effects of sleep deprivation on vestibular responses have been the subject of a few studies. It has been shown that sleep deprivation in humans can induce an alteration in the posterior parietal cortex that plays a crucial role in the processing of vestibular information in relation with space representation[9].We aimed to study the effect of duration of SD on Postural Control. Our first hypothesis was that duration of SD deteriorates postural control. We further proposed to test the hypothesis that effect of SD on postural control has a latency period. We also aimed to test the hypothesis that subjective assessment of sleepiness correlates with integrity of postural control.

Material and Methods

Study design: It was a prospective interventional study. Repeated measures of sleepiness and postural control were carried out at 0, 6, 12, 18 and 24 h intervals.

Ethics

Research procedure was approved by the Institutional Ethic Committee. 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. All participants were asked to avoid any heavy exercise before the recording of parameters. They were instructed not to take tea, coffee or any drinks 1 hour before the recordings. This was done to exclude the effects of CNS stimulant substances.

Resting pulse rate and blood pressure were measured at the start of study only for the purpose of routine general examination. Progressive sleepiness and postural control was measured at fixed intervals of 0, 6, 12, 18, and 24 h of SD during their 24 h duty period.

1. **Assessment of degree of sleepiness:** Sensation of sleepiness was subjectively assessed using the "Pictorial Sleepiness Scale Based on Cartoon Faces" and scored on a 5 point scale. This scale, which had been validated for its sensitivity to fatigue, ranks the feeling of sleepiness by comparing self with the expressions of cartoon. Subjects were given a score from 1-5 on the basis of scale.

2. Assessment of Postural control:

Procedure for the One-Leg Stand Test

The test was initiated by giving the following verbal instructions, followed by demonstrations.

• Please stand with your feet together and your arms down at your side, like this. (Demonstrate)
• Do not start to perform the test until I tell you to do so.
• Do you understand the instructions so far? (Make sure subjects indicates Understanding)

Explain the test with following verbal instructions, accompanied by demonstrations:

• When I tell you to start, raise one leg, either leg, approximately six inches off the ground, foot pointed out. (Demonstrate one leg stance)
• You must keep both legs straight, arms at your side.
• While holding that position, count out loud in the following manner: one thousand and one, one thousand and two, one thousand and three, until told to stop. (Demonstrated a count)
•Keep your arms at your sides at all times and keep watching the raised foot.
• Do you understand? (Make sure subject indicates understanding.)
• Go ahead and perform the test. (Examiner should always time the 30 seconds.

The subject was observed from a safe distance. If the subject put the foot down, give instructions to pick the foot up again and continue counting from the point at which the foot touched the ground. If the subject's count was very slowly, terminate the test after 30 seconds.

Video of the test is available at https://youtu.be/7g7vA_qlcko.

Scoring of the One-Leg Stand Test

Examiner should look for the following clues:

A. The subject sways while balancing. This refers to the side-to-side or back-and-forth motion while the subject maintains the one-leg stand position.
B. Uses arms for balance. Subject moves arms 6 or more inches from the side of the body to keep balance.
C. Hopping. Subject is able to keep one foot off the ground, but resorts to hopping in order to maintain balance.
D. Puts foot down. The subject is not able to maintain the one-leg stand position, putting the foot down one or more times during the 30-second count."

Subjects were scored on 0-4.

0- Well balanced/ no swaying
1- The subject sways while balancing
2- Uses arms for balance
3- Hopping
4- Puts foot down

Freidman's statistical test was used to compare the one leg stand test score at different durations of SD. Unpaired t-test was used to compare effect between males and females.

Result

Total 30 participants were studied. Their ages ranged between 26 and 30 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.

Table 1: one leg stand test score for postural control and sleepiness scale during the 24 h duty

SD (h)	One leg stand test score		Sleepiness scale	
	Mean ± Standard deviation	SEM	Mean ± Standard deviation	SEM
0	0.1±0.30	0.05	1.033±0.18	0.033
6	0.1±0.30	0.05	1.433±0.5	0.092
12	0.33±0.60	0.11	1.566±0.72	0.132
18	1.36±0.55	0.10	2.5±0.82	0.149
24	1.83±0.74	0.13	3.76±1.13	0.207

SEM: Standard error of the mean, SD: sleep deprivation

The results revealed that one leg stand test score showed a progressive increase in the mean scores as the duration of SD increases toward 12 h, 18 h, and 24 h [*Table 1]*. There is no significant effect of sleep deprivation on one leg stand test score initially at 6 h and 12 h of sleep deprivation (p> 0.05) as shown in Table 2. Initially after 18 h of sleep deprivation one leg stand test score starts to increase significantly (p< 0.001) .Further as the acute/total sleep deprivation progresses (after completion of 6 hr duty) the one leg stand test score increases significantly even at 12 h interval (Between 2:00 pm to 2:00 am) Table 2 (P<0.001). If acute/ total sleep deprivation further progresses (after completion of 12 hr duty), the one leg stand test score increases significantly even at 6 h interval (Between 8:00 pm to 2:00 am) Table 2 (P<0.001).

Table 2 : Comparison of One leg stand test score at interval of 0, 6, 12, 18, and 24 h of duty period.

Comparison	p-Value
OLS- 8:00 a.m vs OLS- 2:00 p.m (6h)	ns P>0.05
OLS- 8:00 a.m vs OLS- 8:00 p.m (12h)	ns P>0.05
OLS- 8:00 a.m vs OLS- 2:00 a.m (18h)	*** P<0.001
OLS- 8:00 a.m vs OLS- 8:00 a.m(24h)	*** P<0.001
OLS- 2:00 p.m vs OLS- 8:00 p.m (6h)	ns P>0.05
OLS- 2:00 p.m vs OLS- 2:00 a.m(12h)	*** P<0.001
OLS- 2:00 p.m vs OLS- 8:00 a.m(18h)	*** P<0.001
OLS- 8:00 p.m vs OLS- 2:00 a.m(6h)	*** P<0.001
OLS- 8:00 p.m vs OLS- 8:00 a.m(12h)	*** P<0.001

OLS: one leg stand test score

There is positive correlation between pictorial sleepiness scale (degree of sleepiness/ mental fatigue) and one leg stand test score (correlation coefficient "r" = 0.6619) as shown in Fig 1.

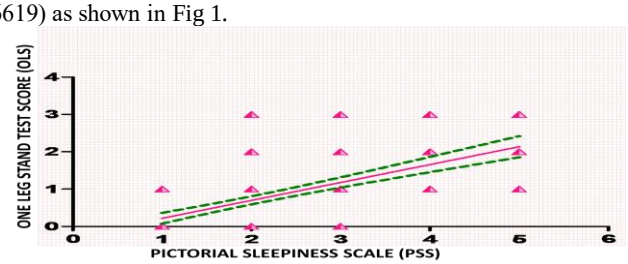

Fig 1: Correlation between postural control and sleepiness.

The one leg stand test score is not significantly different between male and female, at any duration of sleep deprivation (p> 0.05) during 24 h duty as shown in Table 3.

Table 3 : Comparison of One Leg Stand test score period between male and female participants

SD (h)	One leg stand test score				
	Male		Female		P- Value
	Mean ± *Standard deviation*	SEM	Mean ± *Standard deviation*	SEM	
0	0.06±0.25	0.06	0.13±0.35	0.09	0.559
6	0.13±0.35	0.09	0.06±0.25	0.06	0.559
12	0.26±0.45	0.11	0.4±0.73	0.19	0.557
18	1.33±0.48	0.12	1.4±0.63	0.16	0.749
24	1.6±0.50	0.13	2.06±0.88	0.22	0.089

SEM: Standard error of the mean, SD: Sleep deprivation

Discussion

Lal SK et al recognized that a state of sleepiness/mental fatigue leads to deterioration in performance and increase the risk of accidents[4]. Liu Y, Gribble PA and Avni N and Fabbri M et al found that human postural stability has been shown to decrease following 24 h of continued wakefulness [7,10-12]. or with the addition of an attention-demanding task[13]. Nardone *et al.* demonstrated that mental fatigue affect body swing[14] and the study by Fabbri *et al.* revealed that, after a night without sleep, there is a slower processing of visual inputs when maintaining postural

control[12].Peterka RJ and Liu Y and Nakano T et al. have shown that reduction in nocturnal human postural control is related to sleepiness and biological rhythms(e.g. body temperature) and can affect balance[6,7,15]. Gribble PA et al found that a decrease in vigilance results in neurophysiological alterations and slows processing of visual inputs while maintaining postural control[10]. Liu Y et al shown that postural stability and motor control are affected by more than 19, 24 or 48 h of sleep deprivation and the effect of sleep deprivation on postural sway were correlated with reduced levels of Alertness[7].Patel M found that twenty-four hours of sleep deprivation led to the disturbances in postural control which intensified with the duration of sleepless-ness [16]. Fabbri M et al. gave the possible explanation that the changes in the sensory integration may be concurrent with the visual deficiencies caused by sleep deprivation[12].In our study we found that one leg stand test score showed a progressive increase in the mean scores as the duration of SD increases toward 12 h, 18 h, and 24 h It denotes the deterioration of postural control as the duration of SD increases.In addition to this there is no significant effect of sleep deprivation on one leg stand test score initially at 6 h and 12 h of sleep deprivation ($p > 0.05$). The detrimental effect of SD on postural control is significant at 18 h of SD. The deterioration of postural control speeds up as duration of SD progresses as noted from the OLS at 2.00 p.m and 2.00 a.m and 8.00 p.m and 2.00 a.m There was positive correlation between pictorial sleepiness scale (degree of sleepiness/ mental fatigue) and one leg stand test score ("r" = 0.6619). It means as degree of sleepiness increases postural control worsens in all subjects.There is statistically no significant difference in one leg stand test score between male and female at any time duration of sleep deprivation ($p > 0.05$) during 24 h duty. It shows sleep deprivation affects postural control similarly in male and female.The changes in postural control after sleep deprivation in the present study were consistent with the results of an earlier study by Liu Y, Higuchi S[7] and Fabbri M[12] and Patel M, Gomez S et al[16]. In general, their results showed that postural sway increased after a sleepless night.

Conclusion

We conclude that sleep deprivation significantly deteriorates the postural control as objectively assessed by the one leg stand test. The onset of effect of sleep deprivation is at 18 h of SD. Both the sexes seem to be equally affected. In addition to this we found positive correlation between degree of sleepiness and worsening of postural control. The early acute effect of sleep deprivation in medical doctors may be attributed to chronic sleep loss. Sleep deprived resident doctors may be prone medical errors. Assessment of postural control by simple one leg stand test, while on duty for 24 h could be a quick, inexpensive way to predict effects of SD.

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