COGNITIVE PSYCHOLOGY

Psychomotor Skills in Total Sleep Deprivation

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ABSTRACT

Introduction: **Recently, the human dimensions of vulnerability to health, performance and cognitive ability due to sleep deprivation (SD) have received significant attention in psychology, health science, sleep research, cognition and so on. Sleep as a circadian behaviour has profound effect on body restitution, facilitation of motor function, memory, learning and other cognitive domains. A good number of studies have evidenced the effect of sleep deprivation (SD) on psychomotor skills (PMS), a vital cognitive domain. SD impairs psychomotor skills (PMS) considerably, shown by the studies conducted in western cultural context. Yet, pose a concern for not knowing how SD adversely affects PMS amongst the peoples of other cultural context since cultural differences are at play on cognition.**

Objectives: **Our objective of the present study was to investigate the effect of Total Sleep Deprivation (TSD) on Psychomotor Skills (PMS) in Bangladeshi cultural context.**

Methods: **Two randomized group design was followed to collect the data where experimental group (33 adults) was kept totally sleep deprived for 24-hour a day and the control group (36 adults) was kept in normal setting. Crawford Small Parts Dexterity Test (CSPDT) was used to measure the PMS.**

Results: **Results revealed a significant decline in PMS of experimental group who were kept sleep deprived (t = - 2.36, p < 0.05). Results echoes with previous findings in that PMS are the human capability of combination of cognitive and motor processes, skills that are vital for humans at work.**

Conclusion: **The discussion on perception and cultural issues on sleep-cognition issue is important since perception on SD and its effect on cognitive performances has variability in respect of cultural diversity. Human perception is always biased by cultures. The concept of culture and cultural influence on sleep-cognition link is crucial. Human psyche is better understood in the particular cultural setting where the individual lives. The concept of culture is treated as particular society, its specific cultural norms, its people's habit, attitude, perception and learning, and this disconnects the practices, ideas and perceptions prevail in other peoples of different cultural settings. So, the findings of the present study show the viability of studying sleep-cognition link in other cultural context, thus allowing investigators to significantly increase cultural validity over stereotyped data dependency.**

KEY WORDS

sleep deprivation, total sleep deprivation, psychomotor skills, cultural issue

INTRODUCTION

Sleep is a naturally recurring state whose characteristics are alteration in consciousness, inhibition to sensory activity and voluntary muscles, which is sharply distinguished from wakefulness. In contrast, wakefulness is the absence of sleep and is marked by consciousness, awareness and activity. Sleep is a universal need of all higher forms of lives including human being. Absence of sleep has severe physiological and psychological consequences (Colten, Altevogt, 2006).

Psychomotor Skills (PMS), also called perceptual-motor skills as one of the cognitive performances is the ability that requires a combination of cognitive and motor processes. It includes hand-eye coordination tasks (Boyle, Santelli, 1986; Crawford, 1956). It is based on one's ability to process external sensory stimuli in conjunction with the muscular sensations involved in the action. PMS is defined as the skills that include hand-eye coordination tasks such as driving a car, operating machine, use of precision instruments or tools, sewing, playing in instrument, writing or typing (Afify, Zawawi, Othman, Al-Dharrab, 2013; Lehmann, Martus, Little-Elk, Maass, Holmer, Zurbuchen, Bretthauer, Buhr, Ritz, 2010). In this study, we define this as dexterity actions which demonstrate the fine motor skills like use of precision instruments. Psychomotor learning is the relationship between cognitive functions and physical movement. PMS can be divided into two types; (1) gross motor skills, and (2) fine motor skills. Gross motor skills describe activities in which large muscles are involved like throwing or driving. Fine motor skills refer to actions using only the hands or fingers like typing or sewing.

Sleep and sleep deprivation (SD) have been studied for decades. Scientific literature reveals that sleep as a circadian behaviour has profound effect on body restitution, facilitation of motor function, working memory, psychomotor skills, consolidation of memory and learning (Ropper, Samuels, 2009; Stickgold, 2005; Philibert, 2005). Sleep deprivation negatively affects work performance in terms of productivity, quality and working relationships. Sleep loss or prolonged wakefulness pose significantly adverse effect on cognitive performances (Fougnie,

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2008; Fuchs, Burgdorf, 2008; Chee, Chuah, Venkatraman, Chan, Philip, Dinges, 2006; Babkoff, Zukerman, Fostick, Ben-Artzi, 2005; Dorrian, Rogers, Dinges, 2005; Van Dongen, Vitellaro, Dinges, 2005; Naghavi, Nyberg, 2005). Sleep loss was found associated with an increased risk of fatal occupational accidents with men being at a higher accident risk (Akerstedt, Fredlund, Gillberg, Jansson, 2002). Visuomotor performances are impaired by sleep deprivation (Zils, Sprenger, Heide, Born, Gais, 2005; Raidy, Scharff, 2005). Sleep loss impedes engagement of spatial attention (Bocca, Denise, 2006). Sleep deprivation causes a detrimental effect on psychomotor skills (Hamui-Sutton, Barragán-Pérez, Fuentes-García, Monsalvo-Obregón, Fouilloux-Morales, 2013). A 12-hour night work system and sleepiness showed a negative impact in postural and psychomotor performance of night workers (Narciso, Barela, Aguiar, Carvalho, Tufik, de Mello, 2016). A significant ($P < .001$) inverse relationship was found between psychomotor performance and hours of sleep amongst nurses who worked at night shift (Johnson, Brown, Weaver, 2010; Johnson, Umlauf, Brown, Weaver, 2007). In real-world settings, the adverse effects of SD are confirmed amongst health care workers, military personnel, security people and professional drivers (Otmani, Pebayle, Roge, Muzet, 2005; Philibert, 2005; Russo, Kendall, Johnson, Sing, Thorne, Escolas, Santiago, Holland, Hall, Redmond, 2005).

However, inconsistent results are also found in some others studies. Studies where subjects faced only one night SD under controlled conditions have failed to find any effect on psychomotor vigilance (Nilsson, Söderström, Karlsson, Lekander, Akerstedt, Lindroth, Axelsson, 2005; Quigley, Green, Morgan, Idzikowski, King, 2000). No effect was observed on psychomotor skills of surgeons after assessing the impact of 24-hour night calls having one night of sleep loss (Lehmann *et al*., 2010). A full night of SD demonstrated no statistically significant difference on fine motor skills (Sheraly, Yee, Goldman, 2012). Study found no effect ($p > .05$) of partial sleep deprivation (PSD) on fine motor skills between the group who was chronically sleep deprived and the group who rested adequately (Khazaie,Tahmasian, Ghadami, Safaei, Ekhtiari, Samadzadeh, Schwebel, Russo, 2010).

It is acknowledged that the importance of studying cognitive processes in different cultural diversities should be emphasized so that human behaviour and cognition can better be understood in a wide spectrum (Wilhelm Wundt, 1916). Human psyche is better apprehended when laboratory experiments are added on with evidences from a specific culture a person lives in. Humans often get reluctant in considering their own culture until they come into contact with other means of doing the things (Bonn, 2015). The perception towards SD and its effects on PMS in regard to cultural and communal diversities may vary. Hence, study on SD-cognition link in different cultural context is unavoidable in pursuit of drawing more concluding remarks on the field. Again, the studies, so far, have merely been conducted in western cultural settings, US in particular. Notwithstanding, the studies have great contribution on the field of sleep-PMS research. Yet, there are still lack of answers about SD and its effects on PMS in other cultural settings, pose a concern for not knowing how SD adversely affects PMS amongst these peoples. Therefore, it is felt necessary to investigate the SD-PMS link in South-Asian cultural context, Bangladesh in particular.

Variables

The variables taken in this study are as follows:

a) Independent variable: Total sleep deprivation of 24-hour a day including night-time sleep.

b) Dependent variable: Psycho-motor skills.

Objective of the Study

The objective of the present study was to investigate whether there is any effect of total sleep deprivation (TSD) on psychomotor skills (PMS).

Hypothesis

It was hypothesized that there will be significant effect of total sleep deprivation on psychomotor skills.

MATERIALS AND METHODS

Subjects

Subjects were drawn from entire Bangladesh through advertisement in national dailies. Both male and female were chosen as research population estimator for this study. A total of 100 individuals ranged from 18 to 40 years were selected following some inclusion and exclusion criteria. The age group is considered to be the vital working force irrespective of culture, and the potential civil and military personnel belong this age group (Miller, Shattuck, 2005). Sleep requirement for the individuals from their mid-20s to middle ages are fairly stable at around eight hours per night in 24-hour cycle of a day (Miller, Matsangas, Kenney 2011), estimated as common across the cultures. Hence, the subjects taken for the study are as important as dynamic working force in civil and military in Bangladeshi culture belong to this age group. Statistically, data required from the subjects were 74. They were randomly assigned to experimental (TSD for 24- hour a day) and control (regular sleep) group. After completion of data collection procedure, a total of 69 participants were found having followed total research protocol. They were 36 in control group and 33 in experimental group. Finally, data obtained from the participants were 69 who completed the full research procedure. Distribution of sample is shown in Table-1.

Table 1: Distribution of samples in experimental and control group

Group	Male	Female	Total
Control (X_1)	21	15	36
Experimental (X_2)	8	25	33
		Grand Total	69

Psychometric tools

To collect the data following psychometrics tools were used.

1. Sleep tracker: Xiaomi Mi Band, model-MI3 M4, was used as sleep tracker to obtain sleep record. This device is also used to obtain record of physical activity, called actimeter. This is a wrist-worn actimeter having sensor called accelerometer, works on motion-sensing technology, which measures the rate of change of movements in X,Y,Z axis. These information are then translated into data like walking or sleeping, and gets synchronized with the software installed in mobile application. This device was used to have record of participants' sleeping/snoozing time in 24-hr day. US military has been extensively using similar device in conducting sleep research where keeping records of sleep of the respondents are essential (Miller, Shattuck, Matsangas, 2010; Matsangas, Miller, 2006). This method of detecting the sleep pattern is not 100% accurate. However, if the purpose is to know whether the subject has slept or not, the device is fairly valid and reliable (Miller *et. al*., 2010).
2. Sleep log: It is a self-reported record of a respondent's sleep-wake timing with related information, typically over a period time. The information includes time of sleeping and waking up, total bed time, nap time, total sleep including nap a day, quality of sleep (very poor, poor, moderate, good and very good), frequency of toilet-going at night, and use of any drug, alcohol, caffeine, cigarette before sleep. Each and every subject was provided with sleep log to know their sleeping hygiene and pattern at least one week before the test is conducted. This sort of sleep log is widely used in sleep research in US military.
3. Crawford Small Parts Dexterity Test (CSPDT): The Crawford Small Parts Dexterity Test (CSPDT) developed by John Crawford (1956), revised in 1985 was used to measure PMS in this study. This is a performance test designed to assess eye-hand coordination and fine motor dexterity. The CSPDT is a timed test of both manual and finger dexterity that requires use of tweezers and a screwdriver for a series of tasks on an assembly plate. This equipment is used for two tests; (1) Crawford Screws, Part-I, and (2) Crawford Pins and Collars, Part-II.
4. Personal information form: A guided personal information form was used to collect data about subject's present health condition,

mental health, past history of illness, previous work experience of night-shift work, tobacco and alcohol habit, and use of any drug or medication.

Procedure

An advertisement both in native and English language, was circulated through national dailies for recruiting the research participants. In response to the circular, a total of 146 subjects responded to be volunteers in this study. We sorted 100 out 146 respondents based on few inclusion and exclusion criteria and recruited them. We excluded the subjects who were reported sick, having record of past history of grave physical and mental illness, being on any long-term medications, experienced in night-shift work, alcoholic, substance abuser, having sleep disorder or symptoms thereof, experiencing habitual irregular sleeping habits (sleep less than 6.5 hours/night), and severe morning or evening chronotype. The respondents whose sleep tracker and sleep log indicated habitual good sleep (sleep not less than 6.5 hours/night, and sleeping no later than 1:00 AM and waking no later than 9:00 AM) entered the study after giving informed consent. All participants were prohibited to smoke, taking stimulants, consume any medications, caffeine or alcohol for at least 24 hours prior testing.

After being chosen the participants were given a sleep log and a sleep tracker. All participants were required to record their sleep data such as total sleep hours, sleeping time and waking time. On the other hand, the sleep tracker automatically kept record of activity time and sleep time by means of modern GIS technology. The participants were then randomly assigned into control and experimental group. The experimental group was kept sleep deprived for 24-hour a day prior study time, whereas, the control group experienced regular sleep. All participants were taken to sleep laboratory 12 hours before the test was administered. Participants were allowed to work out their normal daily routine in day time. This protocol strengthen and ensured ecological validity of the study (Dickinson, Drummond, McElroy, 2017; Sánchez-Ortuño, Edinger, Means, Almirall, 2010). A full one-night adaptation in lab was given to the respondents prior testing. Subjects, informed consents were taken before carrying out the study. All aspects of the study were clearly informed to the respondents and confidentiality of their personal data was assured except only for research purpose. Respondents were accompanied and looked after by trained research staffs during adaptation night and study time.

Our target was to collect data from 74 participants (37 for control and 37 for experimental group). At the end of all procedure, 36 participants from control group and 33 participants from experimental group completed the total data collection procedure. Other participants failed to complete the whole study procedure on account of their refusal, sickness, act of failure to comply with study protocol, and unexpected emergencies. During sleepless night, the experimental group were kept awaken while they read books, papers, or magazines, listened music, browsed internet, did social networking, playing chess, and chatted with research staffs. In contrast, participants of control group were allowed to experience their regular sleep.

After the intervention (TSD) to the experimental group, we administered CSPDT on experimental and control group. The test took around 16-20 minutes to complete. The CSPDT is a culture-fair and individually administered test. There were eight in number trained test administrators who administered the test under the supervision of researcher. After finishing the testing procedure the participants were thanked and given token of memento. Finally, they were allowed to leave the laboratory.

RESULTS

The data of the present study was analyzed using SPSS v.20. Descriptive and inferential analyses were carried out. The findings of the present study are illustrated in Table-2.

Table 2: Descriptive and inferential statistic of experimental and control group

Group	N	Mean	Std. Deviation	Df	T	Sig.
Control (X_1)	36	16.5889	3.60184	67	-2.360	.010
Experimental (X_2)	33	18.8776	4.43942			

The findings indicate that there is a significant decline in psychomotor skills in experimental group (p = .010).

DISCUSSION

It was hypothesized that total sleep deprivation (TSD) would significantly affect the test scores of the respondents of experimental group. It was assumed that the respondents who were totally sleep deprived for 24-hour a day would score less on the psychomotor skills (PMS) than the respondents who obtained regular normal sleep at night. The results have demonstrated that TSD can lead to significant decline in performance of PMS. Although the task is procedurally simple and facilitated by prior-learning, yet, prolonged time of wakening leads to significant decline in PMS. The declining performance of experimental group across the test, is a frequently-observed pattern in the studies of SD and human performances in PMS (Hamui-Sutton *et al*., 2013; Narciso *et al*., 2016; Johnson *et al*., 2010; Johnson *et al*., 2007; Otmani *et al*., 2005; Philibert, 2005; Russo *et al*., 2005).

This empirical presentation is merely a beginning of our endeavour in investigating sleep-cognition link in a particular cultural context, Bangladesh in particular. It would positively motivate the researchers to further research activities to draw more remarks in sleep-cognition dynamics in future. Key components like visual function, tracking, attention, reaction time, motor skills are linked with dynamic cognitive processes that engage for performing the task of PMS. The findings are strongly supported by ecological validity (Dickinson *et al*., 2017; Sánchez-Ortuño *et al*., 2010), as human behaviours are always expected to be happened normally in natural settings rather than in strict lab control where subjects are dealt with. This pattern of behaviour can better be described in more realistic way. Studies conducted in lab under strict controlled condition have failed to find any effect (Sheraly *et al*., 2012; Lehmann *et al*., 2010; Khazaie *et al*., 2010; Nilsson *et al*., 2005; Quigley *et al*., 2000).

CONCLUSION

The study claims that the dynamic cognitive processes in performing the PMS task is more or less sleep-depended. In TSD, a more thorough evaluation of PMS is needed in other cultural contexts. Moreover, the effects of TSD have not been thoroughly compared among some essential subpopulations like minor ethnical groups. Further investigations into assessment in this regard specific to these populations are justified. Finally, perhaps the pervasive reliance on technology such as computers, cell phones, smart phones, I-pods, MP3 players, and many electronic gazettes might have affected baseline dexterity values in all populations. Dexterity abilities may have improved radically due to the increased use of modern electronic and electro-mechanical devices, or declined based on the automation of work processes that were previously dependent on manual skills, is a concern.

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