



A Cross-Sectional Study to Analyze the Physical and Cognitive Fatigue Due to Sleep Disruption Among Shift Workers in Tamilnadu



Vimala Rani Swaminathan^{1*}, Archana Rajasundaram² and Sasikumar Santhoshkumar¹

¹Department of Physiology, Sree Balaji Medical College and Hospital, Chromepet, Chennai-600044, India;

²Department of Anatomy, Sree Balaji Medical College and Hospital, Chromepet, Chennai-600044, India

E-mail/Orcid Id:

VRS, vimala.vini45@gmail.com, <https://orcid.org/0000-0002-4938-0943>; AR, archana.r@bharathuniv.ac.in, <https://orcid.org/0000-0003-3960-8390>;
SS, dr.sasikumar15@gmail.com, <https://orcid.org/0000-0002-8372-1879>

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Abstract: The objective of this research is to analyse the extent and manner of the kind of fatigue among shift workers in Tamil Nadu, India. As for shift workers, they often have disturbed night's sleep. Shift work is distinguished by its irregular and unique work hours, unlike the regular day-time Schedule. It is combined with circadian alteration, which affects most of the bodily activities. They have diverse sorts of health problems, such as physical and mental fatigue. A Cross-sectional Analysis was done among airport workers. 200 participants were randomly selected for the study aged 35-45 years and conducted for a duration of 6 months in the Airport, Tamilnadu. Sleep quality and cognition were assessed using a validated questionnaire. The muscle fatigue was evaluated using Mosso's ergograph. R-statistical Software (version 4.0.2) was used for Data Analysis. The Primary analyses of data set's normality were done by Kolmogorov - Smirnov Z test. Significant negative correlation exists between global PSQI score and both cognition score ($r = -0.315$, $P < 0.001$) and Work done by Mosso ($r = -0.405$, $P < 0.001$) There is also negative correlation exists between work done and the cognition score ($r = -0.565$, $P < 0.001$) which is statistically significant. Decreased Sleep Quality, more fatigue and lowering of cognition levels not only affects physical health but also the quality of life. It has been noted that sleep disturbance leads to physical and mental exhaustion among Tamil Nadu shift workers. The outcomes underscore the need for targeted interventions to improve sleep-related behaviours as well as the treatment of fatigue in this population. Reducing the disturbances of shift work effects on produce, growth as well as health may be authorized by way of implementing organized work shifts and also promoting sleep promotion.

Introduction

The term "shift work" generally pertains to work-related Activities dedicated to extending services all around the whole day, and the working hours have been divided among 2 or more occupational groups (Craven et al., 2022). The number of shift workers has surged as an outcome of Social, economic and Scientific developments (Kazemi et al., 2016). To Compete with the demand for 24-hour service, the number of individuals in shift work has been growing constantly globally (Albertas et al., 2021). Around 20 percent of workers in industrialized nations work shifts, with three-

quarters of this group being night shift Workers (Yeo et al., 2022). Shift workers have irregular sleep patterns and have major challenges in staying asleep due to disturbances in the circadian rhythm because of their shift patterns, which may affect their work productivity (Madhu and Manna, 2010, 2011; 2021; Andrew et al., 2019; Swaminathan et al., 2024). Shift workers collect sleep debt over the night shift work and experience a detrimental impact on performance along with circadian misalignment (Musab et al., 2024). A multitude of problems might involve feeling exhausted. errors made by humans, somnolence, diminished thinking abilities



and insufficient, decreased quality of sleep have been attributed to working night Shifts (Chellappa et al., 2019). Sleep deprivation causes psychomotor deficits almost identical to those resulting from consuming alcoholic beverages in excess above the permissible amount. Lack of sleep impairs certain areas of neuro-cognitive function involving both mistakes of commission as well as Omission. In addition to the above effects, sleep deprivation also results in fatigue, reduction in physical strength, negative mood states, loss of vigor, confusion and sleepiness (Kayser et al., 2022). An individual's normal daily sleep is diminished by around 2 hours when working in the night Shift. A Cumulative lack of sleep makes the person exhausted and results in unstable, unpredictable sleep episodes that lessen the attention level, raise the mistake rate and may hinder employee efficiency at work (Peng et al., 2018). Sleep deprivation impairs muscle health by increasing protein breakdown and decreasing synthesis. Previous research work confirmed that poor sleep quality reduces muscle strength (Genario et al., 2023). Feeling exhausted can be a positive thing. When a physical effort is transient and reversible, it aids in our performance improvement. This is an everyday circumstance that serves as a reminder of the well-known adage "No pain, no gain". However, its symptoms may also indicate a build-up of fatigue which may have detrimental long-term effects. This is a signal that warns us about the possibility of "overheating Cognitive" and manifests as changed activity in the lateral prefrontal cortex, a region of the brain critical to decision-making. We could have trouble focusing for extended periods of time, make bad choices, get more anxious, lose motivation, and have trouble with working memory. Individuals with lower muscle strength were six times more prone to have cognitive impairment than persons with normal muscle strength (Sui et al., 2021). Muscle strength is one of the influential components of sarcopenia and a better indicator of neuromuscular and poor cognitive function, as power and strength are lost faster than muscle mass. A previous study of aerobic training on executive function among healthy adults concluded that when muscle strength increases, there will be an improvement in cognitive function (Tolea and Galvin, 2015; Sui et al., 2020). Previous studies have been done in simulated laboratory settings to See the relationship between sleep quality, mood changes and cognitive behavior and most of the previous work involved experimental animals or older adults of age group (above 60 years). To the extent of our understanding of the topic, no research has, however, examined how sleep quality affects muscular function

(smaller muscle) and how these both contribute to cognitive fatigue among middle-aged night shift workers in particular. This gap in the literature was the goal of the Current investigation. This study aims to evaluate the effect of altered (disturbed) sleep quality in inducing physical and cognitive fatigue among night shift workers. The objectives of the study are to evaluate the sleep quality of the night shift workers using the PSQI questionnaire, to investigate the changes in muscle strength (due to physical inactiveness and altered Sleep) using Mosso's ergograph, and to identify the changes in the cognitive function using MoCA tool.

Materials & Methods

Study Design and Setting:

A cross-sectional research analysis was done among the airport workers working at international airport , Tamil nadu and the Study was conducted in the same area for a duration of 6 months.

Study Sample:

The list of workers involved in the night and day shifts was collected. Computer-assisted random numbers were allocated. By Simple random sampling method among the regular night and Day Shift workers, the participants were selected and put into two groups for the study.

Inclusion Criteria:

100 regular night and 100 regular day shift workers (200 participants) aged 35-45 years with at least 10 years of experience and working for a duration of 12 hours in the airport sector, having willing to participate are included in the Study.

Exclusion Criteria:

Those with a history of medical disorders in the last year, Current use of any hypnotic medication, musculoskeletal disorders, psychiatric Illnesses and sleep disorders that may interfere with the work done by the muscle and the sleep quality, and those who are not interested in the current study were excluded.

Study tool

PSQI (Pittsburgh Sleep Quality Index)

This is a Questionnaire that evaluates seven traits of sleep: Subjective sleep Quality, Sleep Disturbances, sleep time period, routine sleep efficiency, use of sleeping pills, and malfunction during the day. The Scale Consists of 19 Questions. Each Question has a Score between 0 and 3, in which "0" denotes no sleep-related issues and "3" denotes more sleep difficulties. The total PSQI score ranges from 0 to 21. Based on the Cut-off Score Value of 5, the Score value of <5 is included in good sleep and > =5 in bad sleep categories. It has a diagnostic sensitivity of 89.6%

and a specificity of 86.5% in differentiating poor and good sleepers. The scale reports an internal consistency reliability (Cronbach's alpha) of 0.83 for the seven components (Buysse et al., 1989).

Mosso's ergograph

Angelo Mosso invented the Ergograph in the 1880s (Pal and Pal, 2021). It records skeletal muscle contractions and calculates muscle strength. The instrument also assesses the level of exhaustion in a small muscular group. It is made of a flat hardwood board with two sets of clamps and curved plates to grip and stabilize the subject's forearm.

To secure the position of the index and ring fingers, there are two metal tubes (finger holds). The subject's position was adjusted, and the finger & the forearm were positioned in the holder provided. Weight was suspended in the ergograph, and it needs significant effort by the person to lift it. Once it was lifted, the movements were recorded by the metronome, which was adjusted to a frequency of 30 beats/minute. The sliding plate held a chart paper on which the contractions were recorded using a pencil or ballpoint pen, and the work done by the muscle was calculated [Product of the lifted weight and the Contractions recorded].

MoCA(Montreal Cognitive Assessment)

Montreal Cognitive Assessment is a quick screening tool for mild Cognitive impairment developed by Dr. Ziad Nasreddine in 1995. It evaluates 7 Cognitive domains, including Attention and focus, Memory, executive function, language, visual-constructional Skills, thinking, orientation & calculation. The Maximum Score point is 30. The score value of 26 or above is considered normal. The measuring tool has also received particular recognition for its ability to identify minute cognitive performance modifications. In the validation study, MoCA exhibited 100% sensitivity, 87% specificity, 89% positive predictive value and 91% negative predictive value (Nasreddine et al., 2005).

Outcome measure

Basic Demographic Details like Age, BMI, Sleep hours and physical activeness were collected & recorded (Table 1).

PSQI (Pittsburgh Sleep Quality Index)

The sleep Quality was assessed for all the 200 participants. The Questionnaire was well explained and 20 minutes time was given to Complete it. Based on the Scores obtained, they were Categorized to have good sleep quality & bad one.

Muscle Strength

The participants were demonstrated how to lift the weight in the ergograph, and then they were asked to repeat the same till they got tired. The Contractions were recorded and the work done was calculated.

Cognitive function

MoCA tool was well explained & 10 minutes time was given to complete it. Based on the Scores obtained, their cognition level was determined

Statistical Analysis

R-statistical Software (version 4.0.2) was used for data analysis. The primary analyses of data set's normality were done by Kolmogorov - Smirnov Z test. $P > 0.05$ indicated normal Gaussian distribution. Independent Sample t-test was done and the mean values were compared between the groups. Pearson's correlation analysis was done between the study variables and $P < 0.05$ was deemed statistically significant.

Ethical Approval

The Study was carried out with ethical permission from the Institutional Ethical Committee of SBMCH and Written Consent was attained from each participant prior to the Study's implementation.

Result

The baseline characteristics are given in Table 1 and it shows the Age-matched distribution of the participants. The BMI of both the study groups shows no significant difference ($P > 0.7$). The habitual sleeping hours for the night workers (6.57 Vs 7.04, $p = 0.11$) is less when compared to the day workers.

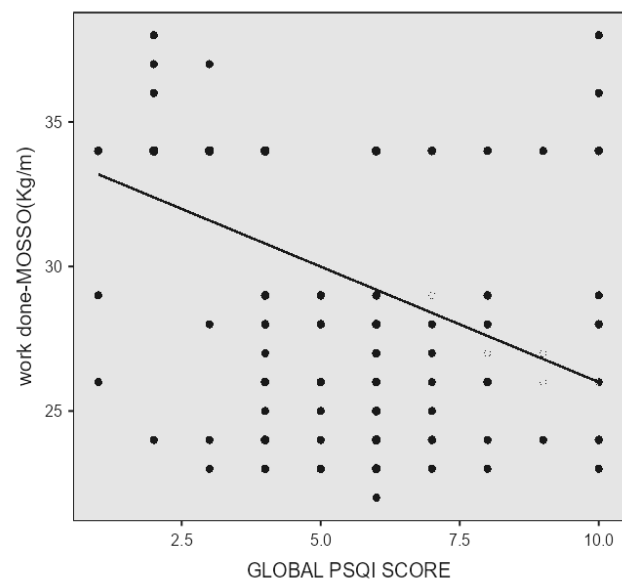


Figure 1. Correlation between work done by the 2 groups and the sleep score.

Table 1. Details of the participants of the study.

Variables	Night workers(n=100) Mean± SD	Day workers(n=100) Mean± SD	P-value
AGE	39 ± 3.62	38.2 ± 3.4	0.003
HABITUAL TIME ASLEEP (<6 and ≥ 6 hours)	6.57 ± 1.1	7.04 ± 0.887	0.11
BMI (kg/m ²)	27.2 ± 2.81	25.1 ± 2.42	>0.7
SLEEP QUALITY (GOOD <5 & BAD ≥ 5)	6.03 ± 2.8	3.98 ± 2.57	<0.001
Work done-MOSSO(Kg/m)	25.8 ± 2.15	34.2 ± 0.744	<0.001
MoCA total score(cognition)	26 ± 1.3	28 ± 0.44	<0.001

Table 2. Mean and standard deviation of different components of cognition and cognitive score in the 2 groups (Independent t-test, $p<0.05$ statistically significant).

DOMAINS	DAY SHIFT WORKERS		NIGHT DUTY WORKERS		
	Mean	SD	Mean	SD	P-value
VISUO SPATIAL	4.2	0.33	4.0	0.35	0.48
NAMING	3	0	3	0	0.119
ATTENTION	5	0.27	5	0.32	0.053
LANGUAGE	2.5	0.33	2.9	0.41	0.087
ABSTRACTION	2	0	2	0.28	0.157
MEMORY	3.3	0.31	2.9	0.87	$<.001$
ORIENTATION	6	0	5.9	0.33	$<.001$
MoCA Total SCORE	28	0.44	26	1.3	$<.001$

Table 3. Frequency distribution.

	Night workers(n=100) Frequency %	Day workers(n=100) Frequency %
	WORK LOAD MEDIUM/HIGH	89.0 %
LOW	11.0%	30.0 %
WORK ACTIVITY MORE	73.0 %	63.0 %
LESS	27.0 %	37.0 %

Table 4. Correlation Matrix

		GLOBAL PSQI SCORE	COGNITION SCORE	work done- MOSSO(Kg/m)
GLOBAL PSQI SCORE	Pearson's r	—		
	df	—		
	p-value	—		
COGNITION SCORE	Pearson's r	-0.315***	—	
	df	198	—	
	p-value	$<.001$	—	
Work done- MOSSO(Kg/m)	Pearson's r	-0.405***	-0.565***	—
	df	198	196	—
	p-value	$<.001$	$<.001$	—

* $P<0.05$, ** $p<0.01$, *** $p<0.001$

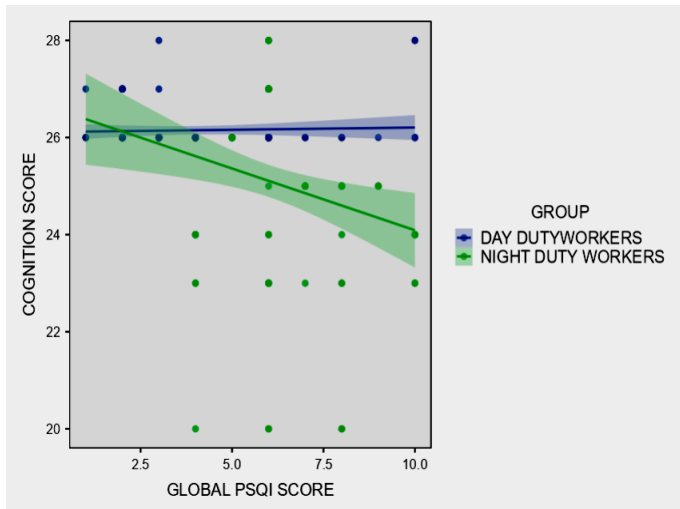


Figure 2. Correlation between the sleep score and the cognition score of the night and day Shift workers.

Also the sleep quality of the night workers based on the PSQI score is comparatively low when to that of their day duty counterparts (6.03 Vs 3.98, $P < 0.001$), the mean value of work done by the night workers is less when compared to Day workers (25.8 Vs 34.2, $P < 0.001$) which is statistically significant. In addition to this, the cognitive score (MoCA) of the Day duty participants is more when compared with the night shift participants (28 Vs 26, $P < 0.01$) and the values are statistically significant. Table 2 provides the data about the Mean and standard deviation of different components of cognition and cognitive score in the 2 groups ($p < 0.05$ statistically significant). Table 3 illustrates the frequency distribution of the number of participants based on the workload & work Activity. The workload is high, and work activity is more for the majority of the night shift workers when compared with the day workers. Table 4 shows the correlation Matrix of global PSQI score, Cognition score and the work done by Mosso's ergograph. A significant negative correlation exists between the Global PSQI score and both cognition score ($r = -0.315$, $P < 0.001$) and Work done by Mosso ($r = -0.405$, $P < 0.001$) (Figure 1 & Figure 2). There is also a negative correlation between work done and the cognition score ($r = -0.565$, $P < 0.001$), which is statistically significant. This indicates altered sleep is related to low work done by the muscle, and both of the above result in a change in the Cognition level.

Discussion

The present study concentrated on the altered Sleep quality effects in inducing physical and cognitive fatigue among the night shift workers. The results specified that there was a reduction in sleep quality and muscle strength among the night workers. And also the cognitive level was slightly low for the night workers when compared

with the day workers. And there exists a negative correlation between Global PSQI score and both cognition score ($r = -0.315$, $P < 0.001$) and Work done by Mosso ($r = -0.405$, $P < 0.001$). In terms of cognitive function and muscle strength, the results of our study were mostly consistent with those of prior research. The Study carried out among emergency physicians exhibited a distinctive decline in short-term memory for both night and day Shifts (Zhang et al., 2024). And this decline may be related to shift worker's circadian disturbance as well as the tiredness or stress brought on by lengthier working duration (Zavec et al., 2020). One of the negative aspects of shift work is tiredness and exhaustion, which can lower attentiveness, interfere with cognitive function, and elevate the incidence of accidents (Carty et al., 2022). Our study results coincide with the above study findings as the night workers' muscle strength was comparatively low compared to day workers. Additionally, a number of Studies have demonstrated that shift workers experience excessive daytime sleepiness, with approximately 32% of them reporting insomnia symptoms with a decrease in sleep quality, which might compromise the safety of work (Shortz et al., 2015). A study by Elhami et al. proved that there is a reduction of 2 hours of sleep in the average daily sleeping time among night shift Workers, which leads to 10 to 15 seconds of microsleep, which leads to poor sleep quality and fatigue. Shift workers, since they try to sleep during the day time, their pattern of sleep is interfered with by environmental noise and other factors, and they cannot have the same quality of sleep as enjoyed by night sleepers (Elhami Athar et al., 2020). Our Study supports the above study results as the quality of sleep of night workers was bad when compared with the day duty counterparts, based on the sleep score level. Another study suggested that by limiting the Hippocampal AMPA receptors, sleep deprivation may have an impact on spatial working memory. This decrease in sleeping hours affects the AMPA and NMDA receptor expression, which affects the synaptic strength and brain plasticity and is largely attributed to spatial working memory deficit (Gothe et al., 2020; Namsrai et al., 2023). Lack of sleep or change in sleep quality impairs one's capacity for learning, focus level and reaction time, and motor coordination and causes fatigue. It makes it harder to make decisions and inhibits one's capacity to communicate and handle the demands of the work (Jia et al., 2019). Due to the altered sleep hours, the physical Activeness and work done during the day are decreased, and the shift workers get fatigued Sooner (Knowles et al., 2018). Sleep affects the majority of the Activities of the body. When one is deprived of sleep for

one night, it increases their stress level, decreases the ability to do the work and also affects cognitive function (Thompson et al., 2022; Zhao et al., 2021). An altered sleep-wake cycle, by altering the metabolic process, causes unfavorable protein balance and harms the health of the skeletal muscles (Lamon et al., 2021; Uchida et al., 2023). There is a bidirectional association between physical and mental decline. Evidence from previous research work indicates cognitive impairment is more likely to occur in those with sarcopenia. A study done among older women reported that cognitive impairment was twice as common in women with pre- sarcopenia and five times more common in those with sarcopenia than in non-sarcopenic women (Lee et al., 2018; Keller and Engelhardt, 2014). Another study done among 223 US Adults aged 40+ revealed muscle Strength rather than muscle mass was the primary factor influencing the association between Sarcopenia and cognitive impairment, that suggests efforts that improve muscle strength will potentially mitigate cognitive decline (Ramoo et al., 2022; He et al., 2021). In our study, the cognitive score of the night shift workers was slightly low when compared with the day workers. A significant negative correlation exists between work Done (Mosso's ergograph) and cognition level ($r=-0.565$, $P<0.001$), which is statistically significant. Physical (muscular) tiredness causes a decrease in maximum voluntary force (neuromuscular functional fatigability) or an increase in the sense of effort for a given level of power or force (subjective fatigability). Cognitive fatigue is the psychobiological state experienced after performing an intense and/or prolonged cognitive task, characterized by a feeling of exhaustion and lack of energy. Physical and cognitive fatigue can contribute to each other because physical fatigue puts an individual under constant strain and stress, and persistent mental fatigue can physically emerge as a sense of physical exhaustion. Decreased sleep quality, more fatigue, and lowering of cognition levels not only affect physical health but also the quality of life. All these have a greater impact on the worker's performance. The results of this study provide valuable insights regarding the health risks associated with shift work and outline the harmful Consequences of altered sleep on physical and mental health.

Study limitation

The research work has been biased in its selection because it excluded female participants. The objective measures of sleep and cognition were not done, which may have revealed more information, and it sets the stage for future research.

Conclusion

The current study demonstrates that, in comparison to day workers, night shift workers will experience physical and cognitive exhaustion due to disrupted sleep patterns. Changes in sleep patterns and sarcopenia should be regarded as risk factors for a decline in cognitive function. Cognitive and motor abilities are more likely to deteriorate at the same time when a person's muscle strength declines. The effects of working night shifts on one's health and well-being are complicated. Our objective is to maintain shift workers' overall health, so we must consider health promotion in addition to health protection. Effective interventions aimed at arranging shift schedules per ergonomic standards, vigilant health monitoring, and social support for shift workers are crucial preventative and corrective strategies that enable individuals to continue working without experiencing severe health impairments. Extended naps must be permitted in order to enhance cognitive function and lessen exhaustion. To lower the danger of mishaps and human error, personnel must be trained in workplace safety and personal health.

Conflict of interest

All authors state that none of their personal or financial ties might have unintentionally influenced the study that was presented.

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