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Effect of Altered Sleep, Perceived Stress on Muscle Strength between Night and Day Shift Workers: A Cross-Sectional Study in Chennai

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Abstract: A minimum of 20% of the global population suffers from sleep debt, which includes shift workers. The risks to one's health and well-being are caused by shift work, increased workload, and other substantial problems. Sleep disruptions will lead to stress, catabolize muscle proteins, and reduce muscular strength in night shift workers. To assess whether sleep quality and perceived stress level have an effect on muscle strength among shift workers. A cross-sectional analysis was performed on the airport workers. One hundred night duty workers and one hundred day duty workers aged 25-40 were randomly selected, and the study was conducted for four months in Sree Balaji Medical College and Hospital, Tamil Nadu. A validated questionnaire evaluated the quality of sleep and stress levels. Muscle strength was determined using Mosso's ergograph. Version 3.6.3 of the R statistical software was used to analyze the data. Kolmogorov-Smimov 'Z' test was used to determine the data set's normality. Significant negative correlations are observed between Mosso'sergo graph and both PSS ($r = -0.501$, $p < 0.001$) and global PSQI score ($r = -0.331$, $p < 0.001$). P-value <0.05 was considered statistically significant. This indicates that higher muscle strength is related to decreased perceived stress levels and better sleep quality. Workplace health policies have to be improved. Adequate resting time and stress management training are essential to reduce the adverse effects of rotational work on theworker's performance in addition to their well-being.

Introduction

One-third of the life of the human population is occupied by sleep. A sound sleep is the best bridging agent between despair and hope. Sleep is an unconscious condition during which the brain is comparatively more sensitive to internal than external stimuli (You et al., 2023; Scupp et al., 2003). Sleep is classified into two categories: Quiescent sleep and paradoxical sleep. These two types recur cyclically in the entire sleep period. A sleep cycle starts with a brief time of Quiescent stage I, then moves to II, III, IV(75-80% of sleep) and ends with paradoxical sleep (20-25%), for a total duration of 90 to 120 minutes each cycle. Neurons in the central nervous system control the sleep neurons. Circadian rhythm, which controls the daily sleep-wake cycle, is generated by the biological clock located in the suprachiasmatic nucleus of the hypothalamus. The internal sleep-wake cycle synchronizes with the environment due to inputs from the circadian system (You et al., 2023; Scupp et al., 2003).

Sleep is vital for both cognitive and physiological functioning. Inadequate sleep affects the efficiency and effectiveness of work; it is also detrimental to health. Shift work causes alteration in the sleep-wake cycle. Large groups of people are involved in shift work to fit themselves in the high societal expectations (Knowleset al., 2018). Nearly 15% of the population engaged in rotational work in developed countries (Niu et al., 2011; Rosdiana et al., 2019; Amiri et al., 2021). This kind of work causes disturbances of circadian rhythm and leads

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to physiological and psychological problems, mainly for those who work the night shift due to their altered sleep pattern. Research work related to disturbed sleep has affirmed a range of probable risky effects, generally related to more stress. Stress is the body's overall response to the demands placed upon it (Walvekaret al., 2015).

Stress becomes pathological and produces detrimental effects as its intensity rises. Workers express the stress related to their jobs as a sense of fatigue. A positive association exists between inadequate sleep and increased stress levels. Due to the altered sleep-wake cycle, even though the night shift workers sleep in the morning, their sleep is interrupted by light and ambient noise in the surroundings, and they are more susceptible to stress, which indirectly affects their work performance. Fatigue is the decreased capacity to do the work (Anbumalar et al., 2017). Night shift workers feel more fatigued than daytime workers due to insufficient sleep quality, and lethargy pervades their circadian cycle. All these alter their skeletal muscle health, and the individual's attempt to remain active at work has been hampered by stress (Easton et al., 2024; Devulapally et al., 2018). The skeletal muscle maintains all human movements. Skeletal muscle is the foremost controller of human metabolism and is accountable for the bone's function, which supports mobility and the ability to do work. The constant turnover of proteins preserves the skeletal muscles' structural integrity and quality (Gupta et al., 2022; Poornima et al., 2014). Stress has deleterious effects on skeletal muscle and its strength and also throughout the body. Stress decreases muscle power due to its catabolic effect on muscle proteins. A strong relationship exists between the decreased quality of sleep, more daytime sleep, and high perceived stress (Ajgaonkar et al., 2019). Since the stress system is essential for coping with demanding environments, it is crucial to evaluate how disrupted sleep affects this system and how both perceived stress and sleep loss affect muscle function. Less adequate research has been done on the above factor among the night shift workers. These previous research outcomes and the data impelled for this research to assess how muscle strength is altered due to disturbed sleep and subjective stress in night and day shift workers. The analysis assesses whether sleep quality and perceived stress level have an effect on muscle strength among night and day shift workers.

Materials and methods

Study design: A cross-sectional analysis was performed with airport workers working at Chennai International Airport.

Study setting: The study was conducted for four months at Sree Balaji Medical College and Hospital, Tamil Nadu.

Study population: Airport workers (working in regular night and day shifts).

Sampling method: By using a simple random sampling technique, the study participants are selected based on computer-generated random numbers.

Inclusion criteria: One hundred regular night shift workers and one hundred day shift workers, both males aged 25-40 with at least five years of experience and a work duration of 12 hours, working in the airport sector.

Exclusion criteria: History of any medical ailments in the last 6 months, sleep disorders, under sleep medication, musculoskeletal disorders, and no interest in participating in the study.

Sample size: Based on the earlier study, the sample was approximately 200 (Singh et al., 2018).

Study tool

Pittsburgh Sleep Quality Index

It is a self-report tool that evaluates seven aspects of sleep, including sleep latency, length, habitual sleep efficiency, subjective sleep quality, use of sleeping pills, sleep disruptions, and dysfunction throughout the day. Nineteen items are in the PSQI**.** Each aspect ranges from 0 to 3, with "0" denoting no sleep issues and "3" denoting more severe sleep issues. The seven components add up to the global PSQI score between 0 and 21. A cut-off of 5 on the global PSQI score was used to define overall sleep quality (poor sleepers >5; good sleepers <5). It has 89.6% sensitivity and 86.5% specificity for identifying good and poor sleepers. For each of the seven components, the scale reports an internal consistency reliability (Cronbach's alpha) of 0.83 (Buysse et al., 1989).

Perceived Stress Scale

Cohen, Kamarch, and Mermelstein established this scale in 1983, a reliable, popular tool for measuring the perceived stresslevel of a person in the past month. The appraised items are general. It comprises 10 questions. Items 1, 2, 3, 6, 9, and 10 monitor perceived helplessness. Items 4, 5, 7, 8 measures lack of effect. It ranges from 0-4, (0=never, 1=almost never, 2=sometimes, 3=fairly often frequently, 4=very often).The higher score was 40, which constitutes more levels of stress. Based on the scores,the participants are arranged into 3 categories (Cohen et al., 1994).Low stress(PSS = 0-13),Average stress (PSS= 14 - 26),High stress (PSS= 27-40).

Mosso’s ergograph

Mosso's ergograph (Figure 1) recorded skeletal muscle contraction, and muscle strength was assessed using the same (Pal et al., 2020). Angelo Mosso invented

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the instrument "ergograph " in the early 1880's, which was particularly built to compare physical endurance. It has been used to assess the fatigue of a small group of muscles, such as a single finger. The holder for the finger and forearm has been secured in place. The subject's position was altered, and changes were made to the ergo graph so that the forearm was correctly placed and the subject was also at ease. The ergograph was suspended with the weight of the proper kilogram, which required significant effort to lift. The metronome was set to a frequency of 30 beats per minute. Oscillate once in 2 seconds. Work done is calculated. Work done (in kg) is the product of lifted weight (F in kg), and the contractions recorded (Din cm) (Venkappa et al., 2022).

Outcome measure

Basic demographic details like age in years (to which category they belong), height in meters, weight in kg, habitual time asleep in hours(sleeping lesser or greater than 6 hours), Body Mass Index Kg/m^2 (World Health Organization, 2019), workload (low/high) (Fan et al., 2017), and work activity(more /less) were collected (Table 1).

Pittsburgh Sleep Quality Index

The questionnaire was explained to the participants (both night and day shift workers), and 20 minutes were given to answer all the items. Their sleep quality was measured based on the scores obtained and categorized as good sleepers (≤5) and poor sleepers (>5).

Perceived Stress Scale

The study subjects were explained all ten questions on the scale, and based on the calculated scores, their stress level was categorized as low, moderate, or high.

Muscle strength- Mosso's ergograph

The individual was directed to do a sequence of maximal contractions until they became tired; at that moment, the reading was computed. Fatigue was calculated when the non-dominant hand's middle finger flexor began to lift the weight through utmost contraction and continued to do so until the load could no longer be raised. The muscle contractions of the middle finger flexors are graphed on paper and assessed to ascertain the quantity of work accomplished.

Data analysis

Version 3.6.3 of the R statistical software was used to analyze the data. Categorical data are represented as frequencies and percentages, whereas continuous variables are shown as mean and standard deviation (SD) or interquartile ranges (IQR). For each variable included in the primary analyses, the Kolmogorov-Smimov Z test was used to determine the data set's normality. Appropriate statistical tests were then chosen based on the results. To investigate the relative impacts of independent variables on health outcomes, a linear regression test was performed. A p-value of less than 0.05 was deemed statistically significant.

Ethical approval

The ethical permission of the Institutional Ethical Committee of Sree Balaji Medical College and Hospital(Ref no: 002/SBMCH/IHEC/2023/1904). Written informed consent was taken from the study subjects before the study.

Result

Table 1 compares various characteristics between day duty workers (N = 1001) and night duty workers (N = 1001). On average, day duty workers are slightly older than night duty workers, with ages of 32.2 (SD = 3.4) and 31.0 (SD = 3.6) respectively (p = 0.013). The two groups have no significant difference in BMI (p > 0.9). In terms of workload, the distribution across low, medium, and high categories is similar for both day and night workers (p = 0.11). Similarly, the groups have no significant difference in work activity levels (p = 0.8). However, night duty workers report significantly poorer sleep quality compared to day duty workers, as indicated by higher scores on the global PSQI score (5.64 vs. 3.98, p < 0.001) and lower perceived sleep quality ratings (5.64 vs. 3.98, p < 0.001). Night duty workers also experience higher levels of perceived stress (22 vs. 13, p < 0.001) and exhibit lower levels of morningness (25.9 vs. 34.2, p < 0.001) compared to their day duty counterparts. The correlation matrix illustrates (Table 2) the relationships between Mosso's ergograph (muscle strength), perceived stress scale (PSS), and global PSQI score. Significant negative correlations are observed between Mosso'sergo graph and both PSS (r = -0.501, p <0.001) and global PSQI score (r = -0.331, p <0.001). This indicates that higher muscle strength is related to reduced levels of perceived stress and better sleep quality. However, there is no strong connection between PSS and global PSQI score (r = 0.104, p = 0.146). The linear regression analysis examined the relationship between various characteristics and groups (day duty workers vs. night duty workers), sleep quality, global PSQI score, perceived stress scale (PSS), work activity, and workload (Table 3). Night duty workers have lower scores in comparison to day duty workers (Beta = -8.2, 95% CI [-8.8, -7.6], p <0.001), indicating a substantial difference between the groups. However, sleep quality, global PSQI score, PSS, work activity (more vs. less), and workload (medium vs. low) did not show significant associations with the outcome variables, as evidenced by non-

significant p-values (>0.05). These results suggest that while group (day vs. night duty workers) significantly predicts the outcome, other characteristics such as sleep quality, global PSQI score, PSS, work activity, and workload do not demonstrate significant predictive power in this regression model.

Table 1. Details of the study participants

Attributes	Day duty workers, N = 100[1]	Night duty workers, N = 100[1]	P-value[2]
Age	32.2 (3.4)	31.0 (3.6)	0.013
BMI	25.13 (2.82)	25.15 (2.81)	>0.9
Workload			0.11
Low	25 (25%)	15 (15%)	
High	75 (75%)	85 (85%)	
Work activity			0.8
Less	32 (32%)	29 (29%)	
More	68 (68%)	71 (71%)	
Global PSQI score	3.98 (2.17)	5.64 (2.10)	<0.001
Sleep quality	3.98 (2.17)	5.64 (2.10)	<0.001
PSS score	13 (7)	22 (9)	<0.001
Mosso	34.2 (0.7)	25.9 (2.1)	<0.001
[1]Mean (sd); n (%)			
[2]Welch two sample t-test; fisher's exact test			

Table 2. Correlation Matrix

		MOSSO		PSS	GLOBAL PSQI SCORE
MOSSO	Pearson's r	—			
	df	—			
	p-value	—			
PSS	Pearson's r	-0.501***		—	
	df	196		—	
	p-value	< .001		—	
GLOBAL PSQI SCORE	Pearson's r	-0.331***		0.104	—
	df	198		196	—
	p-value	< .001		0.146	—
Note. * p <0.05, ** p <0.01, *** p <0.001					

Discussion

Shift work impacts employees' sleep patterns, raises stress levels, and changes protein metabolism, which may lessen muscle work by increasing fatigue.This research evaluated the participants' sleep quality, amount of stress, and its impact on muscle strength using a validated questionnaire and Mosso's ergograph, respectively. The study results show that there was the existence of significant negative correlations between Mosso'sergo graph and participants' stress levels(r = -0.501, p <0.001) and global PSQI score (r = -0.331, p <0.001). Tejas et al. (2022) revealed that more stress is linked to decreased quality of sleep. Sleep loss is sleep that is shorter than the 7 to 9 hours per night that adults typically require. Adult sleep patterns have been proven to be unhealthy, leading to increased levels of stress that increase their chance of developing a variety of health issues as well as limiting their ability to perform high-quality work (Tejas et al., 2022). Thompson et al. indicated that when sleep is reduced for one night, it modifies cortisol levels in addition to cognitive function, suggesting that sleep affects the majority of our body's activities(Thompson et al., 2022). Sleep-wake cycle disruption and circadian misalignment are effects of shift employment. The sleeping time, sleep quality, and duration were all changed for night shift workers. They are more exhausted than daytime and evening shift workers, which compromises the productivity and safety of the

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Table 3. Linear Regression for the predictors

Attributes	Beta	95% CI[1]	p-value
Group			
Day dutyworkers	—	—	
Night duty workers	-8.2	-8.8, -7.6	**<0.001**
Sleep quality	0.03	-0.08, 0.13	0.6
Global PSQIscore			
PSS	-0.01	-0.04, 0.02	0.5
Work activity			
Less	—	—	
More	0.04	-0.73, 0.81	>0.9
Workload			
Low	—	—	
MEDIUM	-0.11	-0.93, 0.70	0.8
Null deviance	3,860		
Log-likelihood	-368		
AIC	751		
BIC	774		
Deviance	479		
Residual df	192		
No. Obs.	198		
[1]CI = Confidence Interval			

workplace. Shift work disrupts the circadian rhythm of the worker, has been linked to a number of mental and physical problems, and has a detrimental influence on job performance, safety, and productivity(Kecklund et al.,2016; Fielding et al.,2015). Skeletal muscle fibers are made of 90% proteins. There is a balance between protein synthesis and degradation to maintain muscle mass, which is promoted by anabolic and catabolic hormones, respectively. An altered sleep-wake cycle negatively affects muscle health by raising the amount of catabolic hormones leading to a breakdown of proteins and lowering the anabolic hormones amount(Aisbett et al.,2017; Fullagar et al., 2015; Simpson et al.,2017). Previous reviews confirmed that prolonged bad sleep quality can lower muscle strength by interfering with normal metabolism of muscle protein (Peng et al., 2019; Wolkow et al., 2015). The intrinsic biological clock in skeletal muscle is sensitive to shifts in the shift workers' eating patterns, light exposure, and sleep and wake times (Schroder et al.,2015). Cortisol levels change during shift work as a result of exposure to artificial light. This dysregulation may harm the health of the skeletal muscles by encouraging an unfavourable protein balance. So, regardless of age, shift workers' circadian misalignment and sleep deprivation may also harm their skeletal muscles (Genario et al., 2023; Harfmann et al., 2015). Lamon et al. (2021) found that complete sleep deprivation decreases postprandial muscle protein synthesis by 18%, which results in anabolic resistance. It also encouraged a catabolic environment and concluded that getting little or no sleep was associated with a number of metabolic consequences (Lamon et al., 2021). In their study among medical postgraduate students, they discovered that residents' sleep patterns were mostly unhealthy, leading to high perceived stress, resulting in a number of health conditions and also impairing their capacity to provide high-quality healthcare (Ogawa et al., 2018).In our study, night duty workers report significantly poorer sleep quality than day duty workers and experience higher levels of perceived stress than their day duty counterparts. Significant negative correlations are observed between Mosso'sergo graph and both PSS ($r = -0.501$, $p < 0.001$) and global PSQI score ($r = -0.331$, $p < 0.001$). This indicates that there is a connection between higher muscle strength, decreased stress and better sleep quality. Decreased sleep not only affects the physiological well-being of an individual but also alters it, leading to stress, hastening fatigability and affecting physical fitness and quality of life. The results of this study have important outcomes for workplace safety and health. It offers discerning information about the possible health risks connected to shift work and de-lineatesthe detrimental impacts of shift work on employees' sleep patterns, perceived stress, muscular strength, and general well-being. The study has limitations, including the selection bias; females were not included in the study,

which may have impacted the generalizability of our findings. Future analysis is needed to substantiate the result of the research and analyzean individual's sleep effect on all the muscle groups, including the metabolic level alteration, for a better understanding. Research can focus on finding other elements that exert control over rotational shift, sleep, stress, and muscle strength.

Conclusion

The present study highlights that night shift workers have poor sleep quality and more stress, which significantly affects muscle function when compared with day shift workers, highlighting the need for further research to find some interventions for this specific population. Shift workers have to be educated about sleep hygiene practices.There is a need to improve workplace health policies like adequate resting time and stress management training, which are essential to reduce adverse effects of shift work and improve workers' performance and well-being.

Conflict of interest

All authors reveal no competing interest.

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