The impact of night shift on working memory performance: A pilot study

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Abstract
Introduction: Lack of sleep can have profound effects on performance. Nurses provide services hostelry and the possibility of errors in their job increases. It has been assumed that the rate of medical errors on the night shift may be because of the decline in executive functions of the prefrontal cortex. So the aim of this pilot study was to assess changes in working memory performance before and after the night shift.

Method: This prospective observational study was conducted in hospitals of Sabzevar. 20 shift-worker nurses, 6 men and 14 women were selected by proportional stratified sampling. In order to evaluate the performance of working memory, the auditory form of WMS software was administered. Independent and paired t test, Pierson correlation coefficient and Linear mixed effect models were used for data analysis. The data analysis was done with Stata 14 IC. P-value was considered 0.05.

Results: The results showed that changes in working memory and its components have not been significantly affected by the night shift. In addition, changes in working memory and its components during this period weren’t significantly different between men and women; and these changes were not associated to age. The negative correlation between age and memory components shows a lower level of working memory in older ages.

Conclusion: Working memory and its components of nurses do not significantly change over one night shift.

Keywords: working memory, night shift, shift-work, nurse.
Introduction:
Biological rhythm is one of the fundamental characteristics of living organisms. Human capabilities change in any time of day, week, month and season. Life is in the form of cyclical activities. And there is no life without biological rhythm phenomenon (1). People experience different levels of consciousness during the day. For example, consciousness peak around noon and Short-term memory is at its peak in mornings. In phenomenon like shift-work and jet lag the circadian regulators are adapting to daily changes. And thus people for several days may experience Lack of coordination between what is expected and what they live in (2). Lack of sleep can have profound effects on performance. In laboratory setting, it has shown that lack of sleep affects various operational tasks (3-6). There is considerable evidence that the prefrontal cortex is sensitive to sleep deprivation (7). Brain imaging by PET scan results are consistent with the evidence that sleep deprivation increases metabolism in the prefrontal regions (8). PFC’s vulnerability to sleep deprivation leads to the assumption that tasks in which PFC is involved may be sensitive to sleep deprivation.

Fatigue among shift workers is directly arising from their unconventional working hours. Employees are required to act contrary to the natural cycle of sleeping and waking. The problem of shift workers intensifies when as a result of sleep deprivation and fatigue accumulation; gradually they become chronically sleep deprived. Chronic sleep deprivation causes perpetual drowsiness, reduced alertness and performance, increased fatigue, errors and accidents among this group (9). Nurses provide services hostelry and the majority of nursing staff provide services in addition to their daily work. As a result, the possibility of errors in their job increases. Suzuki et al (2004) suggest that there is a significant relationship between job errors among nurses with night shifts, irregular shifts and age (10). Therefore, the authors assume that the rate of medical errors on the night shift may be because of the decline in executive functions of the prefrontal cortex. Working memory is one of the prefrontal cortex executive functions. The aim of this pilot study was to assess changes in working memory performance before and after the night shift.

Method:
This prospective observational study was conducted in hospitals of Sabzevar. 20 shift-worker nurses, 6 men and 14 women were selected by proportional stratified sampling. The inclusion criteria were: being employed as a nurse, at least one year of experience, no psychiatric diagnosis for sleep disorders, no brain damage due to accidents, having shift rotations with night shifts; And Exclusion criteria were: unwillingness of the subject to continue with the study, not completing the night shift.

In order to evaluate the performance of working memory a computer software was used designed by the Institute of Cognitive Behavioral Sciences Research- Sina. The working memory test is the Digit Span subscale of Wechsler Intelligence Scale-fourth edition, which is consist of two parts: Digit Span Forward and Digit Span Reverse. But the software provides 4 outputs: forward score, reverse score, total score and memory span score. This scale has acceptable reliability and validity and also its psychometric properties has been examined and confirmed in Iran. In this
study we performed the auditory form of working memory software. Subjects learned how to work with the software from the trained research assistants. Subjects were completing the Working Memory Scale once before beginning of the night shift and once immediately after the shift. The tests were taken in a fixed location and away from environmental disturbances. Responses were recorded automatically by the software. Before implementing this study, the executive protocol of the study was approved by the Research Ethics Committee of Sabzevar University of Medical Sciences. Volunteers for participating in the study were informed of the objectives and implementation of the study and in case they had consent they were recruited. Statistical analysis Independent and paired t test, Pierson correlation coefficient were used for data analysis. Linear mixed effect models (random intercept models) were used for prediction of changes in memory (and its components) over the night shift adjusted for age and sex; in addition, time interaction for age and sex were considered. The data analysis was done with Stata 14 IC. P-values less than 0.05 were considered as statistically significant. Results In this study, 20 nurses (6 men and 14 women) with a mean age of 30.6 ± 4.9 years were evaluated. The mean age of male and female nurses were not significantly different (p = 0.425). Results from components of the forward, reverse, total scores of working memory, and memory span are presented in Table 1. The correlation coefficient between age and working memory components at the beginning of the night shift were as follow; forward working memory (r = -.376), reverse working memory (r = -.184), total score of working memory (r = -.326) and memory span (r = -.379). mean scores of working memory and its components did not show significant changes from the beginning to the end of the night shift. All the P-values were higher than 0.05. Table 1) mean scores of working memory and its components at the beginning and end of the night shift and its changes

<table>
<thead>
<tr>
<th>Working Memory</th>
<th>At the Beginning of Night Shift</th>
<th>At the End of Night Shift</th>
<th>Changes</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revers</td>
<td>6.20±1.94</td>
<td>6.50±1.96</td>
<td>-.30±1.78</td>
<td>.460</td>
</tr>
<tr>
<td>Forward</td>
<td>6.15±1.87</td>
<td>6.45±1.67</td>
<td>-.30±1.84</td>
<td>.474</td>
</tr>
<tr>
<td>Total</td>
<td>12.35±3.25</td>
<td>12.95±2.84</td>
<td>-.60±2.70</td>
<td>.333</td>
</tr>
<tr>
<td>Span</td>
<td>5.60±1.23</td>
<td>5.80±1.06</td>
<td>-.20±1.24</td>
<td>.479</td>
</tr>
</tbody>
</table>

Using repeated measure mixed effect model for working memory and its components scores from the beginning to the end of the night shift adjusted for age and gender the result were: In predicting changes in reverse working memory we see this component’s scores increased 0.30 toward the end of the shift, although these changes were not statistically significant; the effect of age and gender were not significant either. In predicting changes in forward working memory there was no change from the beginning to the end of the shift. Changes of total score were 0.60
and were not statistically significant. Also in predicting changes in memory span as it can be seen in Table 2 there weren’t any significant changes.

Table 2) results of the random intercept repeated measure mixed effect model for prediction of changes in working memory and its components over the night shift, adjusted for age and sex

<table>
<thead>
<tr>
<th></th>
<th>constant</th>
<th>time</th>
<th>age</th>
<th>sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revers</td>
<td>Coefficient</td>
<td>6.2</td>
<td>0.30</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.012</td>
<td>0.439</td>
<td>0.243</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>1.3, 11.0</td>
<td>-.46, 1.06</td>
<td>-0.23, 0.06</td>
</tr>
<tr>
<td>Froward</td>
<td>Coefficient</td>
<td>10.3</td>
<td>0.30</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>&lt;0.001</td>
<td>0.454</td>
<td>0.160</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>6.2, 14.5</td>
<td>-0.49, 1.09</td>
<td>-0.21, 0.03</td>
</tr>
<tr>
<td>Total</td>
<td>Coefficient</td>
<td>16.5</td>
<td>0.60</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>&lt;0.001</td>
<td>0.308</td>
<td>0.152</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>8.58, 24.4</td>
<td>-0.55, 1.75</td>
<td>-0.41, 0.06</td>
</tr>
<tr>
<td>Span</td>
<td>Coefficient</td>
<td>8.3</td>
<td>0.20</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>&lt;0.001</td>
<td>0.459</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>5.7, 11.0</td>
<td>-0.33, 0.73</td>
<td>-0.14, 0.02</td>
</tr>
</tbody>
</table>

Then to evaluate the differences in working memory changes and its components in men and women during night shifts as well as varying levels of age, interaction between gender and time and the interaction between age and time were added to the model. In all predictive models of working memory and its components the interaction of age-time and the interaction of gender-time were not statistically significant. This implies that working memory changes during night shifts was not significantly different between male and female nurses; and also changes in working memory and its components during the night shift showed no significant association with age.

**Discussion**

The results of this study showed that changes in working memory and its components have not been significantly affected by the night shift. In addition, changes in working memory and its components during this period weren’t significantly different between men and women; and these changes were not associated to age. This means that changes in working memory in older people are not different with younger people. The negative correlation between age and memory components shows a lower level of working memory in older ages.

The finding that there is a negative correlation between age and working memory components is consistent with Testu’s longitudinal research conducted in 1979 to 1985. He reports that better Results of working memory performance in the morning comparing to the afternoon.
depends on the age of the subject. He states Fluctuations in performance cycle can be influenced by external factors such as age, previous trainings etc. and change (11).

In order to explain the finding that working memory performance did not significantly change from beginning to the end of the night shift, according to the Gates (1916) (12) and Blake (1967) (13) studies which showed that working memory before noon is better than the afternoon, can be said that these results are consistent. Folkard et al (1977) are also showed that working memory in the morning is better than the afternoon (14). According to Folkard (1980) subjects better remember detailed information in the morning (15). Except that nurses had not better performance in the morning than the night, it can show the effect of the night shift. Because normally according to previous research performance should be better in the morning than afternoon.

This study has limitations. This is a pilot study with a small sample size. Subjects have been studied in one night shift and the status of their working memory (And other variables that we have examined in this pilot study) has not been investigated in other work-shifts (morning or evening) so we can compare the results.

Here another question arises, that this study due to its limitations cannot give an answer to. The question is how is the status of their working memory in normal circumstances, and more particularly, at the beginning of the day shift? Are these nurses have had sufficient rest before the night shift?

No significant changes in components of working memory and a slight increase of them could be due to the effect of learning the software. To answer these questions and ambiguities and for an accurate assessment of the actual effect of night shift on working memory and its components, a study should designed with a larger sample numbers in a way that the net effect of night shift can be differentiated. It seems Observational cross over design is a viable proposition.
References


