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Original Article

Nurses working on fast rotating shifts overestimate cognitive function and the capacity of maintaining wakefulness during the daytime after a rotating shift

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ABSTRACT

Objectives: The objective of our study was to explore changes in cognitive functions, sleep propensity, and sleep-related hormones (growth hormone [GH], cortisol, prolactin [PRL], thyrotropin [TSH]) in the daytime of nurses working on fast rotating shifts.
Methods: Twenty nurses who worked two consecutive night shifts and 23 off-duty nurses were recruited from an acute psychiatric ward. The maintenance of wakefulness test (MWT), Stanford sleepiness scale (SSS), visual attention tasks, Wisconsin card sorting test (WCST), multiple sleep latency test (MSLT), and measuring hormones were administered four times throughout the daytime at 2-hour intervals.
Results: The subjects in the off-duty group were more able to maintain wakefulness than those in the night-shift group; however, there were no differences in self-reported total sleep time or sleep latency on the MSLT and SSS scores between the two groups. The subjects in the night-shift group had poorer performances on visual attentive tasks and higher levels of TSH than those in the off-duty group, and this resulted in a lack of a learning effect on the tasks that required a high attentive load.
Conclusions: Nurses working on fast rotating shifts overestimate the cognitive functions and capacity of maintaining wakefulness following daytime sleep restriction. Attention performance depended on the attentive load requirement and was possibly related to TSH level.

1. Introduction

A three-shift system with faster rotation is common in the medical field in Taiwan, where it is assumed that workers will maintain a constant circadian rhythm in coordination with the environment [1]. Most nurses have one day off between the end of consecutive night shifts and the beginning of the next day shift. It would be expected that these nurses should avoid sleeping during the daytime of the off day, as too much sleep in the daytime would affect sleep quality or sleep time at night and therefore indirectly affect the performance of the next day shift.

Sleep-deprivation studies [2] have shown a diverse impact on mood and cognitive performance due to an increase in sleep propensity and destabilization of the wake state. Specific neurocognitive domains, including psychomotor vigilance tasks, sustained attention tasks, and executive function have been shown to be particularly vulnerable to sleep loss [2,3]. These effects of sleep restriction on cognitive performance in healthy adults are consistent with those on the effects of sleep restriction on physiologic sleep propensity measures (maintenance of wakefulness test [MWT], multiple sleep latency test [MSLT]) [4,5]. Many studies have investigated the influence of night shifts on night performance or the effects of partial or total sleep deprivation on cognitive function in a laboratory setting. However, little is known of the ability of nursing staff to remain alert during the daytime after completing consecutive night shifts.

The work schedule of most nursing staff in our hospital consists of repetitive blocks of two consecutive day shifts (8 AM–4 PM. or 8 AM–5:30 PM), two evening shifts (4 PM–12 AM), two night shifts (12 AM–8 AM), and then have at least one day off duty. Using this 3-shift system with fast forward rotation in our hospital, we investigated changes in cognitive function and objectively measured

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sleep propensity in the daytime after two consecutive night shifts. We also measured sleep-related hormones (growth hormone [GH], cortisol, prolactin [PRL], thyrotropin [TSH]) during the daytime.

2. Methods

2.1. Subjects and procedures

Twenty nurses (mean age, 26.0 ± 2.0 y; y of education, 14.7 ± 1.0 y) who worked two consecutive night shifts and 23 off-duty nurses (mean age, 26.1 ± 1.9 y; y of education, 15.3 ± 1.0 y) were recruited from the acute ward of Kaohsiung Municipal Kai-Syuan Psychiatric Hospital, which is the largest psychiatric center in southern Taiwan. All subjects had worked at this hospital for at least one year. The exclusion criteria were current use of hypnotics, regularly drinking coffee, psychiatric illness, major systemic disease, and sleep disorders. All subjects had worked daytime shifts, worked evening shifts, or had been free of duty for at least 3 days before entering the study day. During the night shifts, all subjects were asked to sleep prophylactically between 7 PM and 11 PM. Demographic data, including age, years of education, and mean self-reported total sleep time (including daytime sleep and prophylactic sleep) during the working night for the night-shift group and the day before the study day for the off-duty group were recorded.

The subjects arrived at the sleep laboratory at approximately 9:00 AM at the end of a night shift and on the off-duty day, respectively, and spent approximately 8 hours in the laboratory. After application of the electrodes, the participants completed the following tests: MWT, state-trait anxiety inventory (STAI), Stanford sleepiness scale (SSS), Wisconsin card sorting test (WCST), digit symbol substitution test (DSST), symbol searching test (SST), Taiwan University attention test (TUAT), and the MSLT. In addition, blood samples were collected and tested for cortisol, PRL, GH, and TSH. Each test was performed four times every 2 hours starting at 9:20 AM. The procedure of the measurements is shown in Fig. 1. Blood samples were collected at the end of the MSLT at the bedside. All subjects were required to remain awake during the test day, and all of the tests were individually administered in an equivalent experimental setting. Written informed consent was obtained from all subjects prior to their participation in the study, which was conducted with the approval of the Ethics Committee of Kaohsiung Municipal Kai-Syuan Psychiatric Hospital.

Maintenance of wakefulness test (Maximum 40 minutes)
⇩ 10-minute intervals
State-trait anxiety inventory (1–2 minutes)
⇩ 3-minute intervals
Stanford sleepiness scale (1 minute)
⇩ 3-minute intervals
Wisconsin card sorting test (15–20 minutes)
⇩ 3-minute intervals
Digit symbol substitution test (2 minutes)
⇩ 3-minute intervals
Symbol searching test (2 minutes)
⇩ 3-minute intervals
Taiwan University attention test (3–4 minutes)
⇩ 10-minute intervals
Multiple sleep latency test (maximum, 20 minutes)

Fig. 1. Procedure of measurements.

2.2. Measurements

2.2.1. State-trait anxiety inventory

The STAI [6] is a self-reported measure of both state and trait anxiety. Each inventory contains 20 self-reported items. State anxiety indicates a transitory condition of perceived tension to assess, “How do you feel right now, that is, at this moment?”, and trait anxiety is a relatively stable condition of anxiety proneness to assess, “How do you generally feel”? All items are rated on a 4-point scale (range, 20–80 points) with a higher score indicating a higher anxiety. The STAI has been shown to have good validity and responsiveness as well as good internal consistency (Cronbach $\alpha > 0.85$) and test–retest reliability ($\geqslant 0.75$) [7].

2.2.2. Stanford sleepiness scale

The SSS [8] is a 7-point self-rating scale which is used to quantify progressive steps in sleepiness from one (alert) to seven (no longer fighting sleep).

2.2.3. Wisconsin card sorting test

The WCST [9] can be considered a measure of executive function, requiring the ability to develop and maintain an appropriate problem-solving strategy across changing stimulus conditions to achieve a future goal [10]. Adequate performance on these types of tasks generally depends on frontal lobe function or high cortical function [11]. The computerized WCST consists of four stimulus cards and 128 response cards that depict figures of varying forms, colors, and numbers. The subject is instructed to match each consecutive card from the deck with one of the four stimulus cards that he or she thinks is a match. The number of perseverative errors, number of total errors, number of categories, percent of conceptual level responses, and failure to maintain set were used as dependent variables.

2.2.4. Digit symbol substitution test and symbol searching test

The DSST and SST are subsets of the Wechsler adult intelligence scale [12] involving cognitive, perceptual, and motor abilities. These visual attention tasks rely on both automatic and controlled attention processing. Automatic processing occurs in the parietal, cortical, and thalamic areas, whereas controlled processing occurs in the frontal regions [13,14]. In the DSST, subjects are asked to enter the appropriate symbols into empty squares beneath digits. In the SST, subjects are asked to respond to either one of two target symbols presented with four selective symbols. Both the DSST and SST raw scores are determined by the number of items correctly completed in 120 seconds; then the raw score is transformed to a scale score according to age. The information process index was obtained after converting the sum of the scale scores of the SST and DSST.

2.2.5. Taiwan University attention test

The TUAT [15] also involves attention processing similar to the DSST and SST. The TUAT requires subjects to cross out two target characters from a random list of 780 letters, numbers, and symbols printed on an A4 sheet of paper as fast and as accurately as possible. The number of characters per second (i.e., the number of omissions subtracted from the correct number of characters divided by the time taken to complete the test), number of omissions, and completion time were used as dependent variables.

2.2.6. The multiple sleep latency test

Partial-montage polysomnography was performed consisting of electroencephalography (at F3/A2, F4/A1, C4/A1, C3/A2, O2/A1, O1/A2), electrooculography, and submental electromyography. We visually scored sleep records using the MSLT in 30-second epochs according to the American Academic of Sleep Medicine criteria