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Differences in cortisol profiles and circadian adjustment time between nurses working night shifts and regular day shifts: A prospective longitudinal study

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ABSTRACT

Objective: This study explored the differences in the circadian salivary cortisol profiles between nurses working night shifts and regular day shifts following a slow rotating shift schedule to assess the number of days required for adjusting the circadian rhythm of salivary cortisol levels in nurses working consecutive night shifts and the number of days off required to restore the diurnal circadian rhythm of salivary cortisol levels.

Methods: This was a prospective, longitudinal, parallel-group comparative study. The participants were randomly assigned to night and day-shift groups, and saliva samples were collected to measure their cortisol levels and circadian secretion patterns.

Results: Significant differences were observed in the overall salivary cortisol pattern parameters (cortisol awakening response, changes in cortisol profiles between 6 and 12 h after awakening, and changes in cortisol profiles between 30 min and 12 h after awakening) from Days 2 to 4 of the workdays between both groups. However, on Day 2 of the days off, both groups exhibited similar cortisol profiles and the cortisol profiles in the night-shift group were restored.

Conclusion: Nurses working night shifts require at least 4 days to adjust their circadian rhythms of cortisol secretions. Moreover, on changing from night shift to other shifts, nurses must be allowed more than 2 days off work.

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What is already known about the topic?

- Night shifts affect sleep quality, performance, social life and well-being of nursing staff.
- The off time between shifts affects the speed of recovery from circadian disruption.

What this paper adds

- Based on salivary cortisol data, the study has found that minimal adjustment period required for nurses to get used to night shift is 4–5 days.
- The minimal off period required for nurses to recover from night shift is two days.

1. Introduction

Night-shift workers generally sleep during the day and work during the night, which affects their diurnal circadian rhythm. A disruption in the biological clock of shift workers often results in sleep disturbances and affects their awareness while they work. The interrupted circadian rhythm can cause sleep deprivation, fatigue, and physical collapse and also affects physiological functions (Kudielka et al., 2007). With an increased degree of fatigue, the reaction time of shift workers increases and their attention decreases (Niu et al., 2013; Samaha et al., 2007; Takeyama et al., 2005). Circadian rhythms in cognitive performance have been found associated with 3 basic neuropsychological processes (attention, working memory, and executive functions), which can modulate the execution of many tasks (Valdez et al., 2012), that may explain why alertness increases during the day and decreases during the night. Night-shift workers typically work at the low point of the circadian cycle; therefore, their attention and short-term memory are markedly decreased while working (Valdez et al., 2005). The fatigue and decreased performance of nurses have implications for patient care (Smith et al., 1994).

Cortisol secretion is affected by the diurnal rhythm, sleep–wake cycle, neurological stress signals, and other factors (Refinetti, 2006). The amount of cortisol secretion is determined by the activity of the hypothalamic–pituitary–adrenal axis. The hypothalamic–pituitary–adrenal axis is a major endocrine system that can assist an organism in adapting to bodily and environmental challenges (Tsigos and Chrousos, 2002). Cortisol secretion is at its lowest level during light sleep and gradually increases before deep sleep (Kudielka et al., 2007). The highest levels are achieved within 30 min after awakening, and they continuously decrease throughout the day. The cortisol awakening response is characterized by a rapid increase in cortisol levels within 30 min after awakening. In general, the cortisol awakening response reflects the anticipation of the upcoming day through activation of memory representation and temporal and spatial orientation. These cortisol patterns (i.e., the cortisol awakening response and diurnal slope) can be used to determine the responsiveness of the hypothalamic–pituitary–adrenal axis (Fries et al., 2009; Wilhelm et al., 2007). Moreover, the change in cortisol profiles after awakening indicates that the alterations during the latter part of daily activity occur without any influence from the CAR (Adam and Kumari, 2009). Thus, the cortisol awakening response and diurnal changes in cortisol levels are major measurements of cortisol activity and can be used to indicate the adjustment required to meet environmental challenges (Adam and Kumari, 2009).

The range of cortisol-level fluctuations remains stable throughout the day and night; however, cortisol secretion increases under physical or mental stress (Kudielka et al., 2007, Perkins, 2001, Putignano et al., 2001). The cortisol profiles of day-shift workers typically increase in secretion at 0600 and a decrease at 2100, which is consistent with the circadian rhythms of fixed-day workers (Knauth and Rutenfranz, 1976). By contrast, night-shift nurses, who sleep during the day and provide patient care under stressful conditions during the night, have constantly high cortisol profiles. Fluctuations in the cortisol profiles are lower during night shifts than during the day shifts (Holmbäck et al., 2003; Kudielka et al., 2007; Lac and Chamoux, 2004; Mitani et al., 2006; Muecke, 2005). Czeisler et al. (1986) indicated that circadian rhythms require several days to readjust and that new circadian rhythms adjust at a rate of 1 h/day; accordingly, they recommended giving at least 1–2 days off for sufficient rest to eliminate fatigue and for resumption of the diurnal circadian rhythm (Hossain et al., 2004; Scott et al., 2006; Wilson, 2002). The days off between shifts exhibit varying effects on the speed of recovery from fatigue regarding various shift patterns. A sufficient rest period can facilitate avoiding errors at work that result from decreased alertness (Hossain et al., 2004; Wilson, 2002), indicating the importance of exploring methods that assist shift workers inefficiently recognizing the lag in their circadian rhythms of cortisol secretion. Moreover, determining the amount of time required by nurses to adjust circadian variation may contribute to improving patient care by facilitating an optimal scheduling system.

Previous studies have examined the effects of shift work versus non-shift work and compared shift types and shift systems (Blok and de Looze, 2011). These studies have focused on various outcomes including sleep quality and length (Ansiau et al., 2008), fatigue (Kudielka et al., 2007), cognitive and psychomotor performance (Rouch et al., 2005), accidents (Zuzewicz and Konarska, 2005), working ability (Costa and Sartori, 2007), social life, and health or well-being (Härmä et al., 2006). In addition, previous experimental studies have reported the circadian rhythms of night-shift workers at the end of their shifts and during their days off when they often sleep during the day (Hennig et al., 1998; Kudielka et al., 2007; Lac and Chamoux, 2004). Other studies have analyzed the biological responses produced by sudden changes in work shifts and identified the responses that differed from those of shift workers following slow rotating shift schedules (Kudielka et al., 2007; Lac and Chamoux, 2004). The slowly rotating shift system comprised 1 month of morning shifts, 1 month of evening shifts, and 1 month of night shifts with 8 days off per month. The present study was designed to measure the longitudinal effects of altering work shifts on the circadian cortisol profiles of