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Associations between shift schedule characteristics with sleep, need for recovery, health and performance measures for regular (semi-) continuous 3-shift systems

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ABSTRACT

In this cross-sectional study associations were examined between eight shift schedule characteristics with shift-specific sleep complaints and need for recovery and generic health and performance measures. It was hypothesized that shift schedule characteristics meeting ergonomic recommendations are associated with better sleep, need for recovery, health and performance. Questionnaire data were collected from 491 shift workers of 18 companies with 9 regular (semi)-continuous shift schedules. The shift schedule characteristics were analyzed separately and combined using multilevel linear regression models. The hypothesis was largely not confirmed. Relatively few associations were found, of which the majority was in the direction as expected. In particular early starts of morning shifts and many consecutive shifts seem to be avoided. The healthy worker effect, limited variation between included schedules and the cross-sectional design might explain the paucity of significant results.

1. Introduction

Shift work, i.e. workers succeeding each other at the same work station to perform the same job, is a widespread working time arrangement. Approximately 17% of the working population in the European Union (Eurofound, 2010) and 15% in the US (Bureau of Labor Statistics) works in shifts. In the Netherlands, about 17% of the working population works in shifts (Koppes et al., 2012). Shift work is applied to extend operating hours to evening, night or weekends, to provide coverage of necessary services, or to keep production processes running around the clock. While irregular shift systems are more common in the service sector (e.g. police and healthcare), the vast majority of industrial companies with shift work use a regular 2- or 3-shift system.

Shift work can be burdening to workers due to disturbances of biological and social circadian rhythms, and can negatively affect health and performance in the short and long term. Short-term effects of shift work comprise reduced sleep length and decreased sleep quality (Akerstedt and Wright, 2009; Akerstedt, 1998). These effects differ per shift, with sleep most affected during early morning and night shift periods (Flo et al., 2013; Juda et al.,

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2013). Without sufficient opportunity to recover, accumulated sleep loss is associated with generic outcomes like increased fatigue and impaired cognitive performance (Sluiter et al., 2003; Harma, 2006). Long-term health effects of shift work refer to an increased risk of developing cardiovascular disease, metabolic disorders, breast cancer and gastrointestinal disorders (Puttonen et al., 2010; Knutsson and Boggild, 2010; Knutsson et al., 2013; Wang et al., 2014; Ramin et al., 2014).

The design of a shift system is regarded as a key determinant of shift work-related problems. A shift schedule that minimizes circadian disruption and accumulation of sleep loss across a shift cycle, and concurrently permits adequate recovery during days off, will be beneficial for sleep and alertness (Sallinen and Kecklund, 2010), as well occupational safety and long-term health. From this perspective, a set of ergonomic shift schedule criteria has been proposed to promote health, safety and social well-being (Knauth and Hornberger, 2003). It is advised to 1) minimize the number of consecutive shifts, 2) minimize the number of consecutive working days, 3) provide adequate time to recover between two shifts, in particular after night shifts, 4) avoid early starts of the morning shift, 5) rotate forwards instead of backward (i.e. M(orning) to E(vening) to N(ight) shift instead of N-E-M), and 6) maximize the number of days off during the weekend (i.e. Saturday and Sunday).

Several reviews provide support for the ergonomic criteria by summarizing the effects of these criteria separately on sleep, recovery, health and performance (Bambra et al., 2008; Sallinen and Kecklund, 2010; Pallesen et al., 2010; Folkard and Tucker, 2003). It was shown that industrial performance efficiency is most impaired outside 7:00 to 19:00 and safety risk increases with consecutive shifts, in particular consecutive night shifts (criteria 1 & 2) (Folkard and Tucker, 2003). Quick returns between shifts (criterion 3) and early starts of the morning shifts (criterion 4) decrease sleep duration whilst increasing sleepiness (Sallinen and Kecklund, 2010; Pallesen et al., 2010). A change towards a fast forward rotating schedule seems to be positively related to better sleep quality and alertness (criterion 5) (Bambra et al., 2008; Sallinen and Kecklund, 2010). Recovery is better during a weekend off than during two midweek-days taken off (criterion 6) (Drach-Zahavy and Marzuq, 2013).

Ergonomic shift scheduling recommendations are based on theoretical considerations and supported by mainly intervention studies, in which one or two shift schedule characteristics are changed. Shift schedule intervention studies are the preferred design when examining shift schedule characteristics. Intervention studies offer a powerful design and include both pre- and post-change measurements, and sometimes also a control group. However, intervention studies are hard to accomplish due to challenges implementing and evaluating shift system changes (Knauth, 2001). A drawback of intervention studies is that self-reported effects of the intervention might be influenced by other factors than the schedule change, for example the workers' expectations and attitudes to the shift schedule change. Thus, a new shift schedule that minimizes circadian disruption and cumulative sleep loss may show more self-reported sleep and health problems because the workers' disapprove the intervention. The other way around is also possible, that by simply interfering and paying attention to workers' needs positive effects may be observed, i.e. the 'Hawthorne effect'. An alternative approach is to compare a large number of shift schedules that varies with respect to the scheduling recommendations and examine whether shift systems that fit with the ergonomic criteria's have less problems with self-reported sleep, recovery, health and performance. A drawback of such a cross-sectional design is the risk of confounding and that no causal inferences can be made.

Therefore, the aim of this study is to examine associations between ergonomic shift schedule criteria, separately and combined, for shift-specific and generic health and work functioning measures in a sample of 18 different company locations with 9 different shift schedules. It is hypothesized that shift schedule characteristics meeting the ergonomic criteria are associated with better sleep, recovery, health and performance.

2. Methods

2.1. Study sample and procedure

This cross-sectional study was conducted within the sampling frame of the 'Shift Your Work' study; a Dutch study about the effects of irregular night and shift work on health, work functioning and social life. A paper and web-based questionnaire was sent out to N = 902 shift workers of nine different industrial companies with semi- (excluding weekends) and full-continuous (including weekends) production locations in the Netherlands. The inclusion period lasted from June 2011 to November 2013. All shift workers were informed about the design and aim of the study by the Human Resource departments. The Medical Ethics Committee of the University Medical Center Groningen provided ethical clearance.

2.2. Measurements

2.2.1. Ergonomic shift schedule criteria

The shift schedules were provided by the companies per department or location (Appendix A). All but one shift schedule in our study were regular 3-shift systems, incorporating 3 shifts (morning, evening and night shifts) in a cyclic fashion operated by three or five teams. At one company, the shift schedule also comprised day shifts (4-shift system). Except for the semi-continuous shift systems, the shift schedules involved work during the weekends (Saturday and Sunday).

Based on the six ergonomic criteria presented in the introduction, eight shift schedule characteristics were constructed (Table 1). The criterion to provide adequate time to recover between two shifts was split into two characteristics: maximum number of days off before the night shift and the minimum of days off after the night shift. The night shift was chosen, because it is the most demanding shift and, in our study, most shift cycles ended with night shifts. A characteristic about the average hours worked per week was added. The cut-off values and reference categories for the shift schedule characteristics were based on scientific literature (Knauth and Hornberger, 2003) and experts in the field of ergonomic scheduling.

Shift-specific outcomes were assessed separately for the morning, evening and night shift, while generic outcome measures were assessed overall.

2.3. Shift-specific outcome measures

Sleep quality was assessed with the Karolinska Sleep Questionnaire (KSQ), containing seven items combined in two indices: Disturbed Sleep Index (DSI) and Awakenings complaints Index (AwI), with higher scores indicating worse sleep quality (Akerstedt et al., 2002, 2008). The response categories were: '1: Never, 2: Almost never, 3: Sometimes (once or more per month), 4: Mostly (once or more per week), and 5: Always (almost every day)'. The Disturbed Sleep Index was constructed by averaging scores on the items (i) difficulties falling asleep, (ii) disturbed/restless sleep, (iii) repeated awakenings, (iv) premature awakenings. The Awakenings complaints Index was constructed by averaging the scores on the