Effects on Sleep-Related Problems and Self-Reported Health After a Change of Shift Schedule

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This study prospectively examined the effects of a change of shift schedule from a fast forward-rotating schedule to a slowly backward-rotating one. The initial schedule had a forward rotation from mornings to afternoons to nights over 6 consecutive days, with 2 days on each shift followed by 4 days off before the next iteration of the cycle, whereas the new schedule had a slower backward rotation from mornings to nights to afternoons, with 3 days on a given shift followed by 3 days off before the next shift. Shift workers (n = 118) were compared with a reference group of daytime workers (n = 67) from the same manufacturing plant by means of questionnaires covering subjective health, sleep and fatigue, recovery ability, satisfaction with work hours, work–family interface, and job demands, control, and support. Data were collected 6 months before implementing the new schedule and at a follow-up 15 months later. As predicted, on most dimensions measured the shift workers displayed clear improvements from initially poorer scores than daytime workers, and the daytime workers displayed no improvements.

Keywords: shift work, intervention, follow-up, sleep, Karolinska Sleep Questionnaire

For reasons such as a globalized economy and increasing demands for service around the clock, a large and growing number of people are working irregular hours, including nights. Shift work, including night work, may have various negative physiological and psychosocial effects (Costa, 1997, 2003; Harrington, 1994). The most clearly demonstrated long-term health effects of shift work are gastrointestinal and cardiovascular dysfunctions and diseases (Harrington, 1994; Knutsson, 2003). However, the most commonly reported complaints among shift workers doing night work are sleepiness, fatigue, and insufficient sleep (Åkerstedt, 2003) associated with the interference that night work or rotating shift schedules can cause biological circadian rhythms, the normal sleep–wake cycle, and social and family lives (Knutsson, 2003; Monk, 2000a). Because the shift schedule design has been identified as a major factor related to adverse effects on health (Czeisler, Moore-Ede, & Coleman, 1982; Knauth & Hornberger, 2003), it is important to expand our knowledge of how shift schedules should be designed to minimize adverse health effects.

In this study, we assess the effects on sleep, self-reported health, and work–family interference of a change of shift schedule intended to reduce fatigue. Our aim is to show that a relatively simple modification of a shift schedule may have substantial beneficial effects on workers’ subjective health and wellbeing. To date, few studies have examined this matter (e.g., Barton, Folkard, Smith, & Poole, 1994; Czeisler et al., 1982; Härma et al., 2006), particularly using long-term follow-up, even though shift schedules are frequently changed in today’s working life. This longitudinal and controlled field intervention study addresses this gap in the scientific knowledge of shift schedules.
Shift Schedule Design

Shift schedules have several characteristics, such as direction of rotation, speed of changeover between various types of shifts, length of single shifts and shift cycles, and positioning of days off, all of which may influence the fatigue, performance, safety, and well-being of workers. The fundamental problem is that people’s basic 24-hr circadian rhythm—regulating, for example, hormones, core body temperature, and neurobehavioral functions—is generally rigid and cannot instantly adjust to the changing sleep–wake pattern of rotating shift work (Costa, 2003; Monk, 2000a). A homeostatic function is also involved, as the urge to sleep increases with time elapsed since awakening. Both circadian and homeostatic processes may thus be implicated in the sleep problems and sleepiness associated with rotating shift work (Åkerstedt, 1998, 2003; Åkerstedt & Folkard, 1996). Two main strategies for facilitating the adaptation to shift work can be recognized, both aiming to minimize continual disruption of circadian rhythms (Czeisler et al., 1982; Folkard, 1992; Monk, 2000a). The first main strategy aims to avoid continual disruptions of circadian rhythms by promoting the achievement of at least a partial circadian adaptation to night work through the scheduling of workers on permanent shifts of a specific type without rotation. However, this still implies an internal desynchronization of a number of physiological and neurobehavioral functions of unequal stability, with consequences for a number of essential functions such as sleep, gastrointestinal, alertness, and performance (Costa, 2003). A similarly purposed strategy is to use slowly rotating shift schedules, that is, with many consecutive shifts of the same type. Adaptation to night work is supposed to be facilitated by strategically timed bright light exposure during night shifts, but also, for example, by melatonin intake, physical exercise, and napping (Baehr, Fogg, & Eastman, 1999; Horowitz, Cade, Wolfe, & Czeisler, 2001; Monk, 2000b). However, a fully changed circadian rhythm is hard to achieve because of daytime light exposure, other external time cues, and the common adoption of a daytime social rhythm on days off (Waterhouse, Reilly, Atkinson, & Edwards, 2007). The consequence is that even with such scheduling, the workers are still essentially rotating between nocturnal and diurnal orientations (Monk, 2000b; Scott & LaDou, 1990).

A second and contrasting main type of strategy aims to avoid circadian adaptation and minimize disturbances of circadian physiological functions by rapidly rotating between various types of shifts, that is, with only a few consecutive night shifts at a time (Folkard, 1992; Knauth & Hornberger, 2003). However, various degrees of disturbed sleep–wake pattern and sleepiness problems still appear, particularly during morning and night shifts (Åkerstedt, 2003). Sleepiness during night shift is partly a result of working during the lowest point (nadir) of the circadian cycle at the end of the night. Sleepiness may also be caused by the homeostatic function because it is often the case that a long time has elapsed since the individuals have had their main sleep session. In addition, the main sleep session before a night shift often occurs during the day and will therefore be short both because of temporal proximity to the circadian peak (acrophase) in the afternoon and because of environmental disturbances (Åkerstedt, 2003; Åkerstedt & Folkard, 1996). Morning shifts are associated with difficulty awakening and sleepiness during the day. There is often a sleep deficit on the night before a morning shift, possibly resulting from difficulties advancing the bedtime because of circadian factors or social and family life factors (Folkard & Barton, 1993; Kecklund, Åkerstedt, & Lowden, 1997).

Direction of rotation is another characteristic of shift schedules. The direction can be forward (clockwise in the order morning–evening–night, i.e., phase delaying) or backward (counterclockwise in the order evening–morning–night, i.e., phase advancing). A forward rotation of shifts has often been claimed to be more favorable than a backward rotation because the internal circadian clock, when free running without various external time cues, is somewhat longer than 24 hr (Czeisler et al., 1982). However, field studies have lent little support to this assumption, and it has been suggested that the combination of rotation direction and the duration of the break between shifts is the most important consideration (Barton & Folkard, 1993; Barton et al., 1994; Tucker, Smith, Macdonald, & Folkard, 2000). One longitudinal study found that a backward-rotating schedule resulted in more fatigue and work–family conflict over time than did a forward-rotating schedule (van Amelsvoort, Jansen, Swaen, van den Brandt, & Kant, 2004). Work–family conflict may itself have various negative effects, such as increased work absenteeism (Jansen et al., 2006), job dissatisfaction, psychological distress, and marital dissatisfaction (Allen, Herst, Bruck, & Sutton, 2000).

Conclusions as to what kind of shift system is least detrimental or most preferable thus partially depend on, for example, the type of outcome studied (such as...
various health outcomes, alertness and performance, sleep disruption, social effects, and workers’ preferences), time perspective (acute or long-term effects), specific combinations of various shift schedule characteristics (continuity, speed and direction of rotation, and positioning of leisure time), and character of the work task to be performed. There is still ongoing debate about optimal shift scheduling. A fast forward-rotating schedule has often been suggested as a generally acceptable compromise that minimizes the physiological, psychological, and social detrimental effects (Folkard, 1992; Knauth & Hornberger, 2003; Kudielka, Buchtal, Uhde, & Wust, 2007) and is particularly beneficial for elderly workers (Hakola & Härmä, 2001; Härmä et al., 2006). However, with respect to sleep length, a meta-analytic review by Pilcher, Lambert, and Huffcutt (2000) concluded that slowly rotating systems would be the best general compromise.

Background and Hypotheses of the Present Study

This study was carried out at a manufacturing plant at which the workers had reported excessive fatigue to the Labor Inspectorate, providing the incentive for a change in shift schedule. The initial schedule was a continuous, fast forward-rotating 24-hr shift work schedule, with two shifts each on mornings, afternoons, and nights, followed by 4 days off. The new schedule was a slower backward-rotating schedule, with three shifts each on mornings, nights, and afternoons and 3 days off between each shift block. The main advantage identified with the new schedule was the lower number of consecutive shifts (three vs. six) before days off work, offering more frequent opportunities for recovery and resetting circadian phase shifts. The possible drawbacks of the new schedule were that the three consecutive morning shifts and night shifts could result in slightly greater degrees of phase advance and phase delay, respectively. However, the latter risk was assumed to be outweighed by the far better opportunities for resetting any circadian phase shifts on the intermediate days off and by the fact that the new schedule led to an 8-hr reduction in monthly working hours. Owing to the intermediate days off, we assumed that the consequences of rotation direction would probably be only marginal. We predicted.

Hypothesis 1. The shift workers would report fewer problems with recovery, sleep, and fatigue after the change to the new shift schedule.

Another feature of the new schedule was an increase in free weekend days and entire weekends, which was assumed to be favorable in terms of time-based work–family balance. Working at hours that are usually highly valued for leisure time, such as weekends and evenings, often implies more work–family conflict, particularly when shifts are fixed to such hours (Demerouti, Geurts, Bakker, & Euwema, 2004; Staines & Pleck, 1984). The predicted reduction of fatigue could also be assumed to be favorable for the strain-based work–family balance. We expected positive changes to occur primarily in the direction of work to family, but not obviously in the opposite direction, and predicted.

Hypothesis 2. The shift workers would report less work-to-family interference after the change to the new shift schedule.

Subjective health complaints have been associated with long-term stress (Ursin & Eriksen, 2001) and are common among shift workers (Costa, 2003; Scott & LaDou, 1990). Stress may cause sleep disturbances, and lack of recovery has also been suggested as a link between adverse work demands and subjective health complaints (Sluiter, de Croon, Meijman, & Frings-Dresen, 2003). Work–family conflict among shift workers has been shown to be associated with decreased subjective health (van Amelsvoort et al., 2004). Given that the change of schedule should lead to improved recovery ability and a better work–family balance, we predicted.

Hypothesis 3. The shift workers would report fewer subjective health problems after the change to the new shift schedule.

Increased fatigue and subjective health complaints may also be an effect of a high-strain work situation characterized by high demands and low control (Karasek et al., 1998). The health effects may even be worsened if there is also low job support (Stansfeld & Candy, 2006). A change in job strain can thus be assumed to affect well-being. At the work site for this study, however, there were no plans to change the work content or organization, which is why we expected no major changes in these dimensions; hence, we also predicted.

Hypothesis 4. The shift workers’ ratings of job demands, job control, or job support after the change to the new shift schedule would not
change to an extent that would be significantly detectable.

Method

Procedures

The study was initiated by a request from the company’s management to the research group at the Occupational and Environmental Medicine Clinic at Lund University Hospital for information about health effects related to working hours and shift schedules. This led to an agreement to study the psychosocial workload, self-reported health, sleep, and fatigue of all employees at the work site as a basis for a planned change in shift schedules and a later follow-up study. Two weeks before the baseline examination, all employees were invited to a 1-hr lecture on various health aspects of shift work. They were also informed of the purpose and procedures of the study.

A few weeks after the baseline examination, the research group reported the essential group results to the company management and the labor union representatives and provided general advice about the health aspects of shift scheduling. Negotiations began between the company management and the labor union representatives, resulting in the decision to replace the shift schedule with a new one. The research team was not involved in the negotiations or even present at the company during the negotiation period. The initial schedule was a continuous, fast forward-rotating 24-hr shift work schedule, which was converted to a slower backward-rotating schedule. The initial schedule had the pattern M M A A N N - - - - , where M = morning, A = afternoon, N = night, and - = day off; the new schedule was M M M - - - N N N - - - A A A - - - . This change led to fewer shifts in total, so each worker had to do an additional 8 hr of work per month on another shift team. Still, the new schedule resulted, on average, in an 8-hr reduction in monthly working hours, with a corresponding reduction in salary. Both shift schedules were continuous and regular, and shifts lasted no more than 8 hr. The shift change hours, which remained unchanged, were 6 a.m., 2 p.m., and 10 p.m.

The new schedule was implemented 6 months after the baseline measurement of subjective health, and the follow-up took place 15 months later. The questionnaires were filled in at the work site on a daytime shift under supervision of the research group.

Participants

All 369 available employees were invited to participate, and 283 of them (77%) responded to the baseline questionnaire. Of those, 186 were employed in blue-collar 8-hr shift work, and 97 were employed in blue-collar or white-collar 8-hr daytime work 5 days a week. At follow-up, 118 shift workers (98 men and 20 women, mean age = 44.6 years, SD = 9.7) and 67 daytime workers (56 men and 11 women, mean age = 45.8, SD = 9.6 years), the latter constituting a control group, were still available and participated in the second round.

Measures

Sleep and fatigue. We used three measures to assess this dimension. Sleep disturbances and fatigue over the past 6 months were assessed using the Karolinska Sleep Questionnaire, used in several similar studies (Härmä, Tenkanen, Sjoblom, Alikoski, & Heinsalmi, 1998; Kecklund & Åkerstedt, 1992). The Karolinska Sleep Questionnaire consists of 15 items rated on a 5-point scale with the following response scores or alternatives: never (0), rarely (a few times; 1), sometimes (some/a few times a month; 2), most of the time (some/a few times a week; 3), and always (every day, more or less; 4). Three indices were calculated from 12 of the 15 items: awakening problems (hard to wake up, not recovered at awakening, and exhaustion at awakening), daytime sleepiness (sleepiness during work/leisure, irritability/tiredness in the eyes, involuntarily falling asleep at work, involuntarily falling asleep during leisure time, and struggling to stay awake), and sleep disturbances (hard to fall asleep, repeated awakenings with difficulties falling asleep again, premature awakening, and disturbed sleep).

Occupational fatigue was assessed using the Swedish Occupational Fatigue Inventory, encompassing five dimensions of physical and mental fatigue after a typical workday: physical exertion, physical discomfort, lack of motivation, sleepiness, and lack of energy (Åhsberg, 2000). The Swedish Occupational Fatigue Inventory has previously been used in shift work studies (Åhsberg, Kecklund, Åkerstedt, & Gamberale, 2000) and consists of five subscales of four items, each rated on a 7-point scale (range = 1–7) with two verbal anchors at the extremes, that is, not at all (1) and to a very high degree (7). Recovery ability was assessed using a single item concerning the number of days needed for “recovery after a work week,” responded to on a 5-point scale.
(range = 1–5) with a different verbal label for each item (i.e., less than 1 day, 1 day, 2–3 days, longer, and do not feel recovered; Czeisler et al., 1982). The scale was dichotomized by the need for more than 1 day for recovery because in our experience, the majority of the general population reports a need for 1 day of recovery or less.

Work–family interference. Work–family interference was measured bidirectionally, that is, taking into consideration the influences both of work on the family and of the family on work (Frone, Russell, & Cooper, 1992). Eight items were responded to on a 4-point scale (range = 0–3), as follows: not at all (0), to some degree (1), to a large degree (2), and does not apply (3; recoded to 0). Four of the items constituted a work-to-family interference index, and the remaining four items constituted a family-to-work interference index. In each dimension, two items covered time-based interference, and the other two covered strain-based interference (Netemeyer, Boles, & McMurrian, 1996).

Subjective health. Individuals’ own appraisal of their general health has been shown to be a good predictor of morbidity and mortality (Idler, Russell, & Davis, 2000). We used three measures to assess this construct.

Self-Rated Health was used to assess the individual’s global experience of his or her health status. This measure has been widely used in epidemiological research and has displayed good correlations with health determinants (Eriksson, Uden, & Elofsson, 2001). It is a single item concerned with how the person feels right now, physically and psychologically, with respect to health and well-being (Bjorner et al., 1996). The response is chosen from a 7-point scale (range = 1–7) with verbal anchors at the extremes, that is, very bad, couldn’t feel worse (1) and very good, couldn’t feel better (7).

The Symptom Checklist–35 (SCL–35) is an abbreviated version of the Symptom Checklist–90 (Derogatis, 1992), which has been widely used as a measure of psychological distress. It includes 35 items from the full 90-item SCL, making up the three Somatization, Depression, and Anxiety subscales, expected to reflect symptoms common in long-term stress. The items are rated on a 5-point distress scale (range = 0–4), with the verbal labels not at all (0), a little bit (1), moderately (2), quite a bit (3), and extremely (4).

The Lund Subjective Health Complaints inventory (Österberg, Persson, Karlson, Carlsson Eek, & Ørbaek, 2007) is similar to the Ursin Health Inventory/Subjective Health Complaints scale (Eriksen, Ihlebaek, & Ursin, 1999) and addresses the frequency of common mental and physical health complaints over the preceding 30 days. The 29 items are responded to on a 5-point scale (range = 0–4), reflecting how frequently a symptom has been encountered over the preceding 30 days: never (0), rarely (a few times; 1), sometimes (once or twice a week; 2), most of the time (several times a week; 3), and always (every day, more or less; 4).

Psychosocial workload. This was assessed by means of the Job Content Questionnaire (Karasek et al., 1998), using the dimensions of job demands, job control, and social support at work, representing one of the leading models in research into work stress and health (Stansfeld & Candy, 2006). The Job Content Questionnaire consists of 29 items rated on a 4-point agreement scale (range = 1–4) with the labels do not agree at all (1), do not agree (2), agree (3), and agree completely (4).

Statistical Analysis

We used the linear mixed-models module in SPSS 13.0 to specify a repeated measures model for baseline and follow-up data, using the restricted maximum likelihood method. Group (shift workers or referents) and time (baseline or follow-up) were forced-in variables, and age and gender were a priori introduced as possible effect modifiers in the model and kept if the predictive value of each variable when included in the model was $p \leq .20$ (Maldonado & Greenland, 1993; Mickey & Greenland, 1989). The prime interest in the overall analysis, however, was not the main effects but rather the Group $\times$ Time interaction, reflecting possible differential development in group ratings from baseline to follow-up. Because post hoc testing of interaction effects was not possible in the SPSS linear mixed-models module, we created a new four-group variable for within-group analyses, replacing the two variables group and time, as follows: (a) daytime workers at Time 1 (T1), (b) shift workers at T1, (c) daytime workers at Time 2 (T2), and (d) shift workers at T2.

We computed standardized effect sizes (ESs) of the change from baseline to follow-up as Cohen’s $d$, that is, the mean difference for each group from T1 to T2, divided by the average standard deviation from the two measures of each group separately (Dunlop, Cortina, Vaslow, & Burke, 1996). The ES thus reflects the degree of change in terms of standard deviation.

For the dichotomized single-item variable capturing recovery, we analyzed within-group change from
baseline to follow-up using the McNemar test, whereas we analyzed between-groups difference at baseline using Fisher’s exact test. In all analyses, we used a basic alpha level of $p \leq .05$, which was further adjusted for multiple comparisons using the Bonferroni–Holm test (Hochberg & Tamhane, 1987) within the set of variables used to answer each of Hypotheses 1–4. Statistical significance was inferred only when the $p$ value fell below the adjusted alpha level.

**Ethics**

Participation was voluntary, and the company management had no knowledge of the identity of participants and nonparticipants. The study was approved by the Ethics Committee of the Medical Faculty, Lund University, number LU 151–01.

**Results**

**Intervention Effects**

All questionnaire ratings obtained at baseline and follow-up are presented in Table 1.

**Hypothesis 1.** Ratings indicated different patterns of development in the two groups from baseline to follow-up, as indicated by statistically significant interaction effects between time and group for the measures of awakening, sleepiness problems, and sleep disturbances of the Karolinska Sleep Questionnaire and for occupational fatigue as measured with the Lack of Energy, Lack of Motivation, and Sleepiness scales of the Swedish Occupational Fatigue Inventory. At follow-up, in comparison with baseline, the shift workers displayed moderately reduced problems across all these measures ($p \leq .005$, ES range $= 0.26–0.39$). The daytime workers displayed no improvement on the same measures and had a partly increased degree of occupational fatigue, as indicated by worsened scores on the Swedish Occupational Fatigue Inventory Lack of Motivation scale ($p = .003$, ES $= 0.41$). On the separate dichotomized single item of time needed for recovery (data not shown in Table 1), 57% of the shift workers reported a need for at least 2 days of recovery after a work week with the initial schedule, whereas only 21% reported the same need after the schedule change ($p < .001$; statistically significant after Bonferroni–Holm correction). There was no significant change among the daytime workers; 21% at T1 and 24% at T2 needed at least 2 days of recovery after a work week ($p = .80$). Thus, Hypothesis 1 was supported.

**Hypothesis 2.** The shift worker group displayed a reduced work-to-family interference ($p < .001$, ES $= 0.48$) at follow-up, which was not observed in the daytime worker group (Time × Group interaction, $p < .001$). Family-to-work interference did not develop differentially across groups (Time × Group interaction, $p = .78$). In essence, Hypothesis 2 was supported.

**Hypothesis 3.** Ratings indicated different patterns of development in the groups from baseline to follow-up, as indicated by statistically significant interaction effects between time and group for the measures of self-rated health and mental distress, that is, Lund Subjective Health Complaints, Self-Rated Health, and SCL-35 (Time × Group interaction, $p = <.0003–.017$), except for the SCL-35 Anxiety subscale (Time × Group interaction, $p = .28$). Within-group comparisons indicated that the shift worker group had slightly to moderately improved subjective health and well-being at follow-up compared with baseline ($p$ range $= <.001–.02$, ES range $= 0.17–0.41$), whereas no change was seen in the daytime worker group ($p$ range $= .33–.80$). Thus, Hypothesis 3 was supported.

**Hypothesis 4.** Job Content Questionnaire ratings of job support indicated a very slight improvement in the shift worker group only ($p = .002$, ES $= 0.07$; Time × Group interaction, $p = .001$). Moreover, only the daytime workers displayed moderately reduced job control at follow-up ($p = .011$, ES $= 0.30$; Time × Group interaction, $p = .017$). A significantly different development across groups from baseline to follow-up was not seen in the Job Content Questionnaire job demands ratings. Thus, Hypothesis 4 was only partly supported.

**Dropout Analysis**

There were no significant differential dropout rates with respect to group (37% of shift workers and 31% of daytime workers dropped out, $p = .36$) or gender (24% of women and 36% of men dropped out, $p = .16$) and no overall age differences between continuous participants and those who dropped out. Nor were there any differences in either group in any of the baseline out-
## Table 1

**Mixed-Models Analysis of Outcomes Measured Before (T1) and After (T2) a Change of Shift Schedule in Shift and Daytime Workers**

<table>
<thead>
<tr>
<th>Dimensions, scales, and variables</th>
<th>Shift workers (n = 118), T1–T2</th>
<th>Daytime workers (n = 67), T1–T2</th>
<th>Interaction Time × Group p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean difference</td>
<td>95% CI</td>
<td>p</td>
</tr>
<tr>
<td><strong>Sleep and fatigue</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KSQ awakening problems&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>-.30</td>
<td>-.43, -.17</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>KSQ sleepiness problems</td>
<td>-.32</td>
<td>-.46, -.19</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>KSQ sleep disturbance&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.21</td>
<td>-.33, -.10</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SOFI-20 Lack of Energy&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.55</td>
<td>-.81, -.29</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SOFI-20 Physical Exertion&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.11</td>
<td>-.30, -.09</td>
<td>.280</td>
</tr>
<tr>
<td>SOFI-20 Physical Discomfort&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>-.43</td>
<td>-.64, -.21</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SOFI-20 Lack of Motivation</td>
<td>-.32</td>
<td>-.54, -.09</td>
<td>.008&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>SOFI-20 Sleepiness&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.58</td>
<td>-.81, -.35</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td><strong>Work–family interference</strong></td>
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<tr>
<td>Work to family&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.19</td>
<td>-.27, -.12</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Family to work&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.08</td>
<td>-.15, .00</td>
<td>.041</td>
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<td><strong>Subjective health</strong></td>
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<tr>
<td>LSHC&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.14</td>
<td>-.22, -.06</td>
<td>.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>SRH-7&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>.60</td>
<td>.38, .83</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>SCL-35 Somatization&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>-.15</td>
<td>-.24, -.07</td>
<td>&lt;.001&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>SCL-35 Anxiety&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.12</td>
<td>-.20, -.05</td>
<td>.002&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>SCL-35 Depression&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.14</td>
<td>-.23, -.06</td>
<td>.001&lt;sup&gt;c&lt;/sup&gt;</td>
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<td><strong>Psychosocial workload</strong></td>
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<tr>
<td>JQC Job Demands&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.05</td>
<td>-.11, .00</td>
<td>.056</td>
</tr>
<tr>
<td>JQC Job Control&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.03</td>
<td>-.06, .11</td>
<td>.545</td>
</tr>
<tr>
<td>JQC Job Support&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.13</td>
<td>.05, .22</td>
<td>.002&lt;sup&gt;c&lt;/sup&gt;</td>
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</table>

**Note.** Measurements were made 6 months before (Time 1, or T1) and 15 months after (Time 2, or T2) implementing a new shift schedule. Mean difference scores and 95% confidence intervals (CIs) are based on estimated marginal means adjusted for age and gender when these are included as covariates in the model (i.e., when p < .20). A negative mean difference score indicates an improvement, except for SRH-7 and the JQC Job Control and Job Support scales, on which a positive mean difference score is favorable. For the Time × Group interaction term, the p values are from the repeated measures analysis using mixed models, whereas the p values for changes within each group from T1 to T2 are the results of post hoc analyses with a computed interaction variable in mixed models. The effect size (ES) is reported as Cohen’s d and indicates the magnitude of change from T1 to T2 in the two groups, computed as the mean difference within groups from T1 to T2, divided by the average standard deviation of the two time points within each group, separately. KSQ = Karolinska Sleep Questionnaire (scale range = 1–5); SOFI = Swedish Occupational Fatigue Inventory (scale range = 1–6); LSHC = Lund Subjective Health Complaints (scale range = 1–5); SRH-7 = Self-Rated Health (scale range = 1–7); SCL-35 = Symptom Checklist–35 (scale range = 0–4); JQC = Job Content Questionnaire (scale range = 1–4).

*Age was included as a covariate. Gender was included as a covariate. Statistically significant value after correction for multiple comparisons within each dimension using the Bonferroni–Holm test (Hochberg & Tamhane, 1987).*

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**EFFECTS ON SLEEP OF A CHANGE OF SHIFT SCHEDULE**
come measures between those who dropped out and those who continued to participate. However, the shift workers who dropped out were somewhat younger than those who continued to participate ($M = 39.9$, $SD = 14.5$ years, vs. $M = 44.6$, $SD = 9.7$ years, respectively), for which reason we analyzed whether any of the outcome measures were correlated with age in the latter group. The only correlations found were with the Swedish Occupational Fatigue Inventory variables for physical exertion ($r = .23$, $p = .003$) and physical discomfort ($r = .23$, $p = .003$) and with the SCL-35 Somatization subscale ($r = .22$, $p = .003$), indicating poorer scores with increasing age.

**Initial Characteristics of the Shift-Working Group**

Because some of the daytime workers had work tasks not completely comparable to those of the shift workers, we made an initial check of the comparability of these groups to an external reference group of white-collar workers ($n = 355$) previously examined using similar methodology. The daytime workers proved quite similar to this group in the measures of subjective health available to both groups (Self-Rated Health, Lund Subjective Health Complaints, and SCL-35), whereas the shift workers differed from the external reference group in a way similar to how they differed from the daytime workers.

**Descriptive Statistics**

Tables 2 and 3 present detailed descriptive raw data and zero-order correlations between scales for shift workers and daytime workers, together with the internal consistency values for the scales; baseline data are shown in Table 2 and follow-up data in Table 3.

**Discussion**

The main result of the change of shift schedule was a clear pattern of improvement on the initially negative reports in the dimensions of sleep, fatigue and recovery, subjective health, and work–family interference, and no improvements were found in the daytime working group. All these findings were in line with Hypotheses 1–3.

Although the changes occurred in the predicted direction, there are still uncertainties about the mechanisms of the positive effects. This is partly because the change of schedule involved changes in several components simultaneously, such as fewer consecutive shifts, slower speed of changeover between various types of shifts, more days off in total, a changed positioning of the days off, and a changed rotation direction. Even if the relative importance of each of these changes cannot be evaluated individually, we discuss some possible mechanisms.

Concerning Hypothesis 1, the improvements in recovery ability, sleep, and fatigue may possibly, because of the shorter shift blocks (three consecutive shifts as compared with the previous six consecutive shifts), result in less accumulated fatigue before having an opportunity for recovery. The increase in the total amount of leisure time may also have contributed to these improvements by offering more time for recovery. The slower speed of changeover, that is, the amount of leisure time between shifts of various types, may also have contributed to buffer any potentially negative effects of the backward-rotating schedule that replaced the previous forward-rotating schedule (Czeisler et al., 1982; Tucker et al., 2000).

In the context of the present multidimensional change of shift schedule, the results do not support backward rotation’s having negative effects compared with forward rotation.

The second supported hypothesis, that the shift workers would report a better work–family balance after the change of schedule, was partly based on the changed positioning of days off, which was believed to be favorable from a social and family perspective because of its likelihood of reducing time-based work-to-family interference. It was also partly based on the supported assumption that fatigue would be reduced after the change of schedule, which could in turn lead to reduced strain-based work-to-family interference (Jansen, Kant, Kristensen, & Nijhuis, 2003). The scale had a poor internal consistency, which is why the results may originate more from some items than from others. Still, the findings contribute to previous knowledge gained by the prospective study of work–family balance and as an outcome of a work organization intervention (Allen et al., 2000). The findings support suggestions of possible facilitation from work roles to family roles (van Steenbergen, Ellemers, & Mooijaart, 2007). We expected no obvious change in influence from family to work, and none was found.

The third supported hypothesis, that the shift workers would report improvements in subjective health after the change of schedule, was based on the assumption that subjective health complaints are related to the total wear and tear on the individual from long-term stress and lack of recovery. Because work–family balance, sleep, and recovery were reported to have improved and
Table 2
Raw Scores and Zero-Order Correlations at Baseline Among Shift Workers and Daytime Workers, With Measures of Internal Consistency of the Scales

<table>
<thead>
<tr>
<th>Variable</th>
<th>Shift workers (n = 188)</th>
<th>Daytime workers (n = 67)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
</tr>
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<tr>
<td>1. Age</td>
<td>44.59 9.72</td>
<td>45.83 9.62</td>
<td>-</td>
<td>.08</td>
<td>.24</td>
<td>.19</td>
<td>- .03</td>
<td>.27</td>
<td>.09</td>
<td>.04</td>
<td>-.19</td>
<td>.15</td>
<td>-.04</td>
<td>.14</td>
<td>.17</td>
<td>.12</td>
<td>.04</td>
<td>-.07</td>
<td>-.03</td>
<td>.04</td>
<td>-.24</td>
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<td>2. KSQ awakening</td>
<td>2.71 .86</td>
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<td>- .22</td>
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<td>.51</td>
<td>.56</td>
<td>.47</td>
<td>.30</td>
<td>.33</td>
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<td>.54</td>
<td>-.52</td>
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<td>.52</td>
<td>.52</td>
<td>.46</td>
<td>.17</td>
<td>-.16</td>
<td>.43</td>
<td>.39</td>
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<td>3. KSQ sleepiness</td>
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<td>2.04 .55</td>
<td>.03</td>
<td>.50</td>
<td>(.79)</td>
<td>.51</td>
<td>.45</td>
<td>.43</td>
<td>.39</td>
<td>.22</td>
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<td>.59</td>
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<td>.35</td>
<td>.46</td>
<td>.24</td>
<td>.07</td>
<td>-.28</td>
<td>.28</td>
<td>.13</td>
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<tr>
<td>4. KSQ disturbed sleep</td>
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<td>2.46 .91</td>
<td>-.01</td>
<td>.61</td>
<td>.52</td>
<td>(.85)</td>
<td>.58</td>
<td>.56</td>
<td>.56</td>
<td>.40</td>
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<td>.71</td>
<td>-.36</td>
<td>.58</td>
<td>.45</td>
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<td>.15</td>
<td>-.13</td>
<td>-.02</td>
<td>.07</td>
<td>.12</td>
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<td>5. SOFI-20 Lack of Energy</td>
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<td>1.45 1.46</td>
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<td>.56</td>
<td>.60</td>
<td>.58</td>
<td>(.89)</td>
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<td>.74</td>
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<td>.74</td>
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<td>.53</td>
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<td>-.09</td>
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<td>.08</td>
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<td>6. SOFI-20 Physical Exertion</td>
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<td>.50 .072</td>
<td>.15</td>
<td>.35</td>
<td>.49</td>
<td>.47</td>
<td>.67</td>
<td>(.92)</td>
<td>.59</td>
<td>.41</td>
<td>.45</td>
<td>.54</td>
<td>-.40</td>
<td>.66</td>
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<td>.17</td>
<td>-.10</td>
<td>.03</td>
<td>.17</td>
<td>.06</td>
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<td>7. SOFI-20 Physical Discomfort</td>
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<td>1.28 1.46</td>
<td>.13</td>
<td>.41</td>
<td>.53</td>
<td>.50</td>
<td>.79</td>
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<td>(.77)</td>
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<td>.51</td>
<td>.66</td>
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<td>.31</td>
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<td>.22</td>
<td>-.25</td>
<td>-.06</td>
<td>.18</td>
<td>.01</td>
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<td>8. SOFI-20 Lack of Motivation</td>
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<td>0.61 0.87</td>
<td>.00</td>
<td>.52</td>
<td>.49</td>
<td>.56</td>
<td>.73</td>
<td>.54</td>
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<td>(.88)</td>
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<td>.44</td>
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<td>.37</td>
<td>.64</td>
<td>.58</td>
<td>.25</td>
<td>-.21</td>
<td>-.09</td>
<td>.44</td>
<td>.03</td>
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<td>1.29 1.16</td>
<td>.01</td>
<td>.59</td>
<td>.57</td>
<td>.60</td>
<td>.83</td>
<td>.63</td>
<td>.71</td>
<td>.76</td>
<td>(.88)</td>
<td>.37</td>
<td>-.30</td>
<td>.44</td>
<td>.37</td>
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<td>.11</td>
<td>-.12</td>
<td>-.12</td>
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<td>.06</td>
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<td>10. LSHC</td>
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<td>1.76 0.47</td>
<td>.11</td>
<td>.54</td>
<td>.71</td>
<td>.66</td>
<td>.73</td>
<td>.61</td>
<td>.74</td>
<td>.62</td>
<td>.75</td>
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<td>-.47</td>
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<td>.30</td>
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<td>-.07</td>
<td>.26</td>
<td>.22</td>
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<td>11. SRH-7</td>
<td>4.77 1.45</td>
<td>5.04 1.16</td>
<td>-.15</td>
<td>-.41</td>
<td>-.53</td>
<td>-.40</td>
<td>-.58</td>
<td>-.45</td>
<td>-.54</td>
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<td>-.45</td>
<td>-.43</td>
<td>.04</td>
<td>.21</td>
<td>-.24</td>
<td>-.26</td>
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<td>12. SCL-35 Somatization</td>
<td>.71 0.64</td>
<td>.48 0.46</td>
<td>.17</td>
<td>.42</td>
<td>.57</td>
<td>.56</td>
<td>.75</td>
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<td>(.89)</td>
<td>.46</td>
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<td>-.17</td>
<td>.08</td>
<td>.20</td>
<td>.05</td>
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<td>13. SCL-35 Depression</td>
<td>.64 0.64</td>
<td>.54 0.60</td>
<td>-.02</td>
<td>.53</td>
<td>.52</td>
<td>.55</td>
<td>.69</td>
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<td>.71</td>
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<td>.88</td>
<td>.30</td>
<td>-.16</td>
<td>-.06</td>
<td>.40</td>
<td>.32</td>
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<td>14. SCL-35 Anxiety</td>
<td>.57 0.61</td>
<td>.56 0.55</td>
<td>.03</td>
<td>.46</td>
<td>.57</td>
<td>.53</td>
<td>.70</td>
<td>.50</td>
<td>.69</td>
<td>.69</td>
<td>.70</td>
<td>.77</td>
<td>-.55</td>
<td>.81</td>
<td>.89</td>
<td>(.90)</td>
<td>.37</td>
<td>-.11</td>
<td>-.08</td>
<td>.44</td>
<td>.35</td>
</tr>
<tr>
<td>15. JCQ Job Demands</td>
<td>2.43 0.30</td>
<td>2.53 0.38</td>
<td>.02</td>
<td>.17</td>
<td>.23</td>
<td>.19</td>
<td>.40</td>
<td>.36</td>
<td>.23</td>
<td>.21</td>
<td>.30</td>
<td>.24</td>
<td>-.21</td>
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<td>.15</td>
<td>.52</td>
<td>.03</td>
<td>-.20</td>
<td>.44</td>
<td>.26</td>
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<td>16. JCQ Job Control</td>
<td>2.62 0.42</td>
<td>2.97 0.35</td>
<td>-.04</td>
<td>-.12</td>
<td>-.19</td>
<td>-.19</td>
<td>-.23</td>
<td>-.09</td>
<td>-.29</td>
<td>-.22</td>
<td>-.31</td>
<td>-.21</td>
<td>.18</td>
<td>-.19</td>
<td>-.17</td>
<td>-.19</td>
<td>.05</td>
<td>(.58)</td>
<td>.24</td>
<td>.08</td>
<td>.30</td>
</tr>
<tr>
<td>17. JCQ Job Support</td>
<td>2.84 0.48</td>
<td>2.88 0.39</td>
<td>-.12</td>
<td>-.14</td>
<td>-.05</td>
<td>-.18</td>
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<td>-.15</td>
<td>-.29</td>
<td>-.25</td>
<td>-.33</td>
<td>-.11</td>
<td>.08</td>
<td>-.16</td>
<td>-.19</td>
<td>-.17</td>
<td>.05</td>
<td>(.79)</td>
<td>-.26</td>
<td>-.09</td>
<td></td>
</tr>
<tr>
<td>18. Work-to-family</td>
<td>.49 0.41</td>
<td>.43 0.39</td>
<td>-.11</td>
<td>.48</td>
<td>.54</td>
<td>.29</td>
<td>.60</td>
<td>.47</td>
<td>.40</td>
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<td>.60</td>
<td>.47</td>
<td>-.38</td>
<td>.52</td>
<td>.55</td>
<td>.54</td>
<td>.20</td>
<td>-.17</td>
<td>-.19</td>
<td>(.54)</td>
<td>.28</td>
</tr>
<tr>
<td>19. Family-to-work</td>
<td>.30 0.37</td>
<td>.38 0.45</td>
<td>-.11</td>
<td>.15</td>
<td>.21</td>
<td>.18</td>
<td>.09</td>
<td>.20</td>
<td>.17</td>
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<td>.22</td>
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<td>.22</td>
<td>.25</td>
<td>.29</td>
<td>-.08</td>
<td>.08</td>
<td>.22</td>
<td>.33</td>
<td>(.75)</td>
</tr>
</tbody>
</table>

Note. Measures of internal consistency appear in parentheses along the diagonal. Correlations for shift workers appear below the diagonal; those for daytime workers appear above the diagonal. KSQ = Karolinska Sleep Questionnaire (scale range = 1–5); SOFI = Swedish Occupational Fatigue Inventory (scale range = 1–6); LSHC = Lund Subjective Health Complaints (scale range = 1–5); SRH-7 = Self-Rated Health (scale range = 1–7); SCL-35 = Symptom Checklist–35 (scale range = 0–4); JCQ = Job Content Questionnaire (scale range = 1–4).
### Table 3
Raw Scores and Zero-Order Correlations at Follow-up Among Shift Workers and Daytime Workers With Measures of Internal Consistency of the Scales

| Variable | Shift workers (n = 118) | Daytime workers (n = 67) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 1. Age   | 46.08 9.54              | 47.73 9.80              | — | .00 | .10 | .18 | -.17 | -.16 | -.04 | -.03 | .05 | .08 | .18 | .01 | .02 | -.14 | .08 | -.19 | -.24 | -.14 |
| 2. KSQ awakening | 2.41 0.71              | 2.32 0.78              | -.08 | (.60) | .60 | .55 | .45 | .25 | .46 | .41 | .38 | .53 | -.46 | .43 | .46 | .49 | .35 | -.15 | -.28 | .34 | .33 |
| 3. KSQ sleepiness | 2.08 0.62              | 2.07 0.62              | .15 | .51 | (.76) | .43 | .35 | .16 | .37 | .37 | .35 | .54 | -.33 | .39 | .25 | .28 | .30 | -.13 | -.20 | .22 | .29 |
| 4. SOFI-20 Lack of Energy | 1.47 1.32              | 1.66 1.41              | .16 | .52 | .53 | .46 | (.89) | .61 | .77 | .64 | .73 | .44 | -.55 | .64 | .60 | .58 | .38 | -.16 | -.14 | .42 | .38 |
| 5. SOFI-20 Physical Exertion | 0.85 0.99              | 0.82 1.39              | .21 | .27 | .42 | .32 | .63 | (.91) | .65 | .48 | .62 | .45 | -.07 | .44 | .23 | .26 | .01 | -.10 | -.04 | .02 | .07 |
| 6. SCL-35 Somatization | 0.58 0.54              | 0.52 0.50              | .23 | .50 | .55 | .45 | .75 | .66 | .82 | .59 | .63 | .77 | -.57 | (.87) | .58 | .68 | .17 | -.07 | -.12 | .26 | .46 |
| 7. SCL-35 Depression | 0.50 0.56              | 0.58 0.63              | .07 | .52 | .46 | .46 | .64 | .41 | .61 | .59 | .60 | .69 | -.44 | .73 | (.92) | .88 | .45 | -.07 | -.20 | .44 | .36 |
| 8. LSHC | 1.47 0.55              | 1.88 0.99              | .22 | .56 | .64 | .65 | .65 | .52 | .67 | .50 | .67 | (.94) | -.15 | .25 | .20 | .24 | .27 | -.02 | -.02 | .13 | .10 |
| 9. JCQ Job Demands | 2.38 0.27              | 2.57 0.39              | -.05 | .24 | .16 | .12 | .27 | .24 | .12 | .13 | .23 | .13 | -.06 | .14 | .12 | .20 | (.43) | .16 | -.10 | .66 | .26 |
| 10. JCQ Job Control | 2.64 0.44              | 2.83 0.48              | -.06 | .14 | -.23 | .11 | -.26 | -.08 | -.19 | .33 | -.27 | -.21 | -.17 | -.28 | -.25 | .04 | (.54) | .37 | -.08 | .20 | .20 |
| 11. Work to family | 0.30 0.35              | 0.47 0.40              | -.11 | .39 | .29 | .34 | .22 | .25 | .25 | .28 | .29 | .22 | -.19 | .28 | .36 | .38 | .24 | -.23 | -.12 | (.57) | .36 |
| 12. Family to work | 0.22 0.34              | 0.31 0.42              | -.04 | .34 | .30 | .21 | .13 | .10 | .11 | .15 | .15 | .31 | -.21 | .31 | .35 | .29 | .04 | -.09 | -.02 | .36 | (.78) |

Note. Measures of internal consistency appear in parentheses along the diagonal. Correlations for shift workers appear below the diagonal; those for daytime workers appear above the diagonal. KSQ = Karolinska Sleep Questionnaire (scale range = 1–5); SOFI = Swedish Occupational Fatigue Inventory (scale range = 1–6); LSHC = Lund Subjective Health Complaints (scale range = 1–5); SRH-7 = Self-Rated Health (scale range = 1–7); SCL-35 = Symptom Checklist–35 (scale range = 0–4); JCQ = Job Content Questionnaire (scale range = 1–4).
fatigue to have been reduced, the improved subjective health is in line with these assumptions.

Our fourth hypothesis was that there would be no significantly detectable changes in reports of job demands, job control, and job support because no changes in these respects were planned; this was not fully supported because there was a slight increase in reported job support among the shift workers after the change of schedule. One could speculate that the improvements in mood and alertness may have had positive effects on the workers’ interaction and cooperation with each other and with their supervisors, resulting in a work climate perceived as more supportive. It is also conceivable that the workers’ experience of having succeeded in influencing the design of the new schedule may have contributed to this improvement. Another observation was a slight decrease in job control among daytime workers. We later learned from company management that there had been a slight reduction in the number of daytime administrative staff, which may explain this change.

Methodological Discussion

This study has several strengths. It was controlled and longitudinal and involved assessment before and after intervention of a number of measures expected to be influenced by the characteristics of shift schedules. The baseline assessment was carried out before a decision to change the schedule had been reached, and well before the change was implemented. Thus, the baseline assessment did not take place as part of an ongoing change process, which could otherwise have influenced self-report ratings through the attitudes associated with such a process. The postchange assessment was carried out more than a year after the implementation, when initial reactions had faded away and adaptation to the new schedule could be presumed to have occurred. In addition, the changes occurred largely as predicted, and there were only marginal changes where we had predicted no changes. For these reasons, the risk that the positive effects could be temporary and would change with time, for example, reflecting a Hawthorne-like effect, or the effect of having been paid attention to, seems small.

One challenge in field intervention studies is the choice and availability of an adequate control group. Because all shift workers changed their schedule in the same way and at the same time, a control group in the shift worker group was not an option. We find the use of a daytime worker group to be justified because the aim of the study was not to compare the degree of health problems associated with shift work with those associated with daytime work, but to examine the changes resulting from the schedule intervention. The use of a control group from the same work site had the advantage that both groups shared a number of characteristics associated with the company and work site, such as cultural or policy factors or overarching economic decisions with consequences for the employees. Most important, we did not expect the actual control group to be involved in any major change in working conditions during the study period. The control group also displayed normal levels of subjective health complaints compared with an external reference group.

Another methodological issue to be considered is the dropout rate between the initial examination and the follow-up, which could potentially have biased the results those who dropped out differed systematically from the participants. However, the only difference found between dropouts and participants was that the dropouts were somewhat younger. As most variables were found not to correlate with age, the age difference is not likely to have had any significant influence on the results. Thus, the results are probably generally valid. However, we have no data at all regarding the 23% of shift workers at the work site who did not participate in even the initial examination, and hence some degree of caution is warranted when generalizing the results. It does not, however, seem plausible that the positive effects among the shift workers following the change of shift schedule could be interpreted as a regression toward the mean, which could have been a risk had there been a selection among the shift workers, but not the daytime workers, of those who were worst off. The satisfactory baseline participation rate and the dropout analyses do not indicate such a selection bias.

Another potential threat to the validity of our conclusions might be any other organizational change to which the shift and daytime workers may have been differentially exposed. However, except for the slight reduction in the number of staff in the daytime group, no changes that might have had any significant important differential influence on the workers’ well-being were reported by either the company management or the labor union representatives. If the reported change of staffing among the daytime workers had resulted in any effect on well-being, it would likely have been in the direction of deterioration and would thus have increased the chance of detecting an intervention effect arising from the schedule change. However, as the changes among the daytime workers were mostly small and not significant, there is prob-
ably a risk of only marginal overestimation of the intervention effects.

The study could have been strengthened by using biological indicators of health status and sleep in addition to self-report measures. An attempt was made to collect saliva for analysis of diurnal cortisol profiles, but the participation was poor and too-few saliva samples were available at follow-up to allow meaningful analyses.

Although we did not evaluate other outcomes, the company management reported that turnover rate and absenteeism had already been low before the intervention and did not obviously change in any direction. There were also no reports of any obvious effects of the schedule change on productivity or other performance indicators, but such effects might of course appear in the long run. The effect sizes in the studied variables were considered small to medium, but are probably still of practical importance because the well-being measures in the shift working group at follow-up resembled those in the daytime working group.

Conclusion

A shift schedule change from a fast forward-rotating schedule to a slowly backward-rotating schedule with intermediate days off between shift blocks was designed in negotiations between company management and the labor union. It resulted in clear improvements in recovery, sleep, and subjective health complaints at 15 months after the change as compared with 6 months before the change. Although the study was prospective and controlled, the mechanisms underlying the improvements cannot be definitively established, mainly because of the complexity of the characteristics that were changed. To contribute to a better understanding of which specific components promote such improved well-being, we suggest a study design that allows the separation of the effects of various schedule characteristics. One possible approach would be to monitor acute effects and variations in sleep and fatigue across an entire shift cycle, which might shed further light on the relative importance of the individual characteristics of a shift schedule.

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