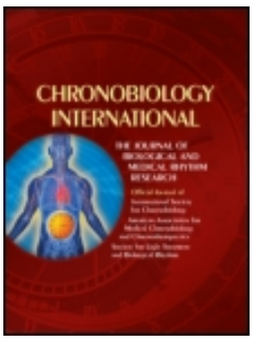

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THE IMPACT OF REST BREAKS ON TEMPORAL TRENDS IN INJURY RISK

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This study examined the impact of rest breaks on temporal trends in industrial accident risks in an attempt to replicate earlier findings of a linear increase in risk as a function of elapsed time on task. In two separate studies, the trend in work-related injuries were studied in relation to the timing of rest breaks. In study one, comparisons were made between on- and off-track workers on weekly rotating three-shift systems operating in a large engineering company. Records of on-duty injuries that occurred over 12 months were examined (N = 4645 incidents). Study two involved interviewing patients who had suffered work-related hand injuries in a variety of occupational settings (N = 407 patients). Hierarchical log linear analysis was used in both studies. In study one, risk increased from the first to the second half-hour of continuous work following a break, but then remained relatively constant in subsequent half-hour periods, although there was a fall in the third half-hour for on-track workers. In some of the data, there was also a decrease in risk in the period leading up to the end of a work period. There was a sharp decline in reported injuries toward the very end of a shift, but otherwise the observed trends did not differ between successive periods of continuous work or between morning, afternoon, and night shifts. In study two, risk increased from the first to the second half-hour of continuous work and then remained relatively constant in the third half-hour. The contrast between the current and previous findings may be due to the relatively unique work environment of the previous study. It is suggested that the current trends reflect the effects of working in a relatively unconstrained task environment, and that causes other than fatigue may underlie the trends observed in both the previous and current studies.

Keywords Rest breaks, Industrial injuries, Risk, Temporal trends, Industrial and Occupational Medicine, Industrial Safety and Hygiene, Shift Work

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INTRODUCTION

It has been previously shown that rest breaks can be an effective means of controlling the accumulation of injury and accident risk over the duration of a work shift in an industrial setting (Tucker et al., 2003). By plotting incident frequency in each successive half-hour of work, it was demonstrated that the risk more than doubled over 2 h of continuous (i.e., between the first and fourth half-hour) work. Each 2 h period of continuous work was followed by a rest break, after which risk returned near to the level observed at the start of the previous period of continuous work. The same two-fold increase was observed over each of three 2 h periods of continuous work within both the day and night shifts. In each case, risk returned to near baseline levels following rest breaks of either 10, 15, or 45 min duration.

As these were the first published data on the effect of rest breaks on injury risk, it remained unclear whether the trend could be generalized to other work settings, other shift schedules, etc. Moreover, the previous study was unable to distinguish between trends for different types of work (e.g., machine-paced versus self-paced). The two studies in the present article seek to address these issues. The first study examined injury data collected at a large production engineering plant in a different organization than in the previous article, but operating within the same industrial sector and in the same country. The second study involved interviewing individuals from a wide range of organizations who received medical treatment for a work-related traumatic hand injury. The conduct of the study and the analysis of the injury data respected the identity and privacy of the workers (Touitou et al., 2004).

STUDY ONE

Methods

Data Recording

Injury report forms at two production engineering complexes were modified to provide shift-work-related information in addition to the primarily medical details that were normally recorded (see Smith et al., 1994, for further details). On-duty injuries incurred within a workforce of approximately 4250 shift workers were recorded for 12 months. The workers (95.5% were male) had a mean age of 30.7 (S.D. $\pm$ 8.7) years, the shift-work experience was 3.7 (S.D. $\pm$ 3.9) years, and the absenteeism rate was about 6%. The analyses examined a total of 4,645 incidents. Minor injuries represented 90.2% of the total and included bruises and foreign bodies in the eye that could easily be washed out. More serious injuries (8.5% of the total) included cuts (requiring plasters, steristrips, or

sutures), crush injuries, and broken bones. Twenty percent of the shift workers reported between two and five injuries over the period of study.

Working Conditions

The shift systems had a weekly backward rotation of three 8 h shifts. Thus, a week of nightshifts was followed by a week of afternoon shifts, then a week of morning shifts, and then another week of nightshifts, etc. The shift changeover times were 06:00, 14:00 and 22:00 h. The schedule of rest breaks during the shifts differed between the two sites (see Table 1). At site one, each shift began with 120 min of continuous work, followed by a 15 min break, then 155 min of work, followed by a 30 min rest break, and then 160 min of work until the end of the shift, thus amounting to a total of two rest breaks/shift. At site two, each shift began with 120 min of work, followed by a 15 min rest break, and then three successive 105 min periods of work separated by two 15 min rest breaks, thus amounting to a total of three rest breaks per shift. Production ceased during all rest breaks.

The shift system provided a constant level of manning from Monday to Friday, and weekends were not normally worked. The shift pattern changed on Fridays, with shorter shifts and no night shift. For this reason, the analysis was confined to injuries that incurred between the Monday morning shift and the Thursday night shift. Supervisory and maintenance personnel worked the shift systems, as did the occupational health nurses who recorded the injury information.

All shift workers experienced similar working conditions in terms of job tasks, environmental factors (e.g., lighting, noise, heat, and humidity), time of day changes, and seasonal variation over the period of data collection. Both on-track and off-track workers were involved in product assembly. In on-track work, the products moved automatically along the production line at a set speed. Thus, each on-track worker had a limited period of time to complete their task, as the product passed by their workstation on its way down the production line (i.e., machine-paced work). In off-track work, the products were assembled in a single location, with each worker being responsible for producing a part of the product at his/her own pace (i.e., self-paced work). The on-track workers typically had a

TABLE 1 Length (min) of Work Periods and Rest Breaks for Each Shift at Sites 1 and 2

Site	Work period 1	Rest break	Work period 2	Rest break	Work period 3	Rest break	Work period 4
1	120	15	155	30	160		
2	120	15	105	15	105	15	105

cleaner working environment than the off-track ones. The nature of the work was similar for both sets of workers, namely, continual repetitive movements leading to the progressive assembly of the product. For both on-track and off-track workers, there was ample opportunity to interact but the team structure on the assembly line allowed more interaction.

Analysis

Cell frequencies were calculated for each half-hour of continuous work (excluding breaks) within each shift. Hierarchical log-linear analyses were then used to examine trends across consecutive half-hours of continuous work. Relative risk ratios (RR) and 95% confidence intervals (CIs) were calculated. The statistical test used in the log-linear analysis was χ^2.

The first analysis examined the trends in risk across the first 90 min of continuous work (i.e., from the start of the shift or from the end of the preceding rest break) for the first three work periods of each shift. The five factors in this analysis were the elapsed time on task (0–29 min, 30–59 min, and 60–89 min), work period (1, 2, and 3), shift (morning, afternoon, and night), work type (on-track and off-track), and site (1 and 2). The second analysis focused on a subset of the data used in the first analysis (i.e., only the data from site one) in order to examine the trends over a longer period of continuous work. Thus, the four factors were elapsed time on task (0–29 min, 30–59 min, 60–89 min, and 90–119 min), work period (1, 2, and 3), shift (morning, afternoon, and night) and work type (on-track and off-track). Two further analyses were conducted in order to examine the trends in risk in the time leading up to the end of a work period. It is important to note that unlike the first two analyses, the latter do not reflect the effects of elapsed time on task. Instead, they are intended to identify trends, such as those resulting from the anticipation of a rest break. In order to perform the third and fourth analyses, the injury frequency relative to the last half-hour of a work period was calculated. The new cell boundaries were thus defined in terms of the amount of time remaining in the work period (i.e., 0–29 min, 30–59 min, 60–89 min and, for site one only, 90–119 min). The analyses took the same general form as the first two analyses, but with the temporal factor being time remaining on task instead of elapsed time on task.

Results

Effects of Elapsed Time on Task

There was a significant interaction between elapsed time on task and work type ($p < 0.01$; see Figure 1). For both types of work, risk was higher in the second and third half-hours, relative to the first. However

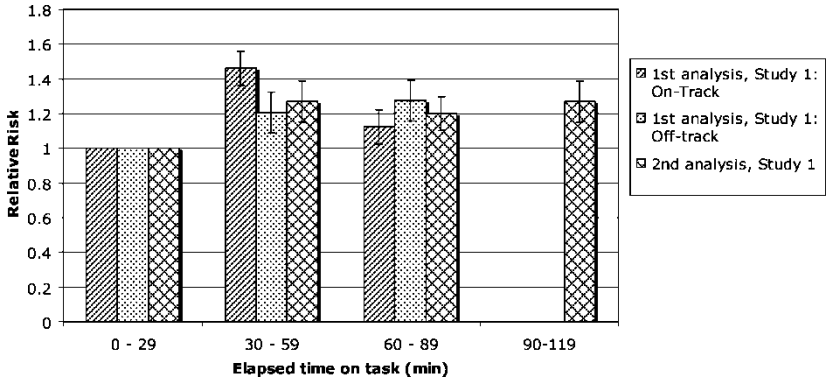

FIGURE 1 Risk of injury relative to the first 30 min on task in study one.

for on-track work, risk declined between the second and third half-hours, while for off-track work, risk remained relatively stable between the second and third half-hours. There were no other interactions involving elapsed time on task, indicating that the temporal patterns of risk did not differ significantly between the three work periods or the three shifts. There were no main effects of either shift or work period, indicating that overall risk did not differ between shifts or between work periods.

Analysis of the subset of data from site one revealed a significant main effect of elapsed time on task ($p < .01$; see Figure 1). Risk was lower in the first half-hour, relative to risk in the subsequent half-hours, but remained relatively unchanged across the second to fourth half-hours. There were no interactions involving elapsed time on task, indicating that the temporal pattern of risk did not differ significantly between the three work periods, the three shifts, or the two work types. There were no main effects of either shift or work period.

Effects of Time Remaining on Task

There was a significant interaction between time remaining on task, work period, and site ($p < 0.01$; see Figure 2). At site one, risk fell substantially in the last 30 min of the third work period, but otherwise was relatively invariant across the last 90 min of work. At site one, risk was marginally higher in the period 30–59 min prior to the end of the second work period, relative to risk in the last half-hour. At site two, risk was marginally higher in the period 60–89 min prior to the end of the first and second work periods. There was no main effect of shift. (It is important to note that in Figure 2, the three especially high values associated with work period three at site one reflect heightened risk relative to the risk in the last 30 min of the third work period at site one. They do not necessarily reflect a substantially greater frequency of injuries, relative

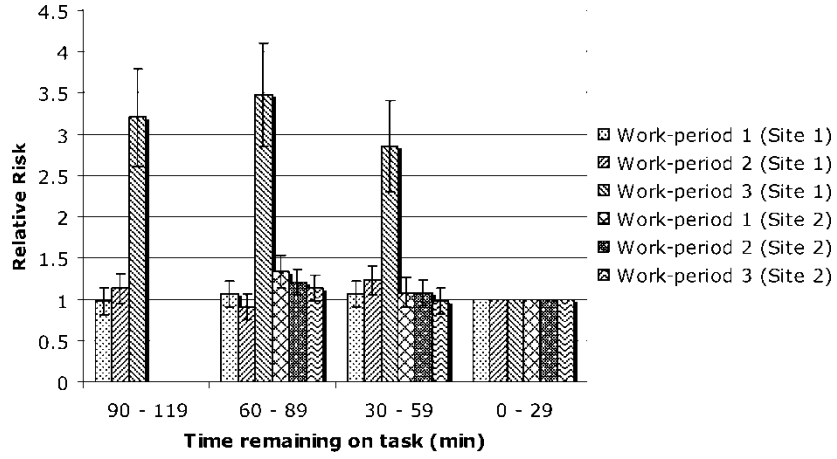

FIGURE 2 Risk of injury relative to the last 30 min on task in study one.

to either the other work periods at site one or the frequencies recorded at site two.)

Analysis of the subset of data from site one showed a significant interaction between elapsed time on task and work period ($p < 0.01$; see Figure 2). Risk remained relatively stable across the last 120 min of the first and second work periods, but declined substantially in the last 30 min of the third work period. There was no main effect of shift.

Discussion

Each of the foregoing analyses indicated an initial increase in risk from the first to the second half-hour on task. However, although a variety of trends were observed in the subsequent half-hours, the linear trend observed in the previous study (Tucker et al., 2003) was not replicated in any of the current analyses.

The trends in risk across the first 90 min of continuous work differed between work types. While risk of injuries in off-track work rose from the first to the second half-hour and remained higher in the third half-hour, the frequency of injuries in on-track work initially rose from the first to the second half-hour but then fell back again in the third half-hour (see Figure 1). It is notable that at site one, the risk of injuries in on-track work fell in the third half-hour but then increased again in the fourth half-hour (not shown). This suggests that the trend in risk for on-track work may be less stable than it is for off-track work. The observation of somewhat different trends in on- and off-track work suggests that the nature of work (e.g., degree of machine pacing) may affect the trend in risk.

Analyses of the trends in the latter stages of the work periods indicated that risk either remained unchanged or decreased as the end of a work period was approached. An especially large decrease was observed in last 30 min of the third work period at site one. This was the last work period of the shift at this site, and so the decline corresponded with the end of the shift. This large decline may reflect a reluctance on the part of workers to report minor injuries when nearing the end of their shift. Similarly, the smaller declines in apparent risk in the run-up to some rest breaks may also reflect under-reporting. Workers may be less inclined to report injuries, especially minor ones, if they believe that doing so may erode their free time (i.e., because they have to spend part or all of their rest break completing the injury reporting procedure). Thus, decreases in the final stages of a shift, or in the final stages of a work period that precedes a rest break, are most likely to be an artifact of changes in reporting behavior. While there is no evidence of changes in injury-causing behavior near the end of a shift (e.g., effects related to the anticipation of stopping work), it is possible that such effects have been masked by pre-break changes in reporting behavior.

STUDY TWO

Methods

The study methods have been published in detail elsewhere (Lombardi, et al., 2003; Sorock, et al., 2003) and are briefly summarized here. A multi-center, interview-based, case-crossover study was designed to assess risk factors for acute traumatic occupational hand injuries. Subjects were recruited from September 1997 to November 2000. During the last nine months of the study, enrolment was restricted to women to increase their numbers. Subjects were recruited in New England from 16 freestanding clinics that were part of two occupational health clinic networks, three manufacturing companies, two hospital-based and one rehabilitation-based occupational health care centers, and a hand surgical practice. The study was approved by the Harvard School of Public Health Human Subjects Committee and the Liberty Mutual Research Institute for Safety Institutional Review Committee, as well as in accordance with the standards set out by the journal (Touitou et al., 2004).

In summary, enrolment eligibility for the study was determined at the initial visit by the treating clinician (or nurse) at the participating health clinic. A subject was eligible if the injury occurred at work within 36 h of presentation and was to the hand, finger, or wrist. The treating clinician initially determined whether the injury was work-related, which was subsequently verified during the subject interview. The type (or nature)

of injury had to be a laceration, crush, puncture, avulsion, amputation, fracture, or contusion. Subjects with hand injuries due to a needle-stick, bite, repetitive motion disorder, cumulative trauma, or a sprain or a strain injury due to a fall were not eligible. A total of 1616 subjects agreed to participate at the clinic sites. Of this total, 94 were not eligible for interview. Of the remaining 1522 subjects eligible for a telephone interview, 1179 (77.5%) completed the interview using a structured questionnaire and were included in the analysis. If a subject did not consent to participate in the study, no phone interview was conducted, and no further information was collected. Thirteen additional interviewed subjects were excluded from further data analysis: four were burn injuries, two were sprain injuries, two had a previous injury, four had poor quality of responses during the interview, and one had an injury caused by violent behavior. Therefore, the total for evaluation was 1166 subjects. The median and mean intervals between injury and interview were 1.3 and 2.0 days; 10% of the subjects were interviewed five or more days after the injury date.

The current analyses of the effects of a break focused on those workers who either reported having a break in the 90 min leading up to the injury, or whose injury occurred within 90 min of the start of their shift. Work shift start time and time of injury were available for 1163 subjects. Elapsed time since the end of the break or the start of the shift was calculated for each subject. A total of 407 injuries were reported as having occurred within 90 min of the last break or since the start of the shift.

The signed informed consent form, along with the case information form (CIF) containing the name, age, gender, date and time of injury, and specifics related to the nature of the injury, were faxed to the data coordinating center. If possible, a trained interviewer telephoned the subject within 48 h of the injury and reviewed the information listed on the CIF. Next, the interviewer administered the structured Hand Injury Study questionnaire. The total interview lasted 21 min on average; once completed, the subject was mailed a US $25 payment. The questionnaire was designed to elicit detailed exposure information for the 90 min span preceding the onset of the hand injury, including the timing of any breaks. Other variables collected were age, gender, ethnicity, work shift start and end times, occupation, company size, safety training, job experience, and control over job pace. Occupations were coded using both the job title and the three most common job tasks reported by the subject according to the U.S. Department of Labor Employment and Training Administration (1991).

Analysis of the injury data involved calculating cell frequencies for each half-hour of continuous work since the last break or start of shift, separately for men and women. A hierarchical log-linear analysis was then used to examine trends across consecutive half-hours of continuous

work. Relative risk ratios (RR) and 95% CIs were calculated. The statistical test used in the log-linear analysis was χ^2. The two factors in the analysis were elapsed time on task (0–29 min, 30–59 min, and 60–89 min) and gender.

Results

Subject Characteristics

Seventy-six percent of the 407 study subjects were men. The mean ($\pm$S.E.M.) age of the subjects was 37.9 ($\pm$0.58) years. On average, the mean age of the women (41.2 years) was slightly higher than that of the men (36.9 years). Most of the hand injuries were lacerations (62.6%), followed by crushes (13.1%), avulsions (8.0%), punctures (6.1%), fractures (4.8%), and contusions (4.1%). A small percentage of subjects (1.1%) had a partial finger amputation. Men experienced more lacerations, fractures, and amputations than women, while women experienced more crush injuries and avulsions. Injuries were mostly minor in severity. Lacerations averaged 1.9 ($\pm$0.06) cm in length and required 4.1 ($\pm$0.15) sutures.

Employment was distributed among machine trades (43.5%), construction (18.2%), service workers (12.3%), packaging and materials handling (9.8%), and benchwork (5.9%). The most frequent occupation among men was machine trades (44.3%) and construction (22.3%), and for women it was machine trades (40.8%) and service work (22.4%). The median length of job experience was 92.6 months for men and 72.4 months for women.

Effects of Elapsed Time on Task

There was a significant effect of elapsed time on task ($p < .001$; see Figure 3). Risk was lower in the first half-hour, relative to risk in the subsequent half-hours, but remained relatively constant between the second and third half-hour. There was no interaction involving gender, indicating that the pattern was the same for men and women.

Discussion

The analysis indicated an increase in risk between the first and second half-hour that was sustained in the third half-hour of continuous work. The magnitude of the differences between the first and subsequent half-hours was greater than those observed in study one. The trends were similar among men and women, despite differences in the occupational profiles and types of injuries among these two groups.

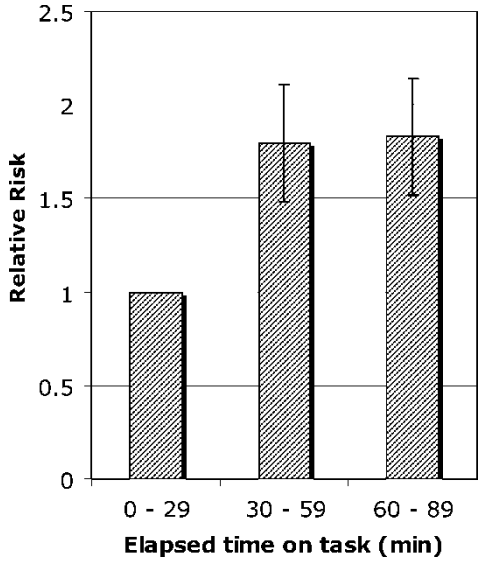

FIGURE 3 Risk of injury relative to the first 30 min on task in Study Two.

GENERAL DISCUSSION

The current trends in injury risk differ markedly from that reported in the previous study (Tucker et al., 2003). In both the previous and current studies, there was a significant increase in risk between the first and second half-hour on task. However, where in the previous study, risk continued to increase over the third and fourth half-hours, in the current analyses, risk either remained around the same level as in the second half-hour or decreased.

The contrast in trends may reflect differences in the types of work being undertaken, in spite of the fact that study one used data taken from the same type of industrial setting as the previous study. In the previous study, the analysis was restricted to data from employees whose jobs involved an invariant routine of continual repetitive movements that were largely machine-paced or otherwise outside the control of the individual. Thus, the work environment of the previous study was highly constrained, with work tasks comprising highly prescribed routines. By contrast, there was relatively little automation in the plant of study one. Work routines (both on- and off-track) were not as precisely prescribed and thus were probably less constrained. Study two examined data from a variety of occupational settings, and it is unlikely that many featured a highly constrained work environment. It is possible that the trend observed in the previous study uniquely reflected an accumulation of the effects of working in a highly constrained task environment. The non-linear trends in the current data may, on the other hand, reflect other changes in behavior

over time, such as risk taking. In this vein, it is perhaps also worth noting that there were marked differences between the organizational climates (e.g., level of morale, perceived job security) at the plant in study one and that in the previous study. This may have contributed to different patterns of volitional, injury-causing behavior. Alternatively, the contrasting trends may reflect other differences between the work environments at the two plants, such as in equipment.

In a recent study of train drivers, it was reported that the rate of signals passed at danger (SPADs) increased linearly as a function of elapsed time on task for the first 90 min and then leveled out (Spencer, 2005). Of course, it is conceivable that had the inter-break intervals in the present authors' previous study been greater than 120 min, a leveling out of risk would also have been observed at a later stage. Nevertheless, taking the SPADs data alongside the current findings, it is tempting to conclude that the linear trend observed in the previous study may represent a special case.

In both the current and previous studies, the same increase in risk was observed on all shifts, meaning it was independent of time of day. This could imply that the increase is not related to sleepiness, as such effects might be more prevalent at certain times of day (e.g., on the night shift). Instead, the observed trends may reflect other factors, such as monotony or stress. In the case of the current studies, the non-linear trend is reminiscent of a vigilance decrement in performance (Mackworth, 1950), although working conditions on a production line are not those traditionally associated with vigilance decrements (Nachreiner & Hänecke, 1992). In the case of the linear trend observed in the current authors' earlier study, it may have reflected an accumulation of stress resulting from working in a highly constrained, machine-paced environment characterized by a lack of autonomy. Such work environments are associated with relatively rapid declines in performance (Broadbent, 1953), higher levels of stress (Frankenhaeuser, 1978), and higher perceived injury risk (Harrell, 1990), although there is no evidence directly linking machine pacing with injury risk. Alternatively, the reduced risk immediately following a break may reflect an increased use of effortful controlled processing (see Schneider & Shiffrin, 1977), which is not sustained over prolonged periods.

In conclusion, it has once again been demonstrated that rest breaks are an effective means of offsetting the accumulation of risk as a function of time on task during industrial shift work. However, in comparison to the authors' previous study, the current findings, which were taken from a broader range of occupational settings, showed rather different temporal trends. Taken alongside other recent findings from the rail industry, they suggest that the beneficial effects of rest breaks may be relatively short-lived in at least some work environments.

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