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Sleepiness, sleep, and use of sleepiness countermeasures in shift-working long-haul truck drivers

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ABSTRACT

Driver sleepiness is a prevalent phenomenon among professional drivers working unconventional and irregular hours. For compromising occupational and traffic safety, sleepiness has become one of the major conundrums of road transportation. To further elucidate the phenomenon, an on-road study canvassing the under-explored relationship between working hours and sleepiness, sleep, and use of sleepiness countermeasures during and outside statutory rest breaks was conducted. Testing the association between the outcomes and working hours, generalized estimating equations models were fitted on a data collected from 54 long-haul truck drivers (mean 38.1 ±10.5 years, one female) volunteering in the 2-week study. Unobtrusive data-collection methods applied under naturalistic working and shift conditions included the Karolinska Sleepiness Scale (KSS) measuring **sleepiness**, a combination of actigraphy and sleep-log measuring **sleep**, and self-report questionnaire items incorporated into the sleep-log measuring the **use of sleepiness countermeasures** during and outside statutory rest breaks. Drivers' working hours were categorized into first and consecutive night, morning and day/evening shifts based on shift timing. The results reveal severe sleepiness (KSS ≥ 7) was most prevalent on the first night (37.8%) and least on the morning (10.0%) shifts. Drivers slept reasonably well prior to duty hours, with main sleep being longest prior to the first night (total sleep time 7:21) and shortest prior to the morning (total sleep time 5:43) shifts. The proportion of shifts whereby drivers reported using at least one sleepiness countermeasure outside statutory rest breaks was approximately 22% units greater for the night than the non-night shifts. Compared to the day/evening shifts, the odds of severe sleepiness were greater only on the first night shifts (OR 6.4–9.1 with 95% confidence intervals, depending on the statistical model), the odds of insufficient daily sleep were higher especially prior to the consecutive night shifts (OR 3.5 with 95% confidence intervals), and the odds of using efficient sleepiness countermeasures outside statutory rest breaks were greater on the first as well as consecutive night shifts (OR 4.0–4.6 with 95% confidence intervals). No statistically significant association was found between shift type and use of efficient sleepiness countermeasures during statutory rest breaks. In all, the findings demonstrate marked differences in the occurrence of severe sleepiness at the wheel, sleep preceding duty hours, and the use of sleepiness countermeasures between different shift types. In addition, although drivers slept reasonably well in connection with different shift types, the findings imply there is still room for improvement in alertness management among this group of employees.

1. Introduction

Professional drivers are known to feel sleepy at the wheel quite frequently. In a Finnish questionnaire study, 40% of long-haul truck drivers reported having difficulties in maintaining wakefulness during at least one-fifth of their journeys (Häkkänen and Summala, 2000). Driver sleepiness compromises

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of occupational and traffic safety, making it one of the major conundrums of road transportation (Craft, 2007; McCartt et al., 2000; NTSB, 1990). In the European Truck Accident Causation study 2007, sleepiness was involved in 19% of the single-truck crashes (IRU, 2007).

Working in road transportation usually means working in shifts. Sleep outside and alertness during hours of work are particularly challenged on night and early-morning shifts (Åkerstedt, 1998; Kecklund and Åkerstedt, 1993; Kecklund et al., 1994, 1997; Sallinen and Kecklund, 2010; Williamson and Friswell, 2011). Main sleep following night shifts has, for instance, been found to be shortened by one-third (Åkerstedt, 1988), and main sleep preceding morning shifts by approximately 2 h (Sallinen et al., 2005). Driving during late night and early-morning hours has also been associated with increased levels of electro-physiologically verified sleepiness (Mitler et al., 1997).

Sleep loss and irregular working hours are rarely avoidable in road transportation, but the adverse effects of sleep loss and nighttime working may be alleviated by using effective strategies, such as proper work/rest scheduling to permit sufficient recovery sleep, limited time awake, napping, ingestion of alertness-enhancing compounds like caffeine, and implementing suitable technologies (Caldwell et al., 2008; Folkard and Tucker,, 2003; May and Baldwin, 2009; Pallesen et al., 2010; Åkerstedt, 1998). In the previous questionnaire studies, professional drivers have reported consuming caffeine and resorting to rest breaks and in-vehicle alertness-enhancing activities (e.g., opening a window) to mitigate sleepiness at the wheel (Anund et al., 2008; Häkkänen and Summala, 2000; Pérez-Chada et al., 2005).

Although the relationship between working hours and sleep and sleepiness is a vastly studied topic in road transportation (e.g., Adams-Guppy and Guppy, 2003; Häkkänen and Summala, 2000; Hanowski et al., 2007; Kanazawa et al., 2006; McCartt et al., 2000; Morrow and Crum, 2004; Perttula et al., 2011; Philip et al., 2002; Sabbagh-Ehrlich et al., 2005; Tzamalouka et al., 2005), there are only few on-road studies investigating driver sleepiness and sleep in connection with different types of work shifts (Kecklund and Åkerstedt, 1993; Mitler et al., 1997). The research literature is also close to being devoid of on-road studies exploring the ways in which professional drivers fight sleepiness on different work shifts. To complete research literature, an on-road study was conducted to elucidate whether different types of work shifts vary in terms of these outcomes among long-haul truck drivers working irregular hours. Driver sleepiness, sleep, and use of sleepiness countermeasures during and outside statutory rest breaks were measured over a period of two weeks in connection with morning, day, evening, and night shifts.

2. Methods

2.1. Subjects

The data were based on a sample of 54 long-haul truck drivers (average age 38.1 years, one female) recruited from four middle-sized haulage companies operating in Finland, and employing a total of 677 drivers at the time of recruitment. To meet the inclusion criteria set for the study, drivers had to be 20–65 years of age, have at least 2 years of trucking experience, and operate during day- and nighttime hours on a regular basis. Two of the volunteers withdrew from the study before data collection was commenced, adjusting the final sample-size at 52. Those volunteering in the study were sent a consent form with an information letter designed to provide study participants with detailed information about the study (aim, stages, time schedule, advantages of the study, potential inconvenience for the participants, possibility to intermit the study at any point) and the research group conducting it.

2.2. Procedures

2.2.1. Pre-measurement questionnaires

At the beginning of data collection, the drivers completed a set of questionnaires, including a background questionnaire with items measuring demographic and health characteristics, the Diurnal Type Questionnaire (Torsvall and Åkerstedt, 1980), the Epworth Sleepiness Scale (ESS, Johns, 1991), and items measuring habitual sleep and daily sleep need.

2.2.2. Field measurements

Field measurements took place in Finland, and were conducted during winter months (November–March) over a period of 14 consecutive days during which drivers' working hours, sleep, sleepiness at the wheel, activity during statutory rest breaks, and use of sleepiness countermeasures at the wheel during and outside statutory rest breaks were measured using a set unobtrusive data collection methods (explained in the sub-Sections 2.3 and 2.4).

2.3. Outcome measures

Driver sleepiness was measured each duty day using the Karolinska Sleepiness Scale (KSS, Åkerstedt and Gillberg, 1990) presented in auditory form with a touch-screen phone attached to the dashboard of a truck. The phone was programmed to prompt drivers to rate their alertness from the beginning till the end of each work shift at 60 min interval. Criteria for driver sleepiness was set to KSS $\geq$ 7, as the KSS ratings exceeding 6 have been found to correlate with physiological indicators of sleepiness, such as sleep intrusions in the electroencephalography (Åkerstedt et al., 2005, 2014a,b). If a driver gave at least one KSS rating of 7 or higher during a work shift, the shift was defined as severely sleepy.

Sleep was measured daily using a wrist-worn actigraph device and a sleep log. The actigraphy-based sleep parameters included bedtime, get-up time, actual sleep time, time in bed, and sleep efficiency. Main sleep (the longest continuous period of daytime or nocturnal sleep) and nap sleep preceding a work shift were measured as actigraphically verified total sleep time (TST) and time in bed (TIB). All sleep hours obtained within 24 h preceding a shift were also calculated. These sleep hours were divided into daily main sleep and daily nap sleep, and further combined into daily sleep total including main and nap sleep. Daily sleep totaling less than 6 h was defined as insufficient daily sleep. According to Bonnet and Arand (1995) this amount of daily sleep may decrease alertness considerably. Sleep loss was measured as a ratio of the amount of habitual sleep to the amount of self-estimated need for sleep (Broman et al., 1996). A work shift was considered being preceded by sleep loss when TST within a 24 h period preceding it was less than 80% of the corresponding daily sleep need. Time since awakening at the end of shift was used as a proxy for sustained wakefulness. The variable was defined as a time period from the end of a main sleep period till the end of a work shift subsequent to it (including possible napping). Items in the sleep log were the following: *If you had alcohol before going to bed, how many servings did you have?; If you resorted to sleep medication before going to bed, how much (mg) of it did you take?; How well do you think you slept?; How was your alertness when you woke up?* The first two questions were open-ended, and the last two were rated on a 5-point-scale with verbal anchors "poorly" (0), "moderately" (2), and "well" (4).

Activity during statutory rest breaks[1] was measured each duty day with a closed-ended self-report questionnaire item (*What did you do during statutory rest breaks?*) incorporated into the sleep log. The questionnaire item did not take a stand on whether the