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Original Article

Maintenance of Wakefulness and Occupational Injuries among Workers of an Italian Teaching Hospital

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ABSTRACT

Background: To assess in a laboratory setting the ability to stay awake in a sample of workers of an Italian hospital and to investigate the association between that ability and the risk of occupational injury.
Methods: Nine workers at the University Hospital of Udine who reported an occupational injury in the study period (cases), and seven noninjured workers (controls) underwent a polysomnography and four 40-minute maintenance of wakefulness tests (MWT). Differences in sleep characteristics and in wakefulness maintenance were assessed using Wilcoxon's rank sums tests and Fisher's exact tests.
Results: Controls had greater sleep latency, lower total sleep time, fewer leg movements, and a higher percentage ratio of cycling alternating pattern, were more likely not to fall asleep during the MWT and were less likely to have two or more sleep onsets. Although not all the differences reached statistical significance, cases had lower sleep onset times in Trials 1–3.
Conclusion: In the literature, the evidence of an association between MWT results and real life risk of accidents is weak. Our results suggest a relationship between the MWT results and the risk of injury among hospital workers.

1. Introduction

Poor sleep quality, fatigue, and sleep disorders among workers are associated with worse occupational performances, safety issues, and increased risk of injury [1–3].

The maintenance of wakefulness test (MWT) is a validated objective test that measures the ability to maintain wakefulness in a quiet, nonstimulating laboratory situation for a certain period of time and has been proposed as an instrument to assess the ability to stay awake in persons whose jobs require that they remain awake for public or personal safety reasons [4,5], such as hospital workers, whose excessive sleepiness and inability to maintain alertness may affect patients' safety and increase their own risk of occupational injury.

Unfortunately, normative data for the MWT are limited, as is evidence of an association between MWT findings from a laboratory environment and the actual risk of injuries due to sleepiness in the real world, where different stimuli and conditions may be present [5]. Additional research has been advocated to investigate further the association between MWT findings and the risk of adverse effects of sleepiness [5].

The objective of the research presented in this article was to assess in a laboratory setting the ability to stay awake in a small sample of workers of an Italian teaching hospital, using the MWT, and to investigate the association between the performance on the test and the worker's risk of occupational injury.

2. Materials and methods

Participants eligible for enrolment in this study were a subgroup of a larger sample selected for a case–control study aimed at investigating the associations between sleep-related exposures,

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sleepiness, and chronotype and the risk of occupational injuries in the University Hospital of Udine, a teaching hospital located in the north-east of Italy. In short, in this case–control study all the hospital workers reporting occupational injuries (including commuting accidents and incidents involving biological risk) between March 25th, 2013 and July 3rd, 2014 were invited to participate as cases and a random sample of all the noninjured workers was invited as the control group. Two-hundred cases and 183 controls agreed to participate and underwent a telephone interview based on a semistructured questionnaire that collected the following information: sociodemographic and job-related characteristics of the participant; weight and height; smoking habits; usual consumption of alcohol and coffee; sleep characteristics; and the Epworth Sleepiness Scale (ESS) [http://epworthsleepinessscale.com/epworth-sleepiness-scale.pdf] to assess daytime sleepiness; and the Italian version (www.ge.infn.it/~squarcia/DIDATTICA/SRS/Questionario_cronotipo.doc) of the Horne–Ostberg morningness–eveningness questionnaire (MEQ) [6] to assess chronotype.

From that pool of workers, we invited cases with a leave ≥ 3 days following the injury and a random sample of controls to undergo further testing from September 2014 to December 2014 to assess their nocturnal quality of sleep and their wake tendency: nine cases and seven controls were available and tested. Regardless of the usual work shift, none of those individuals were tested immediately after a night shift. On a night off work, they underwent a nocturnal polysomnography in their homes and, the following day, a four × 40-minute MWT at the Sleep Clinic of the University Hospital of Udine. For cases, to reduce the likelihood that the usual sleep pattern could be affected by the injury, testing was performed 9–18 months after the injury.

Nocturnal polysomnography was scored by a sleep technologist (E.S.) according to Iber et al [7]. The four 40-minute trials of the MWT were performed at around 10:00 AM, 12:00 noon, 2:00 PM, and 4:00 PM. The test was administered by a sleep technologist (E.S.), according to the protocol recommended by the American Academy of Sleep Medicine [8]. Data were recorded and manually scored in 30-second epochs. Sleep onset was defined as the first epoch of < 15 seconds of cumulative sleep in a 30-second epoch. Trials were ended after 40 minutes if no sleep occurred, or after unequivocal sleep, defined as three consecutive epochs of Stage 1 sleep, or one epoch of any other stage of sleep [8]. Participants who did not sleep during a trial were assigned a value of 40 minutes.

We calculated the median, interquartile range, and minimum sleep latency for each MWT trial and overall. We also classified participants according to the categories proposed by Doghramji et al [9]: pathological (0–19 minutes); intermediate (20–33 minutes); and alert (34–40 minutes) based on each participant's average sleep onset time across the four MWT trials.

Sex, body mass index (overweight/obese if ≥ 25 kg/m^2), current smoking status, night shifts, history of previous occupational injuries, current use of hypnotic drugs, sleepiness level (ESS ≤ 10 vs. ESS > 10), and MEQ type (*definitely morning type:* score 70–86; *moderately morning type:* 59–69; *neither morning nor evening type:* 42–58; *moderately evening type:* 31–41; *definitely evening type:* 16–30) of cases and controls were compared through Fisher's exact tests; age and numeric continuous characteristics of nocturnal sleep were compared using Wilcoxon's rank sums tests.

The number of sleep onsets at the MWT among cases and controls was compared using Fisher's exact test. The median sleep latency in the two groups was compared using Wilcoxon's rank sums test. A p value < 0.05 was considered statistically significant. All the analyses were performed using SAS v9.4 (SAS Institute Inc., Cary, NC, USA).

This study was approved by the Ethics Committee of Udine, Italy.

3. Results

Of the nine cases, six reported a commuting accident and three a traumatic injury. Demographic, sleep-related reported characteristics, and ESS and MEQ scores of cases and controls are illustrated in Table 1. Cases were slightly younger, worked on shifts including nights, included more physicians and nurses, had greater sleepiness as measured by the ESS, reported previous occupational injuries and current use of hypnotic drugs less often than controls, and were more often morning-types than controls, although none of the differences were statistically significant. Regarding nocturnal sleep, controls had a greater sleep latency, a lower total sleep time, and fewer leg movements, although the differences were not statistically significant. The sleep structure was similar among cases and controls. However, cases might have a more disturbed sleep according to the higher percentage ratio of cycling alternating pattern ($p = 0.0148$).

Fig. 1 shows the distribution of the number of sleep onsets at the MWT among cases and controls. Although the differences were not statistically significant (Fisher's exact test $p = 0.2570$), controls were more likely not to fall asleep (4 controls vs. 1 case) and less likely to have two sleep onsets or more (1 control vs. 5 cases).

Fig. 2 shows the distribution of the sleep onset times on the four × 40-minute MWT trials. In Trials 1–3, lower quartiles

Table 1
Demographic, sleep-related reported characteristics, Epworth Sleepiness Scale (ESS), and morningness–eveningness questionnaire (MEQ) scores among a sample of nine workers (cases) of the University Hospital of Udine who reported an occupational injury between March 25, 2013, and July 3, 2014, and seven noninjured workers (controls).

	Cases ($n = 9$)	Controls ($n = 7$)
Female, %	89	100
Age (y), median, IQR	44, 38–50	46, 44–52
Overweight/obese, %	23	29
Smokers, %	0	29
Job type, %		
Physician	22	0
Nurse	55	29
Administrative	0	43
Auxiliary	22	14
Technician	0	14
Night included in usual shifts, %	33	14
Previous occupational injuries, %	44	57
Use of hypnotic drugs, %	11	29
Normal (< 10) ESS, %	67	86
MEQ type, %		
Definitely morning	22	0
Moderately morning	56	57
Neither	22	29
Moderately evening	0	14
Definitely evening	0	0
Sleep latency (min), median, IQR	6, 3–8	12, 1–19
Total sleep time (min), median, IQR	436, 394–451	396, 377–421
Sleep stages (%), median, IQR		
Awake	4, 4–7	5, 2–6
N 1	4, 3–8	4, 3–6
N 2	39, 34–46	45, 39–45
N 3	27, 25–31	26, 23–28
REM	21, 19–23	20, 17–23
REM latency (min), median, IQR	94, 90–98	108, 48–114
Arousal index (n/h) median, IQR	4.7, 3.1–6.4	4.5, 3.2–6
Number of awakenings, median, IQR	9, 6–15	10, 6–17
Total legs movements, median, IQR	45, 10–380	10, 0–72
Apnea–hypopnea index (n/h), median, IQR	0.7, 0.3–4.2	0.5, 0.3–2.6
Percentage ratio of cycling alternating pattern (%), median, IQR	30, 18–33	11, 7–15

IQR, interquartile range; REM, rapid eye movement.