Safety and Health at Work 7 (2016) 120–123

Contents lists available at ScienceDirect

Safety and Health at Work

journal homepage: www.e-shaw.org

Original Article

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

Francesca Valent [1,2,3,*], Elisa Sincig [4], Gian Luigi Gigli [4], Pierluigi Dolso [4]

[1] Epidemiologic Service, Regional Health Directorate, Friuli Venezia Giulia Region, Udine, Italy
[2] Unit of Hygiene and Clinical Epidemiology, University Hospital of Udine, Udine, Italy
[3] Department of Medical and Biological Sciences, University of Udine, Udine, Italy
[4] Neurology Clinic, University Hospital of Udine, Udine, Italy

ARTICLE INFO

Article history:
Received 12 February 2015
Received in revised form
6 October 2015
Accepted 11 October 2015
Available online 26 October 2015

Keywords:
case–control study
maintenance of wakefulness test
occupational injury
teaching hospital

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,

* Corresponding author. Servizio Epidemiologico, Direzione Centrale Salute, Integrazione Socio-Sanitaria, Politiche Sociali e Famiglia, Regione Autonoma Friuli Venezia Giulia, Via Pozzuolo 330, 33100 Udine, Italy.
E-mail address: valent.francesca@aoud.sanita.fvg.it (F. Valent).

2093-7911/$ – see front matter
http://dx.doi.org/10.1016/j.shaw.2015.10.002

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 $\times$ 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 $\times$ 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.

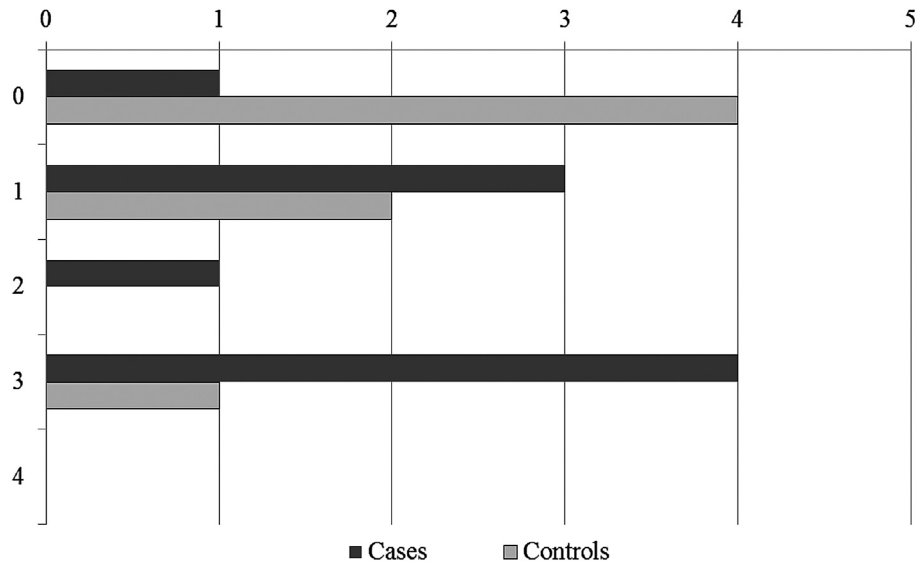

Fig. 1. Distribution of the number of sleep onsets at the four × 40-minute maintenance of wakefulness tests among cases ($n = 9$) and controls ($n = 7$).

corresponded to lower times among cases than among controls. No controls fell asleep during Trial 1, however, cases were less likely than controls to fall asleep during Trial 4. The difference between cases and controls reached statistical significance at Trial 1. The median (and interquartile range) of the average onset times for cases and controls across the four MWT trials were, respectively, 32 (22–37) minutes and 40 (33–40) minutes (Wilcoxon's rank sums test $p = 0.1062$). According to the average sleep onset times, 67% of cases and 43% of controls were classified as *intermediate*, the remainder as *alert* (Fisher's exact test $p = 0.3409$).

4. Discussion

This study compared findings from the four × 40-minute MWT trials among nine hospital workers who reported an occupational injury during the previous 18 months and seven who did not sustain any injury in the same period. Overnight polysomnography revealed slightly longer sleep latency, shorter sleep duration, and a higher number of awakenings among controls; should these differences have affected the subsequent MWT, we would have expected controls to experience more sleepiness than cases on the four trials. By contrast, controls were more likely to stay awake in all four trials and less likely to fall asleep in two or more trials. Furthermore, the minimum and lower quartile of sleep onset times on Trials 1–3 were shorter for cases than for controls. In addition, the average sleep time onset across the four trials was shorter among cases and a smaller proportion of cases resulted in *alert* according to the classification proposed by Doghramji et al [9]. Despite the very small sample size that prevented most of our analyses from being performed with sufficient statistical power to reasonably exclude that the results are only due to chance, our findings suggest that individuals who are prone to injuries are less likely to maintain wakefulness in a laboratory setting. This is consistent with the proportion of cases totaling normal ESS scores, lower than the proportion of controls, and could be explained, at least in part, by a worse sleep quality as indicated by a higher cyclic alternating pattern (CAP) rate [10].

We did not find any pathological MWT (i.e., average sleep latency 0–19). However, the fact that more cases had an intermediate result (20–33) than controls is consistent with Philip et al [11], who reported a significant increase in the number of inappropriate line crossings during a driving session on a real car driving simulator for individuals with pathological MWT as compared with alert

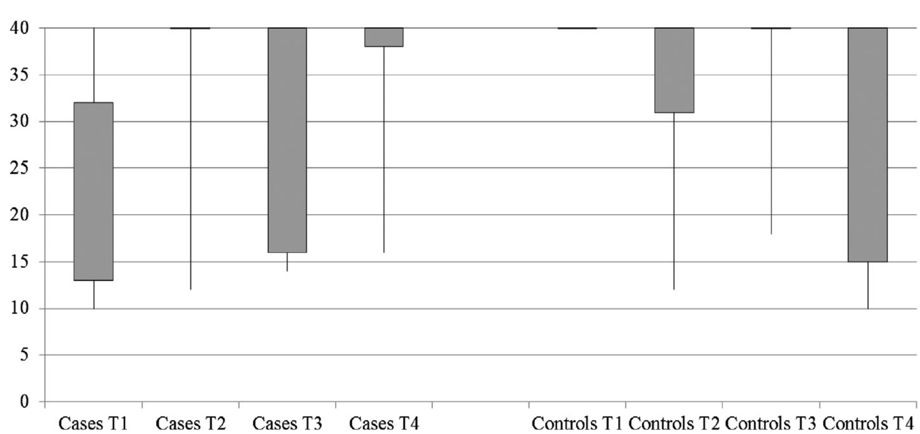

Fig. 2. Distribution of sleep onset times for the four × 40-minute maintenance of wakefulness test trials among cases ($n = 9$) and controls ($n = 7$). The grey bars indicate the lower and upper quartiles, the black continuous lines below the bars indicate the minimum values. Wilcoxon's rank sum test p-values were $p = 0.0134$ in Trial 1, $p = 0.9254$ in Trial 2, $p = 0.1343$ in Trial 3, and $p = 0.8468$ in Trial 4.

individuals and a smaller nonsignificant increase among those with an intermediate result.

Among controls, who had not suffered any occupational injury in the previous months, more than one-half were able to stay awake on all the four trials, which is what we expect from individuals who need to work at high levels of safety, often required in the hospital environment. The fact that in Trial 4, the distribution of sleep onset times among controls was skewed toward shorter values than among cases was counterintuitive, also considering the fact that, on the MEQ, controls were more often evening-type, and thus more likely to perform better in the afternoon, than cases. Our findings might indicate that the effort to remain awake for some controls was so great that after 6 hours they were exhausted and fell asleep quite quickly.

The main limitation of this study is the small sample size that makes the statistical power insufficient to exclude chance as a possible explanation for most of our results. The test is very time-consuming for those who have a regular job, thus the availability to participate was limited. However, even with this reduced number of individuals, we were able to detect a significant association (the difference in sleep onset time in Trial 1). In addition, although nonsignificant, most of our results are consistent with other research [11] indicating that an objective measure of the ability to stay awake might be useful to discriminate workers at increased risk of injury.

Because the normative data for the MWT are limited and the evidence of an association between MWT results and real life risk of accidents is still weak, the possible routine applications of the test in an occupational medicine setting for the primary prevention of adverse events remain unclear. However, our results indicate that there might be some relationship between the MWT results, i.e., an individual's wake tendency and the risk of injury among hospital workers. Further research is warranted to assess whether the MWT could be used as a screening for secondary prevention of occupational injuries and adverse safety outcomes among hospital workers who have already sustained an injury.

Conflicts of interest

All authors have no conflicts of interest to declare.

Acknowledgments

This work was supported by the Italian Ministry of Health through the Ricerca Finalizzata Bando Giovani Ricercatori 2009, under Grant GR-2009-1569913.

References

[1] Patterson PD, Weaver MD, Frank RC, Warner CW, Martin-Gill C, Guyette FX, Fairbanks RJ, Hubble MW, Songer TJ, Callaway CW, Kelsey SF, Hostler D. Association between poor sleep, fatigue, and safety outcomes in emergency medical services providers. Prehosp Emerg Care 2012;16:86–97.

[2] Rajaratnam SM, Barger LK, Lockley SW, Shea SA, Wang W, Landrigan CP, O'Brien CS, Qadri S, Sullivan JP, Cade BE, Epstein LJ, White DP, Czeisler CA., Harvard Work Hours, Health and Safety Group. Sleep disorders, health, and safety in police officers. JAMA 2011;306:2567–78.

[3] Centers for Disease Control and Prevention (CDC). Short sleep duration among workers—United States, 2010. MMWR Morb Mortal Wkly Rep 2012;27:281–5.

[4] Sullivan SS, Kushida CA. Multiple sleep latency test and maintenance of wakefulness test. Chest 2008;134:854–61.

[5] Wise MS. Objective measures of sleepiness and wakefulness: application to the real world? J Clin Neurophysiol 2006;23:39–49.

[6] Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol 1976;4:97–110.

[7] Iber C, Ancoli-Israel S, Chesson A, Quan S, for the American Academy of Sleep Medicine [Internet]. The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications, 1st ed. Westchester (IL): American Academy of Sleep Medicine. 2007 [cited 2015 Feb 2]. Available from: http://www.nswo.nl/userfiles/files/AASM%20-%20Manual%20for%20the%20Scoring%20ofSleep%20and%20Associted%20Events%20-%2005-2007_2.pdf.

[8] Littner MR, Kushida C, Wise M, Davila DG, Morgenthaler T, Lee-Chiong T, Hirshkowitz M, Daniel LL, Bailey D, Berry RB, Kapen S, Kramer M., Standards of Practice Committee of the American Academy of Sleep Medicine. Practice parameters for clinical use of the multiple sleep latency test and the maintenance of wakefulness test. Sleep 2005;28:113–21.

[9] Doghramji K, Mitler MM, Sangal RB, Shapiro C, Taylor S, Walsleben J, Belisle C, Erman MK, Hayduk R, Hosn R, O'Malley EB, Sangal JM, Schutte SL, Youakim JM. A normative study of the maintenance of wakefulness test (MWT). Electroencephalogr Clin Neurophysiol 1997;103:554–62.

[10] Terzano MG, Parrino L, Spaggiari MC, Palomba V, Rossi M, Smerieri A. CAP variables and arousals as sleep electroencephalogram markers for primary insomnia. Clin Neurophysiol 2003;114:1715–23.

[11] Philip P, Chaufton C, Taillard J, Sagaspe P, Léger D, Raimondi M, Vakulin A, Capelli A. Maintenance of wakefulness test scores and driving performance in sleep disorder patients and controls. Int J Psychophysiol 2013;89:195–202.