Sleep Medicine 33 (2017) 36–42

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

Individuals with pain need more sleep in the early stage of mild traumatic brain injury

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ARTICLE INFO

Article history:
Received 18 December 2015
Received in revised form
3 June 2016
Accepted 6 June 2016
Available online 22 October 2016

Keywords:
Traumatic brain injury
Pain
Sleep
Actigraphy

ABSTRACT

Objective: Hypersomnia is frequently reported after mild traumatic brain injury (mTBI), but its cause(s) remain elusive. This study examined sleep/wake activity after mTBI and its association with pain, a comorbidity often associated with insomnia.
Methods: Actigraphy recording was performed for 7 ± 2 consecutive days in 56 individuals at one month post-mTBI (64% male; 38 ± 12 years), 24 individuals at one year post-mTBI (58% male; 44 ± 11years), and in 20 controls (50% male; 37 ± 12 years). Pain intensity and its effect on quality of life was assessed with a visual analogue scale and the Short Form Health Survey (SF-36) bodily pain subscale.
Results: Overall, few differences in sleep/wake patterns were found between mTBI patients and controls. However, higher percentages of mTBI individuals with moderate-to-severe pain were found to require more than eight hours of sleep per day (37% vs11%; $p = 0.04$) and to be frequent nappers (defined as those who took three or more naps per week) (42% vs 22%; $p = 0.04$) compared to those with mild or no pain at one month postinjury. Correcting for age and depression, The SF-36 score was found to be a significant predictor of sleep duration exceeding eight hours per day at one month (odds ratio = 0.95; 95% confidence interval = 0.92–0.99; $p = 0.01$), but not at one year post-mTBI. Pain and increased sleep need (in terms of hours per day or napping frequency) were found to co-exist in as much as 29% of mTBI patients at one month postinjury.
Conclusion: Pain could be associated with more pronounced sleep need in about one-third of mTBI patients during early recovery. Unalleviated pain, found in more than 60% of mTBI patients, should therefore be looked for in all mTBI patients reporting new onset of sleep disorder, not only in those with insomnia.

1. Introduction

Mild traumatic brain injury (mTBI) occurs when an external force applied to the head causes alterations in brain functions such as decreased consciousness, memory loss, and/or changes in mental status at the time of the injury [1]. The incidence of civilian mTBI is rising worldwide, mainly because of injuries associated with greater use of motor vehicles in low- and middle-income countries, as well as falls, assaults, and work accidents [2]. In the United States alone, it is estimated that more than 1.4 million individuals sustain an mTBI annually [2]. Specific operational criteria for the clinical diagnosis of mTBI include the following: loss of consciousness not exceeding 30 min, a period of posttraumatic amnesia (ie, characterized by an inability to remember the moments preceding and/or after the impact) lasting less than 24 h, and a Glasgow Coma Scale score from 13 to 15 within the first 30 min postinjury [3]. Using the same criteria, sports-related

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http://dx.doi.org/10.1016/j.sleep.2016.06.033
1389-9457/

mTBI with altered mental state is generally referred to as concussion [4].

Pain and sleep complaints are common after mTBI [5]. Up to 51% of mTBI patients develop some form of headache in the days after the injury [6]. Even years postinjury, an impressive 30–54% of mTBI patients still complain of recurrent and/or episodic headaches, and about 11% complain of joint pain [7,8]. New onset of sleep–wake disturbances (SWD), mainly insomnia, fatigue, and excessive daytime sleepiness, are also frequently reported (by up to 72% of patients) in the first few months after TBI [9]. In recent years, particular attention has been paid to the development of hypersomnia after brain trauma, as found in about 20–30% of patients with mild to severe TBI, that could interfere with their return to previous activities [10,11].

According to the Encyclopedia of Sleep Discorders [12], posttraumatic hypersomnia is a disorder of excessive sleepiness that occurs within 18 months of a traumatic event involving the central nervous system. This disorder may manifest as longer sleep duration, excessive daytime sleepiness, or both [10,11,13]. According to some experts, patients with hypersomnia sleep at least one to two more hours per day compared to their pre-TBI condition, something that is referred to as pleiosomnia [13]. However, the baseline for establishing the one-to-two-hour increase in sleep need is based on TBI patients' subjective recollections of the amount of sleep that they used to get before the injury, and may therefore be imprecise [9]. Furthermore, increased sleep need could be mistaken for delayed sleep phase syndrome in younger TBI patients [14,15]. More importantly, the amount of sleep that TBI patients get may not necessarily represent the amount that they need, depending on family obligations and employment status. Unfortunately, these factors are rarely accounted for in TBI sleep research.

To date, the neurobiological bases for increased sleep need after TBI remain unknown; nevertheless, increased sleep need post-TBI has been associated with obstructive sleep apnea and depression [9]. Additional risk factors that predispose to development of posttraumatic SWD remain to be identified, however, as these conditions are unexplained in about 43% of individuals with TBI [16]. We recently found that pain was associated with changes in sleep microarchitecture in the first few weeks after mTBI [17]. Pain could also interfere with sleep in the chronic TBI phase (ie, more than six months postinjury), as both pain and sleep disturbances can persist years after the initial trauma [6,18,19].

In the present study, we examined whether pain was associated with sleep need exceeding 8 h per day at one month and one year after mTBI. We hypothesized that persistent pain is a contributing risk factor for the development and maintenance of excessive sleep need. We also explored the putative relationship between pain and napping behavior in this patient group.

2. Methods

2.1. Study design, sample, and ethics

A prospective cohort study design was used. Patients seeking care for first-time TBI (two patients per day on average) from 2005 to 2012 at the emergency department of a tertiary trauma center in Canada, who did not have any psychiatric or neurological condition or pain (acute or chronic) before the injury were screened and invited by a research nurse to participate in a home-based actigraphy and a two-night laboratory polysomnography assessment at approximately one month post-TBI. Nightshift workers, patients more than 65 years of age, and patients using medication or any substance known to influence sleep were not considered. All patients assessed at one month postinjury were invited to participate in a one-year follow-up assessment.

A control group composed of healthy individuals with no history of brain injury or sleep disorders was recruited directly via referrals and local newspaper advertisements. Controls were carefully selected to ensure comparability with mTBI patients in terms of sex (the majority were male) and age (18–63 years). All participants (ie, mTBI patients and controls) provided written consent. The study was approved by the ethics board of the trauma center.

2.2. TBI severity

Mild TBI diagnosis was confirmed by a trauma neurosurgeon (J.F.G.) based on the World Health Organization Task Force criteria [20], which include an initial score of 13–15 on the Glasgow Coma Scale upon presentation for healthcare, and a period of loss of consciousness or posttraumatic amnesia not exceeding 30 min after impact.

2.3. Sleep/wake assessment

Sleep/wake patterns were recorded with an actigraphy watch (Actiwatch2, Philips Respironics) that was worn on the patient's nondominant wrist for at least five consecutive days. For each recording day, participants were instructed to press on an event marker button when they were in bed ready to sleep and to press it again when they got out of bed. They also recorded in a sleep diary the time that they went to bed and woke up, as well as the frequency and duration of daytime naps. Participants' daily sleep/napping activities were estimated as follows: 1) if they pressed the event marker button, sleep/nap interval onset and offset were determined by the marker; 2) if they did not press the button, sleep/nap interval onset and offset were determined by bed and wakeup reports in the sleep diary; and 3) if they did not press the button or complete the sleep diary, sleep/nap interval onset was determined as the time when bodily activity dropped sharply, and offset was determined as the time when bodily activity rose [21,22]. Other variables were estimated using actigraphy software (Respironics Actiware, version 5.57) according to standard methods, including time spent in bed, sleep-onset latency, and nighttime sleep and wake duration [23]. Sleep efficiency percentage (ie, [total night time sleep duration/time in bed] $\times$ 100) was also computed.

2.4. Self-reported measures

Questionnaires were administered to all participants to collect sociodemographic, medical, and psychological data, including education level, marital status, and primary occupation at the time of assessment. Participants' mean pain intensity experienced over the last week was reported on a 100-mm visual analogue scale (VAS; score ranging from 0 = no pain to 100 = worst pain ever felt) on the last day of actigraphy assessment. Patients with mTBI were asked to report pain intensity exclusively related to the traumatic injury. In this study, participants (mTBI patients and controls) who reported moderate-to-severe pain over the last week (pain intensity $\geq$30 mm on the VAS) were considered to have pain, and those who reported either mild (pain intensity <30 mm on the VAS) or no pain were considered to be pain free. In addition, participants reported how much the pain that they had experienced over the last week had affected their quality of life, by rating the 36 items on the bodily pain subscale of the Short Form Health Survey (SF-36) [24]. In a prospective study of 514 TBI patients, the bodily pain subscale of the SF-36, with a score ranging from zero to 100 (such that higher scores indicated less impact on quality of life), was found to be a valid measure of health-related quality of life in this patient group [25]. In addition, in our study, all mTBI participants reporting moderate-to-severe pain were asked to identify on