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Original Article

Sleep difficulties one year following mild traumatic brain injury in a population-based study

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ABSTRACT

Background: Sleep quality affects all aspects of daily functioning, and it is vital for facilitating recovery from illness and injury. Sleep commonly becomes disrupted following moderate to severe brain injury, yet little is known about the prevalence of sleep disruption over time and how it impacts on recovery following mild injury.

Methods: This was a longitudinal study of 346 adults who experienced a mild brain injury (aged ≥16 years) identified within a population-based incidence sample in New Zealand. The prevalence of sleep difficulties was assessed at baseline (within two weeks), one, six and 12 months, alongside other key outcomes.

Results: One year post injury, 41.4% of people were identified as having clinically significant sleep difficulties, with 21.0% at a level indicative of insomnia. Poor sleep quality at baseline was significantly predictive of poorer post-concussion symptoms, mood, community integration, and cognitive ability one year post injury. The prevalence of insomnia following mild traumatic brain injury (TBI) was more than three times the rate found in the general population. Of those completing a sleep assessment at six and 12 months, 44.9% of the sample showed improvements in sleep quality, 16.2% remained stable, and 38.9% worsened.

Conclusions: Screening for sleep difficulties should occur routinely following a mild brain injury to identify adults potentially at risk of poor recovery. Interventions to improve sleep are needed to facilitate recovery from injury, and to prevent persistent sleep difficulties emerging.

1. Introduction

Traumatic brain injury (TBI) is the leading cause of disability in young adults worldwide [1], and the personal, societal, and economic costs of sustaining a TBI are substantial [2,3]. The effects of TBI are wide ranging and disabling, with symptoms persisting for many years after injury, even following a mild TBI [4,5]. The most common symptoms following a mild TBI include memory difficulties, fatigue, and poor sleep [6]. In the general population, rates of sleep problems can vary considerably based on how sleep is measured. Based on the Diagnostic and Statistical Manual of Mental Disorder (DSM) criteria [7], around 6% of people experience insomnia, with 34.5% found to be classified as poor sleepers [8]. Within the general population, poor sleep has been associated with an increased risk of poor health [9], absenteeism from work, and increased risk of accidents [10–12]. Following a TBI, the effects of poor sleep can be even more profound, exacerbating symptoms and impeding the ability to perform well at work or engage in rehabilitation [13–17]. Indeed, following moderate and severe TBI, poor sleep has been found to be associated with lower mood and poorer functional status [15]. Yet, despite its impact, sleep is one of the least explored symptoms following a mild TBI [17]. Understanding the role of sleep in recovery from injury and its impact on other symptoms is important to informing treatment and improving patient outcomes [18].

Sleep difficulties can occur as a direct result of the injury (eg, due to biochemical changes post TBI and injury to areas of the brain responsible for sleep) or as a secondary consequence in response to increased fatigue, lower mood, and changes in lifestyle following injury [17,18]. Current evidence suggests that the most common sleep difficulties experienced are falling asleep (sleep-onset latency),

Abbreviations: TBI, traumatic brain injury; ESS, Epworth Sleepiness Scale; PSQI, Pittsburgh Sleep Quality Index; HADS, Hospital Anxiety and Depression Scale; CNS-VS, CNS Vital Signs Neuropsychological test; CIQ, Community Integration Questionnaire; PCS, Rivermead Post-Concussion Symptom Scale.

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poorer sleep efficiency, longer sleep duration, increased used of napping [18,19], and increased sleep disruptions [20]. Whilst some cases of poor sleep post TBI resolve spontaneously, evidence suggests that sleep difficulties can become persistent for several years after injury [17]. In moderate and severe TBI, increased age, reduced cognitive ability, and being female have been identified as predisposing risk factors of poor sleep [21], yet it remains unclear if these factors are also risk factors of poor sleep following mild TBI.

A meta-analysis of prevalence studies on sleep difficulties following TBI [22] revealed that 49% of people experience clinically significant sleep disturbance post TBI, with 25–29% experiencing a specific sleep disorder. Whilst previous evidence has highlighted that sleep is highly problematic following TBI, estimates of the number of people affected vary widely. Variations may be due to differences in clinical definitions of sleep difficulties and sleep disorders, severity of TBI included, follow-up time points studied, and sample sizes used [17,22–24]. A further limitation of the evidence is that few studies have recruited participants who did not seek hospital treatment following injury. Non-identification of cases is particularly problematic when studying the prevalence of symptoms following mild TBI, as injuries may be overshadowed by other more obvious or severe injuries and/or people may not be aware of the need to seek medical treatment following a mild TBI [25]. Indeed, about 30% of cases seek treatment from community practitioners such as physiotherapists or general practitioners [26]; thus, findings from hospital-based studies may not be generalisable to the whole mild TBI population. This study aims to determine the prevalence of sleep difficulties in a population-based sample of adults who experienced mild TBI, and to identify their trajectory for recovery over the year following injury.

2. Methods

2.1. Study population

This study was conducted as part of a longitudinal, population-based TBI incidence cohort study known as *Brain Injury Incidence and Outcomes in the New Zealand Community* (BIONIC). Complete details of the methodology and TBI incidence findings have been published separately [26,27]. Within the main BIONIC study, all cases of TBI that occurred during a 1-year period (1 March 2010 through 28 February 2011) in the Hamilton and Waikato Districts of New Zealand (NZ) were identified. TBI was defined by the World Health Organisation criteria [28] as an acute brain injury resulting from mechanical energy to the head from external physical forces. People who received an injury to the upper half of their body from an external force were screened by a researcher to determine if a TBI had occurred and been 'missed'. People were asked how the injury occurred, if their head had been hit during the incident and if so if they had (1) lost consciousness or had been knocked out; (2) if they had been dazed or confused afterwards; and (3) if they could remember what had happened to them (as previously recommended) [29]. Information on all potential TBI cases based on self-report and/or medical records was reviewed by a diagnostic adjudication group including neurologists and neuropsychologists to determine if each case met the inclusion criteria for TBI for this study.

2.2. Procedures

All confirmed TBI patients were invited to participate in follow-up assessments at baseline (within two weeks of the injury) and at one, six, and 12 months to monitor their recovery. Assessments were completed in person at the participant's place of residence or at another mutually convenient location such as a private room at a general practice, library or at the university. The TBI incidence study included people of all TBI severities; however, 95% of TBIs identified were classified as mild (defined as a Glasgow Coma Score of 13–15 and/or post-traumatic amnesia of <24 h). Based on recommendations that the prevalence of sleep difficulties in TBI should be examined by the level of severity, in addition to the suggestion that sleep problems may be more likely to be disrupted following mild brain injury [16], only data on mild TBI cases aged ≥16 years were extracted for this analysis. As there is considerable heterogeneity of sequelae following mild TBI, each patient was further classified as having a high, medium or low risk of further complications in accordance with the Servadei criteria [30].

Patients were retained in the analysis where data on sleep quality were available for at least one follow-up time point. Patients who experienced a recurrent TBI within the 1-year follow-up period or those who had a prior sleep disorder due to a specific physiological cause (such as sleep apnoea) were excluded to reduce the potential impact on the findings from these factors.

Ethical approval was obtained from the Northern Y Health and Disability Ethics Committee of NZ (NTY/09/09/095) and from the Auckland University of Technology Ethics Committee (09/265). All participants included in the analysis provided informed written consent.

2.3. Assessments

At baseline, general demographic information, details of the injury, treatment received and details of co-morbidities and psychotropic medication were obtained from both self-report and medical records. Current work status, prior sleep disorders and prior TBI were obtained from self-report. All of these variables were included in the analyses. Follow-up assessments included self-report questions on medication use and recurrent brain injuries in addition to standardised measures used to assess key outcome domains found to be problematic following a mild TBI as outlined as follows:

2.3.1. Sleep

The Pittsburgh Sleep Quality Index (PSQI) [31] assesses overall sleep quality in addition to seven sub-scales; sleep duration, sleep onset, sleep latency, sleep efficiency, daytime dysfunction, disturbance, and use of medication to aid sleep. Lower scores indicate better sleep quality. A score of >8 has been found to reliably indicate the presence of insomnia in people who have experienced a TBI in accordance with the DSM criteria [19]. A score of >5 has been traditionally used to identify people with clinically significant sleep difficulties (poor sleepers) in the general population [31]. The PSQI is the recommended outcome measure to assess sleep post TBI [22], and it has been found to have a good test–retest reliability and correlates well with sleep diaries and polysomnography measures [32]. To provide a benchmark of sleep quality prior to the injury for comparison, participants were asked on a scale of 0 to 3, 'prior to your brain injury how would you have rated your overall sleep quality?'

2.3.2. Daytime sleepiness

The Epworth Sleepiness Scale (ESS) [33] contains eight items assessing the chance of falling asleep in different daily situations on a four-point scale. A total score is calculated by averaging scores on the individual items (0–24). Higher scores indicate a greater level of daytime sleepiness with a total score of >10 indicating clinical significant subjective sleepiness [33,34].

2.3.3. Post-concussion symptoms

The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) [35] was specifically developed to assess the severity of symptoms experienced after a brain injury. The RPQ has two subscales: the RPQ-3 assesses acute symptoms post TBI and the RPQ-13 assesses symptoms that emerge later post injury, which are associated