Electrophysiological analysis of the sleep onset period: A comparison between subjects with long term insomnia complaints associated with mild traumatic brain injury and matched controls

By

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Abstract

The purpose of the current undertaking was to study the electrophysiological properties of the sleep onset period (SOP) in order to gain understanding into the persistent sleep difficulties of those who complain of insomnia following mild traumatic brain injury (MTBI). While many believe that symptoms of post concussion syndrome (PCS) following MTBI resolve within 6 to 12 months, there are a number of people who complain of persistent sleep difficulty. Two models were proposed which hypothesize alternate electrophysiological presentations of the insomnia complaints of those sustaining a MTBI: 1) Analyses of standard polysomnographic (PSG) sleep parameters were conducted in order to determine if the sleep difficulties of the MTBI population were similar to that of idiopathic insomniacs (i.e. greater proportion of REM sleep, reduced delta sleep); 2) Power spectral analysis was conducted over the SOP to determine if the sleep onset signature of those with MTBI would be similar to psychophysiological insomniacs (characterized by increased cortical arousal). Finally, exploratory analyses examined whether the sleep difficulties associated with MTBI could be explained by increases in variability of the power spectral data.

Data were collected from 9 individuals who had sustained a MTBI 6 months to 5 years earlier and reported sleep difficulties that had arisen within the month subsequent to injury and persisted to the present. The control group consisted of 9 individuals who had experienced neither sleep difficulties, nor MTBI. Previous to spending 3 consecutive uninterrupted nights in the sleep lab, subjects completed questionnaires regarding sleep difficulties, adaptive functioning, and personality.
The questionnaire data confirmed the presence of a constellation of PCS symptoms including changes in adaptive functioning, psychiatric complaints, and disordered sleep, specifically related to sleep onset latency and sleep quality. The objective PSG data also confirmed the presence of sleep difficulties within the MTBI group. However, these data did not support the idiopathic model; no differences were found in sleep parameters other than in sleep onset latency, REM onset latency, and sleep efficiency. The only group difference that was found for mean power over the SOP was within the beta frequency (MTBI group associated with lower cortical arousal than controls). Thus, the presentation of the insomnia complaints secondary to MTBI was also distinct from that of psychophysiological insomniacs. However, consistent and strong group differences were found in the variability of power over the SOP within virtually all of the standard frequency bands such that the MTBI group demonstrated greater variability than controls. As variability in power reflects the magnitude of oscillations in arousal, the results provide a potential mechanism for the sleep pathology found in MTBI. That is, greater variability of power over the SOP may result in conditions that are incompatible with rapid sleep onset.
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Introduction

Before technology allowed scientists to quantify the electrophysiological features which accompany changes in levels of arousal, sleep onset could only be defined by a failure to respond to stimuli in the environment. Several definitions have evolved since that time. In an attempt to standardize the manner in which sleep is studied, Rechtschaffen and Kales (1968) developed criteria whereby a night of sleep is divided into consecutive time periods, called epochs. Epochs are sorted into stages which are determined by information obtained by electroencephalogram (EEG), electro-oculogram (EOG), and electromyogram (EMG). The onset of sleep was defined as the first epoch of sleep stage one as determined by electrophysiological indices (Rechtschaffen & Kales, 1968). However, neither subjective reports of sleep (Anch, Browman, Mitler, & Walsh, 1988) nor behavioural indices of the onset of sleep (Ogilvie, Simons, Kuderian, Macdonald, & Rustenburg, 1991) coincide to a large extent with the standard definition. As there is great variability among various definitions, there has been a movement to reject the notion that the onset of sleep occurs at a specific point in time, but rather that sleep onset be considered a period of transition between the two fundamental states of arousal, wakefulness and sleep. This period of transition is referred to as the sleep onset period (SOP) (Ogilvie & Wilkinson, 1984; Ogilvie & Wilkinson, 1988; Ogilvie, Wilkinson, & Allison, 1989).

In recent years scientists from many countries have closely considered the SOP in order to study how and why people fall asleep, daytime sleepiness, and sleep pathology which arises out of an inability to control the onset of sleep (see Ogilvie & Harsh, 1994).
Such investigations have found that an elaborate system of behavioural, cognitive, physiological, and electrophysiological changes occur during the SOP. For example, Ogilvie et al. (1991) were able to determine that predictable EEG changes accompany the period leading up to and including the onset of sleep. Hori et al. (1994) further elaborated this finding to distinguish 9 EEG stages during the transition from wakefulness to sleep which extend to the appearance of the first spindle during traditional stage two sleep. Studies investigating the SOP using electrophysiological measures have been successful in determining differences between the mechanisms of sleep onset between normal control groups, and groups exhibiting disorders related to sleep difficulties such as insomnia (Lamarche & Ogilvie, 1997), narcolepsy (Alloway, Ogilvie, & Shapiro, 1999), and depression (Armitage, Hudson, Fitch, Pechacek, 1994). The examination of the SOP of yet another special population associated with difficulties during the transition from wakefulness to sleep is the focus of this paper.

Mild traumatic brain injury (MTBI) is a serious problem which affects a large number of people every year. It has been well established in the research literature that MTBI, with even momentary or no loss of consciousness at all, often results in symptoms which include cognitive, physical, and affective difficulties. However, people in general fail to understand the seriousness of such incidents. Baubrey et al. (1989) report that lay people overestimate the amount of impact that is necessary to produce the most common physical symptoms, and judge the cognitive symptoms typical of MTBI no more likely than unrelated symptoms. In addition, according to Segalowitz and Lawson (1995), symptoms of MTBI are often subtle and go unrecognised; as a result, a large proportion
of cases are not reported. In contrast to the prevalence rate of 3%, which is reported by hospitals, a 10% to 31% prevalence rate for MTBI is estimated when self report is used (Segalowitz & Lawson, 1995).

One of the most tenuous difficulties of research into MTBI is how the construct is defined. Experts disagree on every element from how mild is mild, to what the key variables are which determine severity, as well as appropriate terminology for the condition. The following definition of minor head injury (MHI) was developed by Levin and colleagues in a multi-centre study. According to Levin, Gary et al. (1987) there are three components which define trauma to the head as MHI: 1) a loss of consciousness of 20 minutes or less; 2) a hospital admission Glasgow coma scale rating of 13 to 15; and 3) period of hospitalization not exceeding 48 hours.

As the terminology “head injury” encompasses a large number of types of injuries (from gross contusions of the brain, to inconsequential lacerations of the skin), a distinct definition was adopted for the current undertaking that better reflects the specific phenomenon under study. MTBI was defined as a blow to the head in the MHI range of severity, resulting in symptoms associated with post concussion syndrome (PCS) at the time of injury. Refer to Zasler (in press) for a discussion of the issues of nomenclature related to MTBI.

The most prominent symptoms of MTBI are often referred to as PCS. This group of symptoms includes sleep difficulties, dizziness, fatigue, headaches, impairments in attention, poor concentration, sensitivity to noise, memory problems, depression, and others (Bigler, 1990). The time frame of the onset and dissipation, if any, of these
symptoms is not clearly delineated in the literature. The onset could be days or weeks after the injury (Benton, 1989), and the duration is generally regarded as short term, with most symptoms expected to disappear within one to three months (Levin, Mattis, et al., 1987). However, Bigler (1990) reports that symptoms could last up to 6 or 12 months. In addition, there is a body of literature suggesting that a proportion of those who sustain a MTBI report some permanent deficits. That is, although a year or more has passed since the incident, and even upon return to work or school, some individuals may suffer residual effects. For example, Gronwall (1989) reports that there are lasting effects of MTBI on attention and cognition, and others (Segalowitz & Brown, 1991; Segalowitz & Lawson, 1995) have found significant relationships between MTBI and developmental disabilities such as attention deficit, speech, language, and reading disorders suggesting permanent change in neurophysiological function. In general, individuals suffering from concussions have demonstrated a reduction in adaptive functioning up to 5 years after the injury (Eide & Tysnes, 1992).

It is clear by definition that there are associations between MTBI and the state of arousal of the victim. This thesis addresses one of the most common relations between TBI and sleep, that is, the sleep difficulties which are secondary to head injury such as described above. The purpose of the current study was to examine the SOP in order to better understand specific changes in sleep onset mechanisms, if any, that are secondary to TBI. Before the specific symptoms of MTBI associated with sleep are discussed and hypotheses drawn as to differences between the sleep onset mechanisms of the MTBI and controls, it is important to first review the pathobiology of TBI and identify possible
areas of overlap with the areas in the brain associated with sleep.

The Pathobiology of MTBI

The neuropathology of TBI arises out of the accelerative, decelerative, and rotational forces which are exerted on the brain during traumatic impact. When the brain is effected in such a way, there are several outcomes which could result in brain damage. First, interactions between the skull and brain are central. Although cerebral contusions (bruises caused by the brain colliding with the skull) are more typically related to more severe closed head injuries, there is evidence to suggest that they are present in a percentage of cases where injury may be categorized as mild (Levin, Gary et al., 1987). The areas at most risk for damage due to contusions are the frontal cortex (particularly orbitofrontal), and temporal cortex. This is as a result of the protuberances of the inside surface of the skull adjacent to and encapsulating these areas (Bigler, 1990).

Second, but of primary importance, are the diffuse effects which damage axons of neurons as well as the supportive glial cells which are necessary for neuronal survival (Bigler, 1990). It has been recognized for some time that diffuse axonal injury (DAI) may play an important role in the pathobiology of TBI (Oppenheimer, 1968; Gennarelli et al., 1982). Studies examining DAI have demonstrated that the most prominent areas of damage are white matter structures (Bigler, 1990). Specifically, DAI is most often found throughout the brain stem (including medulla, pons, and midbrain structures), the corpus callosum, and even the basal ganglia. Although this type of damage is more widespread in cases of severe TBI, it has been demonstrated that such microscopic
destructive foci can have a permanent effect after MTBI as well (Oppenheimer, 1968).

DAI was once thought to be the result of tiny lesions caused by the shearing of axons at the time of injury. However, with the use of experimental animal model research, Povlishock and colleagues (Povlishock, 1992; Povlishock & Christman, 1995) have demonstrated that axotomy and eventually the diffuse cell death seen in TBI occurs secondary to changes in the permeability of the axonal membrane and subsequent axonal swelling. According to Povlishock (1992), the effects of DAI (i.e. cell death, and deafferentation of adjacent neurons) are not fully realized until days after the insult occurs. Moreover, Povlishock (1992) states that DAI provides for conditions associated with plasticity, the ability of the brain to recover function. That is, subsequent to retraction of the dead axons, the resulting empty target sites may acquire new projections as they are often situated in immediate proximity to networks of healthy neurons of the same system (Povlishock, 1992).

DAI seems to be the most likely mechanism of damage in MTBI. The time course of the sequelae of MTBI coincide with the effects of DAI as outlined by Povlishock and colleagues. As previously mentioned, symptoms of PCS arise in the days following the injury, and in most cases dissipate within six months to a year following the incident. If Povlishock’s model is correct, it provides not only for the mechanism of damage, but also that of recovery. However, it also leaves open the possibility for individual differences in degree of recovery. That is, some people who sustain a TBI may recover some functions and not others, while other individuals may attain a partial recovery of all functions but incur permanent effects to some degree.
It follows from the model that the extent of recovery is related to a number of factors. Severity of the injury would no doubt be related to the potential for recovery. The more damage the less likely that neurons of the same system would be available to project to empty target sites. In addition the effects of multiple injuries could seriously undermine the ability to recover. The cumulative effects of DAI are perhaps the most devastating as they can result in diffuse atrophy and volume loss of the brain (Bigler, 1990).

**Neuroanatomical Correlates of Sleep and Sleep Onset**

Over the history of the search for a neuroanatomical "sleep-wake centre" it has become clear that no solitary structure or area is responsible for the maintenance of the sleep-wake cycle. As described by Villablanca (1974), several specialized structures work in conjunction with one another in an integrative fashion in order to produce wakefulness and sleep. The most notable studies in search for the neuroanatomical correlates of the onset of sleep date back to the 1930's and the pioneering work of Frederic Bremer. The cerveau isole performed by Bremer, a transection of the brain stem at the level of the midbrain, is a surgical preparation which produced continuous slow wave sleep in cats (Bremer, 1935). Bremer attributed the sleep state elicited by the isolated forebrain to a lack of minimal afferent stimulation from the ascending sensory pathways (Bremer, 1974). However, the theory that sleep is a passive process, a default state which occurs in accordance with an absence of sensory stimulation, was to come up against opposition.
Bremer’s passive theory was later refined when in subsequent studies, after encephale isole preparations, transections of the brain stem in the caudal region, sleep wake cycles remained intact (Anch et al., 1988). This finding led to the conclusion that arousal was a function of some system located between the midbrain and the spinal cord. Later, the ascending reticular activating system (ARAS) theory came to the forefront as several studies, most notably those completed by Moruzzi and Magoun (1949), demonstrated that high levels of stimulation to the reticular activating system were associated with waking states, while low levels of stimulation were associated with sleep. However, it became clear that a model which included the ARAS as a solitary sleep centre was not complete. It was demonstrated later that if animals were kept alive who had previously undergone cerveau isole surgery, their sleep-wake patterns would eventually return (Anch et al., 1988).

In accordance with theories which considered the role of the brain stem as a centre for arousal, several studies have demonstrated that there are sleep inducing systems within this structure. For example, Berlucchi, Maffei, Moruzzi, and Strata (1964) demonstrated that temporary lesion procedures to the caudal areas of the brain stem caused sleeping cats to awaken. Moreover, Jouvet and Renault (1966) induced insomnia in experimental animals by lesioning the raphe nuclei, a pathway of neurons which run along the caudal brain stem through the pons and medulla. Thus, along with its role in maintaining levels of arousal, the brain stem has been associated with actively inducing a state of sleep.
The systems which have been associated with inducing a state of sleep are not limited to ascending pathways. Villablanca (1974) presents experiments whereby the thalamus is implicated in playing a role in regard to several aspects of sleep. Villablanca (1974) purports that an intact thalamus is crucial for the production of spindle waves, that damage to the thalamus reduces both REM and NREM sleep, and that the thalamus works in conjunction with other sleep-wake controlling structures such as those found in the caudal and rostral brain stem.

In addition to thalamic influences in the elicitation of sleep, the basal forebrain has also been associated with the processes of falling asleep. Sterman and colleagues have reported a number of studies whereby lesions to the basal forebrain of cats produced a significant amount of sleep reduction, and stimulation of this area induced slow wave sleep (Sterman and Clemente, 1974). The suggestion made by Sterman and Clemente (1974) is that through its projections to the thalamus and the midbrain reticular core, the basal forebrain acts to dampen sensory and motor pathways and initiate EEG synchronization. Indeed, descending cholinergic inhibitory pathways involved in sleep extend from the basal forebrain to the medulla (Steriade & McCarley, 1990).

The evidence for the active control of sleep through descending pathways is not conclusive. For example, single cell studies examining the firing rates of basal forebrain neurons have demonstrated that 70% or more are active during the waking state or are indifferent to state of arousal (Steriade & McCarley, 1990). Therefore, the evidence does not overwhelmingly support a theory of sleep onset which includes activation of a single sleep inducing centre or the passive occurrence of sleep as a function of the absence of
arousal. Most likely, the onset of sleep arises out of the coordination of a number of systems working in conjunction with one another.

Upon consideration of the neuropathology of MTBI, it may be demonstrated that some of the anatomical structures that are at risk of damage due to injury overlap with structures that have been associated with the onset of sleep. It is possible that the sleep inducing structures are at particular risk when considering such damage. Specifically, the raphe nucleus, and the descending sleep inducing pathways from the basal forebrain and the thalamus may be affected by DAI. As experimental lesions to these structures produced insomnia, it follows that damage to these areas could result in similar complaints from those who have sustained MTBI.

**Severe TBI and Sleep**

A substantial body of literature exists within the EEG domain which has linked the field of the study of sleep to severe TBI. There have been a number of studies which have evaluated the use of polysomnographic data in order to determine the prognosis of individuals with post traumatic coma (e.g. Bergamasco, Bergamini, Doriguzzi, & Fabiani, 1968; Rumpl et al., 1983; Rae-Grant, Barbour, & Reed, 1991; Evans & Bartlett, 1995). In general, the results of such studies indicate that the presence of normal sleep and circadian activity is related to favourable outcome (Bergamasco et al., 1968).

More recently, studies have tried to ascertain which components of normal sleep are most predictive of good outcome; Rumpl et al. (1983) suggested that well formed spindle activity was indicative of positive outcome, while Rae-Grant et al. (1991)
developed and were able to validate a scale for prognosis of severe TBI which incorporated a number of components of sleep. The presence of background alpha activity, as well as the presence of symmetrical spindles were strong predictors of good outcome (Rae-Grant et al., 1991).

From the larger body of research, studies of the long-term polysomnographic outcome of severe TBI have been conducted. Cadihac, El Kassabgui, and Passouant (1967) in their study of eight patients who had comas of several days in length, noted disturbances in sleep architecture that persisted, in some subjects, months after consciousness had been regained. Those changes were early first REM stage onset, bouts of insomnia throughout the night and instability of REM periods. Other changes in sleep architecture have also been noted. George and Landau-Ferey (1986) demonstrated that in comparison to normal controls, 12 months after recovering from severe TBI, the patients had more awake time after sleep onset and significantly less REM sleep.

The relationship between disturbed sleep and TBI has been well documented in regard to the occurrence of sleep disorders secondary to severe head injury. Some studies have found evidence for sleep onset insomnia (Manseau & Broughton, 1990) as well as disorders of initiating and maintaining sleep more generally (Cohen, Oksenberg, Snir, Stern, & Groswasser, 1992) in those who have previously experienced traumatically induced coma. However, pathological sleep associated with severe head injury has not been limited to the insomnia type. Further problems that have been related to severe TBI include disorders of excessive daytime somnolescence, delayed sleep phase disorder, jactatio nocturna (head banging or body rocking), and impairments in dream recall.
(Patten, & Lauderdale, 1992; Drake, 1986; Murri, Massetanni, Giovanditti, & Arena, 1985).

**MTBI and Disturbed Sleep**

There is a clear relationship between MTBI and disordered sleep in the research literature. Sleep difficulties are one of the most frequently reported of the symptoms of post concussion syndrome. According to a three centre study conducted by Levin, Gary et al. (1987), difficulty sleeping was the fourth most commonly reported symptom, and occurred in 43.9% of people sustaining MTBI. Moreover, a recent study examining the long term prevalence of MTBI symptoms reported that in a mildly injured sample, 26.3% complained of sleep disturbance five years subsequent to injury (Masson et al., 1996).

Given the well-established relationship between disordered sleep and severe types of head injury and considering that sleep difficulties are one of the most commonly reported problem associated with PCS, surprisingly little research has been conducted on the relationship between MTBI and difficulties with sleep in an in-depth manner. This gap in the literature is evident upon examination of recent reviews of the sequelae of MTBI (Miller, 1996; Swenson, 1997; Zasler, in press). Not only are the sections in such papers regarding sleep brief, but in some cases they refer the reader to studies based on samples of severe head injured populations. Nonetheless, Swenson (1997) reports that alpha wave intrusion into slow wave sleep is responsible for the non-restorative sleep experienced by many with MTBI, and that this could be a contributing factor to fatigue.
Studies of MTBI and Sleep during the first 6 months Post-Injury

An analysis of the few studies that have been conducted in this area provide a more clear picture of the sleep difficulties encountered by those sustaining MTBI. Parsons and Ver Beek (1982) examined the self reported sleep related problems in 75 (16 to 30 year old) subjects before and three months after sustaining a mild MTBI. After sustaining a MTBI, the number of sleep interruptions per night and per week increased, difficulty in returning to sleep after an early morning awakening increased, and an increase in the time needed to function at peak efficiency in the morning was reported. The location of injury was not related to any changes in sleep wake patterns, (Parsons and Ver Beek, 1982). Overall, the problems secondary to MTBI reported by Parsons and Ver Beek (1982) resemble disorders in initiating and maintaining sleep.

Lenard and Pennigstorff (1970) examined overnight polysomnographic (PSG) data in an infant and young child (2 months to 3 years old) MTBI population. Recordings were taken within five days post trauma and compared to recordings taken one to three weeks subsequently. When compared to the later session, immediately following trauma there was more stage 2 sleep, a higher percentage of stages with spindles, the inter-spindle interval was shorter, and spindle duration was longer. In addition, Lenard and Pennigstorff (1970) report more eye movements during the recoding night most proximate to the injury.

Recently, Parsons, Crosby, Perlis, Britt, and Jones (1997) published a study that also examined the overnight PSG in MTBI over the recovery period. PSG recordings were made 72 hours, 6 weeks, and 12 weeks post trauma in subjects aged 15 to 19 years
old. Contrary to the findings of Lenard and Pennigstorff (1970), no differences were found in overall sleep architecture. However, Parsons et al. (1997) do report changes in the power spectral analysis of the first and second cycles of rapid eye movement (REM) and non-rapid eye movement (NREM) sleep. Over the 12 week period there were decreases in mean log power of theta and low alpha during the first cycle of NREM sleep, and during the second cycle of NREM sleep, significant decreases were found in delta, theta, and low alpha frequencies (Parsons et al., 1997). There was also a significant decrease in theta activity during REM sleep from the first recording to the second and third recordings. According to the authors this change represented an intrusion of theta into REM sleep followed by a return to baseline.

Both studies to date which have examined overnight PSG in MTBI used similar designs: multiple recordings were taken over the post-injury/recovery time period. The authors of both papers use the later recordings as controls against which to determine the degree of disruption observed in earlier recordings, and base their conclusions on this comparison. Such interpretations are clearly inappropriate as they are unable to take into account the pre-injury condition of subjects. The authors are forced to falsely assume that by the final recording, a full recovery has been made (which also assumes that every subject will in fact make a full recovery). Notwithstanding this limitation, the PSG studies demonstrate that there are interesting changes in the electrophysiological properties of sleep during the recovery period after MTBI. The most notable such changes were differences in spindle frequency (Lenard & Penigstorff, 1970) and stage specific alterations in delta, theta, and low alpha frequencies (Parsons et al., 1997).
**MTBI and Long Term Sleep Difficulties**

The only studies to date examining the relationship between sleep and MTBI in the long term (i.e. after 6 or 12 months) have examined sleep complaints by self-report survey methods. Perlis, Artiola, and Giles (1997) report findings with their sample of MTBI subjects which were compared to orthopaedic surgery patient controls (in order to determine that sleep complaints were due to the head injury rather than pain). They found that the MTBI subjects more frequently reported problems with the initiation of sleep, difficulties with the duration of sleep, and problems with inappropriate naps during the day. In addition to these subjective perceived difficulties, MTBI subjects also estimated significantly longer sleep onset latencies, significantly more awakenings during the night, and significantly fewer hours of sleep than the controls (Perlis et al., 1997). Because the study did not involve overnight polysomnography, neither an in depth analysis of sleep architecture could be completed, nor could any other psychophysiological comparisons be made between the two groups. However, although there was great variability in length of time since injury, the study did suggest that the sleep related problems reported by individuals with MTBI are long term; the mean time since injury of the subjects was 24.1 months, a time period well beyond when the post concussion syndrome is thought to subside.

The remaining studies also point to long term sleep difficulties in subjects sustaining MTBI. Although difficulties associated with sleep are part of the widely accepted “short term” post concussion syndrome, Eide and Tysnes (1992) found that one to five years after MTBI occurred, 41% of subjects had difficulty with sleeping.
Segalowitz and Lawson (1995) report a survey of university and high school students who were asked questions regarding history of head injury and a number of other symptoms. In general, the significant difference that was found was that sleep difficulty was more prevalent in those who had sustained a minor head injury than those who had not. The university sample from the study was asked more in-depth questions about the kind of sleep difficulties they had. Those subjects with a head injury took longer to fall asleep, reported more difficulties with awakenings during the night, more difficulties with falling back to sleep after awakenings, and were troubled more often by disturbed sleep (Segalowitz and Lawson, 1995). Moreover, those with multiple head injuries reported more sleep related difficulties than those who did not have any injury or those who reported only one injury (Segalowitz and Lawson, 1995). The studies by Segalowitz and Lawson (1995) and Eide and Tysnes (1992) suggest that sleep difficulties are among the long term problems that people with MTBI face.

Beetar, Guilmette, and Sparadeo (1996) conducted a study of a number of populations: two TBI (mild vs. moderate/severe) and neurologic patient control. Similar to the Perlis, Artiola, and Giles (1997) study, the mean time since injury was approximately two years (mean = 23.9, S.D. = 21.2) and there was a large amount of variability between subjects. Nevertheless, Beetar et al. (1996) found evidence for insomnia-type sleep disruption that could not be accounted for by chronic pain. In MTBI subjects between 13 and 59 months post-injury who did not report any pain, there was an insomnia prevalence rate of 28.9%, and a prevalence rate of 23.7% in those without pain who were 60 or more months post injury.
Interestingly, Beetar et al. (1996) report that there were significantly more complaints of insomnia in the MTBI group than there were in the moderate to severe TBI group. This finding was further substantiated by a recent study that examined the long term sleep effects associated with TBI. Clinchot, Bogner, Mysiw, Fugate, and Corrigan (1998) report that the likelihood of acquiring sleep difficulties due to head injury decreased as severity increased.

It should be reiterated that considering the prevalence of sleep difficulties in individuals sustaining MTBI, and the well established relationship between severe head injury and disordered sleep, surprisingly little research has examined the sleep difficulties of MTBI population in depth. To my knowledge, only two such studies have included overnight polysomnographic recording, a procedure integral to understanding disordered sleep. Both of theses studies (Lenard & Pennigstorff, 1970; Parsons et al., 1997) examined short term effects only. Nonetheless, several conclusions may be drawn from the surveys that have been conducted regarding MTBI and sleep difficulty. First, a large proportion of the MTBI population have sleep related complaints. Second, although they have been reported as part of a short term post concussion syndrome, these problems persist, in some individuals, years after the injury was sustained. Third, within this population the sleep disturbance seems to take the form of disorders in initiating and maintaining sleep (difficulties falling asleep being the most common complaint).

Finally, greater sleep related problems are associated with multiple injuries but not necessarily more severe injury.
Insomnia Complaints

The sleep related complaints of individuals with MTBI described above resemble disorders in initiating and maintaining sleep, or insomnia. Insomnia may be defined as a complaint or a group of complaints regarding initiating and maintaining sleep such as difficulty falling asleep, waking up throughout the night, an inability to fall back to sleep once awakened, and early morning awakenings (Hartmann, 1988). However, applying a single label of insomnia does not either explain the disorder or imply a single etiology. In fact, insomnia can be viewed as a disorder which may be acquired from extremely diverse origins. The observation that insomnia complaints arise from several distinct origins has guided the development of, or defined, a number of insomnia sub-types, and in turn, these sub-types direct research and ultimately treatment. For example, one subtype of insomnia, psychiatric insomnia, is comprised of individuals whose primary diagnosis is of a psychiatric origin such as depression. Complaints of an inability to fall asleep or maintain sleep are secondary to the psychiatric illness. Other similar examples are insomnia secondary to medical conditions or insomnia secondary to other sleep difficulties such as obstructive sleep apnea or restless legs.

The International Classification of Sleep Disorders (ASDA, 1990) also identifies two other sub-types of insomnia and classifies them as intrinsic because the origin of the problem is within or arises from within the individual under consideration. Psychophysiological insomnia is also known as learned insomnia because it arises out of anxiety/tension which is followed by learned associations which counteract sleep (ASDA, 1990). That is, during some period in time while an individual experienced
chronic tension, pain, or anxiety, insomnia was learned through either internal conditioned associations (e.g. fear of being unsuccessful at falling asleep leading to increased arousal, which in turn cues the same fear of inability to fall asleep) or external conditioned associations (e.g. sleep environments have become conditioned stimuli for arousal because of previous failure to fall asleep) (Hauri & Fisher, 1986). With psychophysiological insomnia, because the inability to fall asleep is a learned behaviour, the problem persists even in the absence of, or after the original anxiety or tension has subsided.

Idiopathic insomnia (childhood-onset insomnia) is defined as a pattern of chronic inability to obtain adequate sleep that has persisted since childhood. It is believed to be due to some type of dysfunction of the neurological control of the sleep wake cycle (Morin, 1993; ASDA, 1990). Idiopathic insomnia is rare and distinguishable from other types of insomnia because it is stable and persists throughout changes or shifts in emotional well-being or psychological stress (Hauri & Olmstead, 1980). Those individuals diagnosed with this type of insomnia often present with atypical polysomnographic features such as poor spindle development, long bouts of REM sleep with the absence of eye movements, and intermixed sleep stages (ASDA, 1990).

Departures from normal sleep architecture are also characteristic of idiopathic insomnia. A typical night’s sleep may involve very little slow wave sleep (Hauri, 1983), and greater than normal amounts of REM sleep (Hauri, & Olmstead, 1980). In addition, Hauri (1983) reported that in a group characterized as moderate insomnia, on the first night of study, REM onset latency was significantly increased.
The Sleep Onset Period

Recently, investigators have examined the SOP in order to gain understanding into the sleep pathology that is related to the transition from wakefulness to sleep. Some such studies have used electrophysiological measures to successfully determine differences between the mechanisms of sleep onset between normal control groups, and groups exhibiting disorders related to sleep. Among them are studies of difficulties such as insomnia (Lamarche & Ogilvie, 1997), narcolepsy (Alloway, Ogilvie, & Shapiro, 1999), and depression (Armitage, Hudson, Fitch, Pechacek, 1994). The Lamarche and Ogilvie (1997) study used a micro analysis of the SOP in order to differentiate psychophysiological insomniacs, psychiatric insomniacs, and controls. This micro analysis is essentially a between-group comparison of the sleep onset mechanism as determined by electrophysiological indices. That is, the analysis is aimed at determining if groups fall asleep differently. EEG recordings were taken and power spectral analysis was conducted for all standard frequency bands (beta, sigma, alpha, theta, delta) during the SOP. Overall, it was found that the psychophysiological insomniacs displayed different sleep onset mechanisms from the controls and the psychiatric insomniacs. The latter two groups fell asleep in a similar manner. During wakefulness, the psychophysiological insomniacs had more beta (indicating higher physiological arousal) and less alpha; the alpha did not show as dramatic a drop during the descent into sleep. Less delta was shown during the latter stages of the SOP as compared to the other two groups (Lamarche & Ogilvie, 1997).
Lamarche (1995) also examined a measure of variability of the power spectral analysis. Changes in the direction of the slope between consecutive 10 second FFT records were calculated in order to achieve a measure of variability of the sleep onset processes. There was significantly higher variability in psychophysiological insomniacs as compared to controls in the alpha and delta frequency bands. McCartney, Bonato, Ogilvie, and Ogilvie (1998) also found significant differences in variability of power spectral analysis between normal and insomniac populations. They examined standard deviation of power, a more commonly used metric of variability over the first five minutes of stage two sleep. Among several significant findings, McCartney et al. (1998) reported significantly more variability in insomniac than control sleepers.

Rationale and Hypotheses

As survey methods have been successful in determining that persistent insomnia complaints are present in the MTBI population, the purpose of the current study was to obtain and examine a sample from the MTBI population in which such complaints are present. That is, individuals who complain of insomnia secondary to MTBI were studied along with controls, specifically in order to determine any differences in objectively measured electrophysiological data.

Electrophysiological sleep data allow for a number of analyses to be conducted. First, standard descriptors of overall sleep architecture were measured such as sleep onset latency, REM onset latency, sleep efficiency, sleep stage percentages, and wake after sleep onset. Second, a micro-analysis of the sleep onset period was undertaken in
order to gain a better understanding as to the nature of the insomnia-like complaints of MTBI subjects. Measures of power and variability of power within standard frequency bands across the sleep onset period were examined from power spectral analyses that were performed on the data.

Two models are proposed which hypothesize alternate electrophysiological presentations of the insomnia complaints of those sustaining a MTBI. The models are based on groups which have known electrophysiological presentations, and whose etiologies may bear similarities to those of the MTBI population under study. It should be noted that because little is known regarding the electrophysiological presentation of insomnia secondary to MTBI, analyses will be presented that carry no hypotheses (i.e. exploratory analyses).

Idiopathic model

The idiopathic model, purports that the sleep difficulties experienced by those sustaining MTBI will present in a similar manner to idiopathic insomnia, which is thought to arise from damage or change to the neurological systems which maintain the sleep-wake cycles. The most likely mechanism of damage in MTBI results from the diffuse effects which occur when the brain is rapidly accelerated, decelerated, or rotated. The result is that neural tissue is strained and twisted and over time tiny lesions occur within the nerve fibres; damage of this nature is referred to as DAI (Povlishock, 1992; Povlishock & Christman, 1995). As previously mentioned, studies examining DAI have demonstrated that the most prominent areas of damage are rich in white matter (i.e. medulla, pons, and midbrain) (Bigler, 1990), the corpus callosum, and even the basal
ganglia (Oppenheimer, 1968; Gennarelli et al., 1982). As the neuroanatomical structures which are responsible for the maintenance of sleep wake cycles (mainly brain stem structures) overlap with the neuropathology of MTBI, it is conceivable that the sleep difficulties that are experienced by those sustaining a MTBI are associated with actual damage or disruptions within these systems. Moreover, as idiopathic insomnia is thought to be caused by “abnormality of the neurological control of the sleep-wake system” (ASDA, 1990, p.35), it is expected under this model that the sleep difficulties of those sustaining MTBI will present similarly to idiopathic insomniacs. As the electrophysiological presentation of idiopathic insomnia is related to departures from normal sleep architecture, the following would be expected if the idiopathic model is correct:

1. The MTBI group will exhibit significantly greater percentage of REM sleep than controls.
2. The MTBI group will demonstrate significantly less delta sleep (i.e. stages 3 and 4) than controls.

**Psychophysiological model**

The psychophysiological model proposes that post concussion syndrome, which follows MTBI, is the source of the initial levels of anxiety and tension sufficient to induce a psychophysiological presentation of insomnia. As previously mentioned, it is common for individuals who sustain a MTBI to experience cognitive, physical and affective difficulties for a period of time after injury. Included in these are dizziness, pain, sensitivity to noise, and impairment in attention: symptoms which could lead to
difficulties in initiating and maintaining sleep. If an individual developed the internal and external sleep-preventing associations which are characteristic of psychophysiological insomnia in the months following injury, it is possible that even after most of the post concussion symptoms had subsided, difficulties with sleeping could persist.

The psychophysiological model predicts that the MTBI group will present similarly to psychophysiological insomniacs. As the electrophysiological presentation of psychophysiological insomnia involves a specific sleep onset process signature (as measured by a power spectral micro-analysis of the SOP), the following relationships are expected if this model is correct:

1. The MTBI group will have lower delta than controls during the latter portion of the SOP.

2. The MTBI group will not demonstrate the dramatic drop in alpha over the course of the SOP which is characteristic of normal sleepers.

3. The MTBI group will demonstrate higher levels of beta during the initial portion of the SOP.

**Predictions regarding variability**

The variability of the power spectral analyses were undertaken as exploratory analyses. As previous studies have found some evidence for greater variability in insomnia populations as compared to controls (in alpha and delta frequencies) it was expected that there would be higher levels of variability in the MTBI group than the control group.
Method

Subjects

Subject recruitment

Participants for the study were recruited via posters placed around Brock University campus, through surveys filled out by individuals enrolled in the first year undergraduate psychology course, and through an article in the local newspaper. In regard to the survey method, participants completed questions about history of head injury as well as sleep difficulties, and were given the opportunity to indicate whether or not they were interested in being contacted in order to participate in further research.

Volunteers for the MTBI group were asked to come in for an interview and questionnaire period if they satisfied the following criteria based on a telephone interview: i) at least 6 months post injury, but no longer than 6 years post injury; ii) clear experience of a constellation of MTBI symptoms at the time of injury; iii) subjects could clearly distinguish between sleep patterns before and after injury; iv) sleep difficulties arose within a month post injury; vi) sleep complaints were characterized by sleep onset of greater than 30 minutes on more days than not in a given week; vii) within the age range of interest.

Volunteers for the control group were asked to come in for an interview and questionnaire period if they satisfied the following criteria based on a telephone interview: i) absence of history of head injury; ii) absence of history of sleep difficulties; iii) within the age range of interest to the study.
Subject screening and selection

Of the 27 subjects who were recruited and completed the interview and questionnaire session, three were screened out and were not asked to come in for the overnight sessions. Of those three, one was screened out for a history of depression previous to MTBI, one did not meet the requirements for the MTBI group (i.e. sleep difficulties had arisen previous to injury), and one did not meet those of the control group (i.e. had a history of head injury). A further two subjects decided not to take part in the study after the interview and questionnaire session. Subsequent to the first night of the overnight sessions, one subject was released because of an allergic reaction to the hook-up materials. Finally, after the study had been completed, data from three subjects, one head injured and two control, were not used for analyses. One male and one female control subject were eliminated because a normal night of sleep was not obtained over the three study nights, and irregular EEG was obtained, respectively. The third subject was eliminated from the MTBI group because the severity of his injury (unconscious for 90 min., 420 min. of PTA, 120 min. RA) was not within the mild range, and was clearly more severe than any of the other members of the group (See Table 2 for severity information of the MTBI group).

MTBI and control groups

Data from a total of 18 subjects are reported, 9 in each of the MTBI and control groups. Ages ranged from 18 to 26 years. Of the nine subjects from the MTBI group, 6 were male and 3 were female. Of the nine participants in the control group, 5 were female and 4 were male. All of the subjects were students at Brock University except
one, who was a recent graduate. In regard to verbal ability, the means of both groups were approximately one standard deviation above the mean in the general population (controlling for age). Thus, no differences existed between groups for verbal ability and both groups were within the normal range. Refer to Table 1 for a summary of the demographic information for both groups.

Table 2 contains descriptive information regarding the nature and severity of the injuries sustained by the MTBI group. The mean time post injury was 27.78 (SD=15.47) months. All subjects were within a range of 8 months to 4.5 years post injury. At the time of the study all subjects in the TBI group reported persistent post concussion symptoms that had arisen within a month post injury.

According to the definition as previously described, all subjects in the MTBI group fell within the mild range. Each subject had a length of unconsciousness of 5 minutes or less, and spent 17 hours or less in the hospital (directly after sustaining the injury). The length of post traumatic amnesia (PTA) ranged from 5 minutes to 60 minutes (7 of the subjects falling into the 5 to 20 minute range) and subjects experienced 0 to 90 minutes of retrograde amnesia (RA) (7 subjects reporting either 1 minute or less RA).

Most of the injuries were sports related, hockey being the most frequently reported activity during injury. Of the non-sports injuries, the incidents were related to a motor vehicle accident, a bicycle accident, and a fight. Previous to the injury reported in the present work, 5 subjects had sustained at least one blow to the head severe enough to force them to stop what they were doing at the time because of dizziness, disorientation,
or pain; however, none of the previous injuries were greater in severity than that reported herein. The time interval between previous injury and the incident in question was one day for one subject and in the order of years for all other subjects.

During the interview, it was confirmed that each TBI subject reported difficulty with sleeping, and specifically, difficulties with sleep onset: it took each subject 30 minutes or more to fall asleep, more nights than not, each week. Sleep difficulty was not present in any subject previous to injury. Members of the control group reported an absence of head injury and absence of sleep difficulty.

Change in adaptive functioning was reported by subjects in the MTBI group. On the Brock Adaptive Functioning Questionnaire (BAFQ) (Dywan & Segalowitz, 1996), the MTBI group reported a mean change, in the range of 40 to 50 percent, of items within the planning, excess caution, attention, memory, and arousal level scales since the time of injury (See Table 3 for means and SD for all scales). Scores for the anxiety and depression scales and sub-scales of the Personality Assessment Inventory (PAI) (Morey, 1991) are reported in Table 1. Scores above 59 are considered above average for all of the depression and anxiety scales of the PAI; however, “significant” levels of anxiety or depression are not reached until a score above 69 is obtained (Morey, 1991). It may be concluded then, that on average, the MTBI group may be considered slightly elevated for both depression and anxiety. Scores for all scales and sub-scales of anxiety and depression were in the range of 60 to 66, except cognitive depression which was 56.

None of the subjects reported any chronic pain. None of the subjects took prescribed or over the counter medication for the purposes of sleeping. Two subjects
were medicated for asthma, one in each of the two groups.

**Apparatus**

**Questionnaires and tasks**

Several questionnaires were used in order to obtain descriptive information. Those related to sleep included the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), the Sleep Disorders Questionnaire (SDQ) (Douglass et al., 1994), and the Brock Sleep and Insomnia Questionnaire (BSIQ) (Cote & Ogilvie, 1993). The PAI (Morey, 1991) was used in order to acquire indices of depression and anxiety. The BAFQ (Dywan & Segalowitz, 1996), and a health and medical history checklist were administered in order to gain further descriptive information. The WAIS III (Wechsler, 1997) vocabulary test was used in order to obtain a quick measure of verbal ability.

A sleep log was given to the subjects in order to collect a two week sample of normal sleep patterns (i.e. sleep duration, bed time etc...). During the overnight sessions, questionnaires were used which queried sleep-related information regarding the day and night in question. For example, the nighttime questionnaire contained items related to daytime activities such as the intake of medication, amount of activity, as well as sleepiness. The morning questionnaire required subjects to make subjective estimates of length of sleep onset, sleep duration, how typical (or atypical) the nights sleep had been, and rate sleepiness. Copies of all of the questionnaires and documents used in the study except for the PAI are included in the appendix.
The PSQI involves 19 items which intend to measure sleep quality over the month previous to its completion. The measure yields seven sub-scales which include subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. PSQI was collected for the month previous to testing in all subjects. Reliability and validity have been well established for the measure. Buysse et al. (1989) obtained test retest reliability of .85 for global sleep quality and scores for the component scales ranging from .84 to .65. Furthermore validity was established by comparing PSQI score to physicians diagnoses as well as polysomnography (See Buysee et al., 1989 for a summary of results). The PSQI was administered a second time in the MTBI group, for the month previous to injury (or for the time period directly before injury if the month previous to it could not be recalled).

The SDQ is a self report, 175 item multiple choice questionnaire from which four sub-scales are derived: Sleep apnea, periodic limb movements, psychiatric insomnia, and narcolepsy. According to Douglass et al. (1994), the current version of the questionnaire has evolved from a sleep disturbances questionnaire developed by a group of researchers at Stanford University. Reliability and validity for the SDQ have also been well established. Douglass et al. (1994) obtained test-retest reliability values for the four scales which ranged from .753 to .842. In addition, the measure was validated against patient populations as determined by physician diagnoses.

In its revised form, the BSIQ is a mixed format, 125 item, self-report questionnaire. Its primary purpose is to distinguish among the ASDA (ASDA, 1990) sub-
types of insomnia. The following scales were calculated and used for descriptive purposes in the current study: Sleep Quality, Psychiatric insomnia, and Psychophysiological insomnia. To date, no study has been conducted to examine the psychometric properties of the questionnaire. It has primarily been used as a tool to define groups for research participation (e.g. Lamarche & Ogilvie, 1997).

The PAI is a standardized, 344 multiple choice item personality form, and is used in research and clinical settings. One of the advantages of the PAI is that it allows the researcher to acquire an in-depth analysis of each personality construct measured because the scales are broken down into sub-scales. For example, the depression scale is broken down into depression-affective, depression-cognitive, and depression-physiological. The depression and anxiety scales and sub-scales were of interest to the current work. Several studies of reliability and validity have been conducted. In a community college sample, the full scale test-retest reliability was reported as .86 for depression and .88 for anxiety (Morey, 1991). Validity has also been established for the PAI with the use of convergent validity techniques using clinician judgment as well as existing measures of personality for comparison. For a review of these results as well as a more in-depth examination of the reliability see Morey (1991).

The BAFQ is a questionnaire comprised of 68 items which are rated on a Likert scale. The BAFQ was developed in order to measure areas of functioning that may be prone to impairment subsequent to MTBI, but which may not be accounted for by standard neuropsychological tests (Dywan and Segalowitz, 1996). Among the constructs assessed are planning, initiation, flexibility, excess caution, attention, memory, arousal,
emotionality, impulsivity, aggressiveness, social monitoring and empathy. The BAFQ has been used in research, where self and family ratings in the areas of planning and initiation have been demonstrated to be related to frontally distributed electrophysiological/ERP phenomena (Dywan and Segalowitz, 1996).

The Brock sleep laboratory and polysomnographic data acquisition

The Brock University sleep laboratory was used for the collection of polysomnographic data. Within it there are two bedrooms, a monitoring room, and a bathroom. Each bedroom is electrically shielded, sound attenuated, and approximately three metres by three metres in size. In order to make subjects feel more comfortable in the lab environment, the bedrooms were equipped with a dresser (which was available to be used by subjects throughout their stay), mirror, and simulated window. Video information was collected by cameras (which require illumination with a 40W red light) in each of the bedrooms, displayed on monitors in the monitoring room, and recorded on video cassette recorders. Two-way communication was made available in the sleep lab by sound mixing boards, microphones, and speakers placed in each room.

Polysomnographic data (EEG- a recording montage including the entire 10-20 system, EOG, EMG, and ECG) were collected from each subject via a total of 28 Grass (West Warwick, RI) gold disc electrodes. Mark-easy 10-20 (Optimit, Tucson, AZ) caps were used in order to landmark the standard electrode sites. Each site was prepared with alcohol and pumice paste prior to the application of the electrode cream (10-20 paste, D.O.Weaver, Aurora, CO) filled electrodes. The scalp electrodes were fastened with collodion (Xenex laboratories, Coquitlam, BC), and those placed on the skin were kept in
place using micropore tape. In the morning, acetone was used in order to remove electrodes fastened with collodion.

Data were sampled at 200 Hz, converted using an A to D board, and initially recorded on the hard drives of two IBM compatible computers (Pentium-200). Subsequently, the data were written to compact disc for analysis and long term storage. Stellate Systems (Montreal, PQ) software was used in order to record (Harmonie©), score (Luna©), and conduct power spectral analysis (Compressed Spectral Array©) on the sleep data.

Procedure

Interview and questionnaire session

Subjects who met the inclusion criteria for either the MTBI group or the control group were scheduled for individual 2.5 to 3 hour interview and questionnaire sessions. Before the interview was conducted, subjects were given a full description of the study, a tour of the sleep lab, and a demonstration of the techniques used in the lab. That is, subjects were familiarized with the lab surroundings and equipment such as the electrodes and the materials that would be used for hook-up procedures. The interviews were completed in one of two rooms set up for private consultation within the Brock University neuropsychology laboratories and began with the acquisition of informed consent to participate in the study.

The interview portion of the session was conducted in order to determine history of TBI including several standard variables such as cause of injury, time since injury,
length of unconsciousness (if at all), length of post traumatic and retrograde amnesia. An in-depth history of symptoms associated with the incident was also taken at this time with particular attention focussed on sleep difficulty. The questionnaires as well as the vocabulary test of the WAIS III (Wechsler, 1997) were administered following the interview. Before leaving, subjects were asked to complete the two-week sleep log.

**Overnight sessions**

Subjects were scheduled, two at a time for three consecutive overnight sessions at the Brock Sleep lab, the first two for the purposes of adaptation to the laboratory sleeping environment. The first night, subjects were asked to arrive approximately 2-2.5 hours before their regular bed-time (as indicated by sleep log), and on subsequent nights 1.5-2 two. The extra time on the first night was in order to facilitate the administration of the BAFQ.

Electrode hook-up was conducted by the primary investigator as well as several well-trained researchers. The following electrode sites were included in the EEG recording montage from the international 10-20 system (Harner & Sannit, 1974): Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, O2, and A2, referenced to A1. A ground electrode was placed on the forehead between Fp1 and Fp2. The ECG electrodes were applied to the chest below the left and right collar bones. The EMG electrodes were placed on the chin of each subject unless an excess of facial hair would not allow for such an application in which case they were placed on the back of the neck. Electrode hook-up took approximately 1.5 hours; a radio played mix music in order to entertain both subjects and researchers, as well as create a relaxed yet
comfortable environment throughout the hook-up process.

In preparation for each overnight data collection session, the amplifiers were calibrated, and technical instruments were tested and set (i.e. intercom system tested, VCRs and computers set to record). Preceding bedtime procedures, which commenced as close to the subject’s normal bed-time as possible, electrode impedances were checked (on nights 2 and 3, electrodes exceeding 10 Ohms were re-applied) and participants were allowed to visit the bathroom. Subjects retired to bed and the door was closed leaving only the red light and a bed-side table light for illumination. Once in bed, a bio-calibration procedure was conducted whereby polysomnographic data was collected concurrent with subject performance of various biological events that typically occur during sleep. The events included relaxed wakefulness with eyes closed, blinking, eye movements, grinding teeth, swallowing, and coughing. Subsequently, subjects were given instructions to fill out the bedtime questionnaire, and turn out the bed-side lamp, and to go to sleep whenever ready.

Subjects were allowed to sleep, uninterrupted for the duration of the night and were allowed to sleep ad-lib within the constraints of the next day’s schedule; subjects were often awakened in order to get up for class, but were allowed the opportunity to sleep for at least their normal sleep duration (determined by sleep-log) each night. In the morning, electrodes were removed and subjects were allowed to leave at will.

An honorarium was paid for participation in the study: $20 for the interview and questionnaire session, and $80 for the three consecutive overnights.
Analyses

The PSG data from the second and third nights were divided into 30 second epochs and scored according to Rechtsaffen and Kales (1968) criteria. This allowed for the examination of the objective sleep architecture. Several sleep parameters were calculated: Total recording time (TRT), total sleep time (TST), sleep efficiency (SEF) (TST/TRT), sleep onset latency (SOL) (latency from lights out to stage 1 sleep), REM onset latency (ROL) (latency from lights out to stage REM sleep), wake time after sleep onset (WASO), and sleep stage percentages (the percentage of time subjects spent in each of the standard sleep stages). The sleep stages recorded were wake (sW), movement (sM), rapid eye movement (sREM), stage 1 (s1), stage 2 (s2), stage 3 (s3), and stage 4 (s4). These data were used in order to examine the idiopathic model and to determine any group differences in sleep architecture that may be measured objectively.

The SOP analyses were undertaken for the third overnight session for each subject. The SOP (the period of time between lights out until the first spindle) was divided up into quartiles and power spectral analysis was conducted for each quartile and for each of the standard frequency bands (beta, sigma, alpha, theta, delta). The alpha band and the beta band were further subdivided into high and low for the former, and high medium and low for the latter. This subdivision was undertaken so that changes that occur within smaller frequency ranges would not be obscured by averaging all the activity from a given band. The bands widths were defined as follows: delta (1.0 - 3.9 Hz), theta (4.0 - 7.9 Hz), alpha (8.0 - 11.9 Hz), alpha1 (8.0 - 9.9 Hz), alpha2 (10.0 - 11.9 Hz), sigma (12.0 - 14.9 Hz), beta (15.0 - 29.9 Hz), beta1(15.0 - 19.9 Hz), beta2 (20.0 -
Power spectral analyses were conducted with three channels: C4, F4, and O2. Channels were chosen from central, frontal, and occipital sites in order to acquire an even topographical distribution across the scalp. Sites from the right hemisphere were chosen because those on the left were not as consistently acceptable, due to 60 cycle noise picked up as a result of poor electrode application.

For all spectral analyses, portions of the record laden with artifact were rejected. A first-pass was made through the data in order to remove sections with body movement. A second pass was made in order to reject sections with eye movement artifact such as blinking. Eye movement artifact rejection was guided by examination of frontal pole channels (Fp1 and Fp2), but sections were not removed from analysis unless the irregularity was obvious in the eye channels also. Sections of EEG were not removed from analysis which occurred concurrent with eye movements typical of sleep (i.e. slow rolling eye movements associated with stage 1).

The EEG data were re-referenced prior to being subjected to FFT analyses. The re-referencing montage included an average of A1 and A2 as the reference for each EEG channel. The analysis yielded frequency values for each consecutive 5.12 second artifact free section of the data (spectral record). Within each spectral record two 2.56 s FFT analyses were performed and averaged together. A hanning window was used in order to taper the FFT window. Consecutive spectral records were overlapped by 50% in order to account for data eliminated by the tapering window.
Data were first divided into the component frequency bands and, subsequently, a log transformation was conducted. Such transformations are common in psychophysiological research and are performed because of the nature of absolute power values yielded by spectral analysis. When power increases in PSA, it does so in a non-linear fashion. Thus, log transformations were conducted in order to normalize the distribution of power scores obtained.

An example of how power spectral data that are not transformed can obscure results and statistical analyses follows. Consider a situation where higher baseline power values are obtained for one subject over the others; the resulting values for that individual being exponentially larger than the others. This could result in one subject having a much larger influence than the others when group values are summarized in means. Although the log transformation lowers all values, it counteracts this problem because higher values are lowered to a larger extent than lower ones while saving the relative position between higher and lower original values.

Prior to log transformations, the frequency values for each spectral record were summed within the frequency bands as defined above. Subsequent to the transformation, the spectral records were divided into four consecutive and equal portions (quartiles). The mean and standard deviation was taken for each quartile, and for each frequency band. This analysis was repeated for each subject, for sites F4, C4, and O2.
Results

Questionnaire data

Group comparisons were conducted on questionnaire data collected during the interview and questionnaire session. This was for descriptive purposes and to evaluate the success of the screening and selection process. Data regarding current presentation of depression and anxiety, adaptive functioning, and current and pre-injury sleep (MTBI group only) were collected via the PAI, the BAFQ, and multiple self-report measures of sleep and sleep difficulty respectively.

In order to confirm that there was a change in sleep patterns of MTBI subjects, the PSQI was given twice: once for pre-injury condition, and once for current condition. Dependent samples t tests demonstrated that there were significant differences between pre and current conditions (current conditions associated with more difficulty) for the global score ($t(8)=5.44, p=.001$), sleep quality ($t(8)=3.16, p=.013$), sleep latency ($t(8)=5.77, p<.001$), sleep duration ($t(8)=2.86, p=.021$), and sleep disturbance ($t(8)=2.83, p=.022$) (interruption during the night). The pre and current conditions did not differ for sleep efficiency, or daytime dysfunction. An absence of the use of sleep medication was reported in both conditions. Refer to Table 4 for means and standard deviations.

Group comparisons via independent samples t tests were conducted in order to determine whether the MTBI group reported significantly more sleep difficulty than controls. For the PSQI, the MTBI group was significantly higher than the controls for sleep quality ($t(16)=2.29, p=.036$), sleep latency ($t(16)=2.98, p=.009$), sleep disturbances ($t(16)=2.77, p=.014$), and global PSQI ($t(16)=3.99, p=.001$). This
indicated more sleep difficulty among the MTBI group than controls. Group differences were also found for the sleep quality ($t(16)=9.03$, $p<.001$), psychiatric insomnia ($t(16)=3.12$, $p=.007$), psychophysiological insomnia ($t(16)=4.30$, $p=.001$), scales of the BSIQ; and the narcolepsy ($t(16)=3.10$, $p=.007$), psychiatric insomnia ($t(16)=3.69$, $p=.002$), and periodic limb movements ($t(16)=3.27$, $p=.005$) scales of the SDQ. All of these differences were indicative of more sleep difficulty in the MTBI group as compared to controls. Refer to Table 5 for means and standard deviations.

Independent samples t tests examining differences between the two groups were also conducted on the personality variables that were derived from the PAI. In regard to the depression scale and sub-scales of the PAI, there were significant differences between the control and MTBI groups for full scale depression ($t(16)=3.07$, $p=.007$), and physiological depression ($t(16)=1.32$, $p<.001$), but not for cognitive nor affective depression. For the anxiety scale and sub-scales, significant group differences were found for full scale anxiety ($t(16)=2.65$, $p=.017$) as well as all of the sub-scales: cognitive ($t(16)=3.27$, $p=.005$), affective ($t(16)=3.63$, $p=.002$), and physiological ($t(16)=3.70$, $p=.002$). Refer to Table 1 for means and standard deviations.

Finally, significant differences were found when comparing the groups on the various scales of the BAFQ. The MTBI group reported more difficulty with flexibility ($t(16)=5.81$, $p<.001$), planning ($t(16)=3.25$, $p=.005$), excess caution ($t(16)=3.44$, $p=.003$), attention ($t(16)=3.39$, $p=.004$), memory ($t(16)=3.59$, $p=.002$), and arousal level ($t(16)=2.78$, $p=.013$). No group differences were found for initiation, emotionality, impulsivity, aggressiveness, social monitoring, or empathy. Refer to Table 3 for means.
and standard deviations.

PSG sleep parameters

Several standard measures of sleep which are derived from PSG recordings were obtained from the third night of the sleep studies. The purpose of examining such measures was to evaluate the hypotheses derived by the idiopathic model of insomnia, and to compare the MTBI group to normal sleepers in regard to objectively measured sleep (as opposed to self-report). Contrary to the predicted relationships, there were no significant group differences for stage REM, stage 3, or stage 4 percentage. Moreover, the means for the amount of wakefulness after sleep onset (WASO), the number of awakenings, and all of the sleep stage percentages were similar for the two groups. The means and standard deviations for all the PSG measured sleep parameters can be found in Table 6.

Some of the differences that were found in the self report measures were corroborated by the objective recordings. The MTBI group ($M=22.83$ min., $SD=20.67$) had significantly longer SOL than controls ($M=6.94$ min., $SD=4.61$) ($t(16)=2.25$, $p=.039$). Moreover, the MTBI group ($M=92.17$, $SD=4.15$) had significantly lower sleep efficiency than the control group ($M=96.02$, $SD=1.54$) ($t(16)=2.61$, $p=.019$). The only other difference between the two groups for the variable measured was in regard to REM onset latency which was significantly longer in controls ($M=98.61$ min., $SD=31.74$) than MTBI ($M=55.39$ min., $SD=31.77$) ($t(16)=2.88$, $p=.011$).
The advancement of technology has significantly impacted the way businesses operate. Companies are increasingly adopting digital solutions to streamline processes and enhance customer experiences. With the rise of cloud computing, businesses can now focus on innovation rather than infrastructure management. Additionally, the integration of artificial intelligence and machine learning has enabled more sophisticated data analysis, leading to better decision-making.

However, these advancements also present challenges. One major concern is the risk of cyber threats. As more data is stored and processed digitally, the opportunities for cyber attacks increase. Businesses must invest in robust cybersecurity measures to protect against these threats. Furthermore, the ethical implications of AI technology are becoming more apparent. Questions arise regarding transparency, bias, and accountability in AI systems, which require careful consideration and regulation.

In conclusion, the digital age offers numerous opportunities for growth and innovation. But to fully harness these advantages, businesses must also address the challenges that come with it, particularly in the realms of cybersecurity and ethical AI.
Average log power across the SOP

Average log power was examined in order to test the hypotheses derived from the MTBI-psychophysiological model and in order to determine any electrophysiological changes that may occur differentially between controls and the MTBI group. For each of the frequencies observed (delta, theta, alpha, alpha1, alpha2, sigma, beta, beta1, beta2, beta3) split plot 2 (group) by 3 (site) by 4 (quartile) repeated measures ANOVAs were conducted. Group was the between subjects factor and time (quartile) and site (C4, F4, and O2) were the within subjects factors.

There were no 3 way (group by quartile by site) interactions found for any of the frequencies within the average log power analyses. For all interaction and main effects involving a within subjects factor, the Huynh-Feldt epsilon multiplier was used in order to adjust the degrees of freedom to account for possible violations of the assumption of sphericity. In the presence of main and interaction effects for quartile and site, follow-up contrasts were conducted. Polynomial contrasts were examined for effects involving quartiles, and simple contrasts were conducted in order to determine the nature of relationships involving site.

Results for the component bands of alpha (i.e. alpha1 and alpha2) and beta (beta1, beta2, beta3) are not reported as nearly identical results were found in each of the respective overall bands. The only discrepancy was the absence of a main effect for group in the beta1 band concurrent with the presence of such an effect in the overall band and the other two component bands.
Effects involving group

Under the MTBI-psychophysiologlcal model, it was predicted that: (1) The MTBI group would have lower delta than controls during the latter portion of the SOP, (2) the MTBI group would not demonstrate the dramatic drop in alpha over the course of the SOP which is characteristic of normal sleepers, and (3) the MTBI group would demonstrate higher levels of beta during the initial portion of the SOP. Contrary to these predictions, there were no significant interactions or group differences for any of the frequencies observed except for beta.

As no interaction effects were found for either group by quartile or group by site, the group effect for beta was examined collapsing across site and quartile. A statistically significant main effect for group was found for average log power within beta frequency (F(1,16)=5.59, p=.031, $\eta^2=.26$). However, contrary to expectations, the control group demonstrated higher log power than the MTBI group. Means for the two groups, collapsing across site and quartile can be found in Table 7. Moreover, the relationship may be found depicted graphically in Figure 1.

Effects involving quartile

With regard to delta, as no quartile by site or quartile by group interactions were found, effects for quartile were examined collapsing across site and group. As expected, a significant main effect for quartile was found in the delta band for average log power (F(2.75, 44.03)=39.88, p<.001, $\eta^2=.71$). Follow-up polynomial contrasts indicated that the relationship between mean log power in the delta frequency and time across the SOP was linear (F(1,16)=101.64, p<.001, $\eta^2=.86$). The direction of the relationship was such
that increases in time were associated with increases in mean delta log power (See Figure 2). Refer to Table 8 for means and standard deviations.

Within theta frequency, a significant site by quartile interaction effect was found ($F(4.21, 67.32)=3.88$, $p=.006$, $\eta^2=.20$). By examination of Figure 3, it can be observed that in general, theta power increased over the SOP; however, this relationship differed according to site. Follow-up contrasts indicated that the slopes for C4 and O2 of the relationship between time over the SOP and theta consistently converged as the linear comparison was statistically significant ($F(1, 16)=6.90$, $p=.018$, $\eta^2=.30$) (Refer to Table 8). Although the interaction effect was not predicted, the general trend across quartile was consistent with expectations.

Average log power also differed across quartile within alpha frequency. This relationship also depended on site ($F(3.81, 60.90)=39.88$, $p<.001$, $\eta^2=.42$). As expected, and as can be seen in figure 4, in general, alpha power decreased over the SOP. The nature of the interaction was such that the slopes of the C4 and O2 effects converged as time elapsed over the SOP (See figure 4). This was evident in the statistically significant linear comparison between these two sites. ($F(1, 16)=22.63$, $p<.001$, $\eta^2=.57$) (Refer to Table 8).

When effects involving quartile were examined, there were statistically significant findings in the sigma frequency. The relationship between sigma log power and time over the SOP was generally quadratic, decreasing from the first quartile to the second quartile, and then increasing from the third quartile to the fourth (see Figure 5). However like theta and alpha, there was a site by quartile interaction ($F(5.30,$
84.83)=15.04, p<.001, η²=.48). Follow-up contrasts indicated that the differences across the SOP between C4 and F4 were quadratic (F(1, 16)=6.26, p=.024, η²=.28), and the differences between C4 and O2 were linear (F(1, 16)=113.80, p<.001, η²=.88). That is, the C4 and F4 slopes converged and then diverged, and the C4 and O2 slopes consistently converged up to quartile 3. Refer to Figure 5 for a graph of this relationship, and Table 8 for cell means and standard deviations.

Similar to theta, alpha, and sigma, the relationship between average beta log power and quartile over the SOP depended on site (F(3.99, 63.87)=19.03, p<.001, η²=.54). As would be expected, beta decreased over the sleep onset period, but the slopes differed according to site (See Figure 6). The differences between sites C4 and F4 (F(1, 16)=4.57, p=.048, η²=.22) and between C4 and O2 (F(1, 16)=, p<.001, η²=.77) across the SOP were both linear. From an examination of the graph it can be seen that the relationships were such that C4 consistently diverged from F4 and O2 after quartile 2.

**Standard deviation log power across the SOP**

The standard deviation of log power was examined in order to determine whether the sleep difficulty associated with MTBI could be characterized by increased levels of variability in the power spectral data. Consistent with this expectation, statistically significant differences between group were found in the standard deviation log power analyses across most frequency bands.
The analyses performed were identical to those conducted for average log power. That is, for each of the frequencies observed (delta, theta, alpha, alpha1, alpha2, sigma, beta, beta1, beta2, beta3) split plot 2 (group) by 3 (site) by 4 (quartile) repeated measures ANOVAs were conducted. Group was the between subjects factor and time (quartile) and site (C4, F4, and O2) were the within subjects factors.

As for the analyses for average log power, the Huynh-Feldt epsilon multiplier was used where appropriate in order to adjust the degrees of freedom to account for possible violations of the assumption of sphericity. Likewise, in the presence of main and interaction effects for quartile and site, follow-up contrasts were conducted. Polynomial contrasts were examined for effects involving quartile, and simple contrasts were conducted in order to determine the nature of relationships involving site.

Analyses of standard deviation log power within the alpha band are not reported as no statistically significant effects were found. Furthermore, complete results of the breakdown of the beta band into the three component bands are not given. Results for the component bands are only reported where significant effects were found. There were no three way (group by quartile by site) interactions found within any of the frequencies save beta. Such a relationship was neither predicted, nor of interest, and was therefore not formally reported.

**Effects involving group**

As no interaction effects were found for the standard deviation log power within delta, the main effect for group, collapsing across site and quartile, was assessed. Consistent with the expected result, a significant main effect for group was found in the
delta frequency ($F(1, 16)=9.22, p=.008, \eta^2=.37$). As expected, the MTBI group displayed higher standard deviation log power than the control group. Refer to Table 7 and Figure 7 for means, and a graphical illustration of the relationship respectively.

Results in the theta and sigma frequencies regarding standard deviation log power were identical to those found for delta. There were no interactions, but significant main effects for group were discovered for both theta ($F(1, 16)=6.84, p=.019, \eta^2=.30$) and sigma ($F(1, 16)=10.54, p=.005, \eta^2=.40$). In both cases, the MTBI group exhibited significantly more variability than controls. This was consistent with the predicted result. Table 7 includes means for both effects, and graphical depictions of the relationships can be found in Figures 8, and 9 for theta and sigma respectively.

A site by group interaction was found for standard deviation log power in beta ($F(1.94, 30.96)=4.01, p=.029, \eta^2=.20$). This same effect was discovered within beta2 ($F(1.96, 31.29)=7.82, p=.002, \eta^2=.33$), which was the only component band of beta for which an effect involving group was found. Follow-up simple contrasts reached a significant level within the beta2 band and indicated that the difference at site O2 was significantly larger than that of C4 ($F(1, 16)=13.82, p=.002, \eta^2=.46$). That is, there was more variability in beta1 for the MTBI group as compared to controls, but only at the O2 site (refer to Table 7, and Figure 10).

**Effects involving quartile**

Although no predictions were made regarding changes in variability across the SOP, certain effects were discovered. First, a main effect for quartile within the delta band was found such that variability increased over the SOP ($F(3.00, 48.00)=13.31,$...
Upon follow-up polynomial comparisons, the nature of the relationship was found to be linear ($F(1, 16)=33.31$, $p<.001$, $\eta^2=.68$). Refer to Figure 11 for a graphical depiction of this relationship (Means and standard deviations may be found in Table 9).

A site by quartile interaction was found for standard deviation log power in theta ($F(4.38, 70.13)=4.14$, $p=.004$, $\eta^2=.21$). Upon visual inspection of Figure 12, in general, variability increased over quartiles of the SOP, depending on site; while variability at O2 was fairly consistent across quartiles (ie. no change), at F4 and C4 it increased from quartile 1 to 2, decreased from quartile 2 to 3, and then increased again from quartile 3 to 4. Follow-up contrasts were consistent with this interpretation as a significant linear component was found for the C4 with F4 comparison ($F(1, 16)=10.38$, $p=.005$, $\eta^2=.39$), and significant linear ($F(1, 16)=7.02$, $p=.017$, $\eta^2=.31$) and cubic ($F(1, 16)=6.19$, $p=.024$, $\eta^2=.28$) components were found in the C4 with O2 comparisons.

A site by quartile interaction was also found for standard deviation log power of sigma ($F(5.64, 90.16)=7.31$, $p<.001$, $\eta^2=.31$). Visual inspection of Figure 13 revealed that as time increased over the SOP, so did variability in sigma. However, this relationship did differ among sites; after quartile 2, both F4 and O2 diverged from C4 (Refer to Figure 12). Follow-up contrasts confirmed this finding as the linear components of both the C4 and F4 ($F(1, 16)=6.34$, $p=.023$, $\eta^2=.28$), and the C4 and O2 ($F(1, 16)=11.78$, $p=.003$, $\eta^2=.42$) comparisons were statistically significant. See Table 9 for cell means and standard deviations.
In regard to beta, a site by quartile interaction was found for standard deviation log power of both beta ($F(6.00, 96.00)=3.55, p=.003, \eta^2=.18$) and beta1 ($F(6.00, 96.00)=2.32, p=.039, \eta^2=.13$). The linear component of the follow-up comparison between C4 and O2 ($F(1, 16)=5.65, p=.030, \eta^2=.26$) reached statistical significance within the beta band. A clear trend over the quartile is not apparent upon examination of the Figure 14, however, the linear interaction is visible: after quartile 2, C4 and O2 consistently diverge.

Main effects for site

For those analyses that did not involve an interaction with site, the main effect for site was assessed. Although no predictions were made regarding the relationship between the dependent variables and site, collapsing across quartile and group, significant main effects for site were found for average log power ($F(1.51, 24.17)=33.31, p<.001, \eta^2=.62$), and standard deviation log power ($F(1.86, 29.68)=4.19, p=.027, \eta^2=.21$) within delta. For average log power within delta, F4 was greater than C4 ($F(1, 16)=19.61, p<.001, \eta^2=.55$), and C4 was greater than O2 ($F(1, 16)=16.15, p=.001, \eta^2=.50$) (See Figure 15 and Table 10). Standard deviation log power was greater at C4 as compared to O2 ($F(1, 16)=3.91, p=.065, \eta^2=.20$) but this difference was not statistically reliable (Refer to Figure 16 and Table 10).
Discussion

Polysomnographic and power spectral analyses were conducted on the EEG data over the sleep onset period in order to test two models of the insomnia complaints secondary to MTBI. Analysis of the data demonstrated support for neither of the idiopathic or psychophysiological models. However, there were differences in the sleep parameter analysis that provided an objective confirmation of the self-reported disturbances in sleep onset following MTBI. Moreover, power spectral analysis of the sleep onset period revealed group differences which may suggest that individuals who have sustained MTBI and subsequently report sleep difficulties may fall asleep in a manner distinct from that of the general population.

Exploratory analyses were conducted with the power spectral data in order to determine if the sleep difficulties associated with MTBI could be characterized by differences in the variability of EEG within the standard frequency bands. Across the sleep onset period, individuals who had sustained MTBI and reported difficulty with sleep exhibited greater variability than normal controls within most of the standard frequency bands. Variability of this sort is associated with a greater magnitude of oscillation between movements away from and towards sleep. As such, oscillations towards greater wakefulness would have a disruptive effect on the sleep onset process. For this reason it was concluded that high amounts of variability in arousal, as indicated by electrophysiological measures, across the sleep onset period may account for the insomnia-like difficulties that may be experienced by individuals who have sustained MTBI.
Do sleep onset difficulties associated with MTBI present in a similar manner to psychophysiological insomnia?

**Power spectral analysis: Average log power**

Mean log power was examined across quartiles of the SOP in order to evaluate the psychophysiological model of the insomnia secondary to MTBI. It was expected under this model that the MTBI group would show a SOP signature similar to that of psychophysiological insomniacs in regard to the changes in standard frequency bands over time. Specifically, it was hypothesized that the MTBI group would have lower delta than controls during the latter portion of the SOP; the MTBI group would not demonstrate the dramatic drop in alpha over the course of the SOP which is characteristic of normal sleepers. The MTBI group would also be expected to demonstrate higher levels of beta during the initial portion of the SOP.

The results of the current study did not support these hypotheses. Comparing MTBI to control data, there were no statistically significant group effects, group by quartile, or group by site interaction effects in mean log power in any of the standard frequency bands except beta. Within the beta frequency, the direction of the relationship was opposite to that predicted by the psychophysiological model. Collapsing across quartile and site, the MTBI group had lower levels of beta than the control group throughout the SOP. Lamarche and Ogilvie (1997) interpret decreased levels of alpha taken together with increased beta to indicate that psychophysiological insomniacs demonstrate increased cortical arousal over the SOP. Heightened cortical arousal then is at the core of the electrophysiological signature of psychophysiological insomnia.
It cannot be concluded then that insomnia following MTBI presents in a similar fashion to psychophysiological insomnia as there was no evidence from the current study to suggest heightened cortical arousal in the MTBI group. In fact it may be that MTBI with insomnia complaint is associated with decreased cortical arousal as the MTBI group demonstrated consistently lower levels of beta across the entire SOP and at both C4 and F4 sites. This might suggest that individuals whose sleep complaints are secondary to MTBI exhibit a relatively unique electrophysiologically-defined entry into sleep.

Collapsing across groups, dramatic changes in the power spectra were observed across the SOP. In general, these changes included drops in alpha and beta activity as well as increases within the theta and delta bands. These changes reflect the dissipation of activity associated with alert and relaxed wakefulness (beta, and alpha respectfully), and the elevation of EEG frequencies associated with sleep (theta, and delta). Such effects are consistent with previous examinations into the sleep onset period of normal sleepers and were the hallmark findings of the pioneering work in the field (Ogilvie al., 1991). The presence of these changes within the control group validates the methodology of the study, and supports the use of this group as an appropriate comparison basis for the special population under study.

Although no interaction with site was expected for power effects across quartile, such effects were found to be significant within theta, alpha, and beta. However, in each case although the slopes between sites differed slightly, the overall relationship at each site was consistent with the expected finding (See Figures 3, 4, & 6).
The quartile effects, exhibiting consistency between groups, do not lend support to the notion that individuals with MTBI and insomnia complaints enter sleep in a different manner from normal controls. These findings taken together with the main effect for beta as discussed above, may suggest an alternate interpretation to that offered above: The difference in beta between the two groups may be due to baseline values. That is, the differences in beta may not denote a distinct sleep onset mechanism because the difference between the two groups was present at the beginning of the SOP and consistent throughout. Rather, it might reflect a difference in initial level of beta activity, which in turn may be attributable to their brain injury.

Do sleep onset difficulties associated with MTBI present in a similar manner to idiopathic insomnia?

**PSG sleep parameters**

Under the idiopathic model of the sleep onset difficulties associated with MTBI, it was expected that certain differences in sleep architecture would be apparent in the pathological group when compared to controls: increased percentage of sREM, and reduced delta sleep. The findings relevant to these predictions did not support the idiopathic model; there were no significant differences between the groups in the proportion of time spent in any of the standard sleep stages.

There was a significant difference found in REM onset latency, but it was in the opposite direction to that given in reports of moderate idiopathic insomnia. In Hauri’s (1983) sample, on the first night of study, REM onset latency was significantly increased
in idiopathic insomniacs. The direction of the relationship found for the REM onset latency group difference was that the control group had a significantly longer latency than the MTBI group.

The present sleep parameter findings are likely due to a number of factors. First, two subjects in the control group missed their first REM period because of an intermixing with stage 2 sleep. That is, while some evidence of stage REM was contained in the polysomnographic data during the time period when their first REM period should have occurred, no 30 second epoch could be scored REM because none met the full criteria (e.g. absence of spindles). This would have the effect of lengthening the REM onset latency for the control group. Further, there were two subjects in the MTBI group who demonstrated enough evidence of REM sleep within in the first five minutes subsequent to sleep onset that an epoch could be scored REM. Such occurrences are referred to as sleep onset REM (SOREMP) periods and are associated with narcolepsy (Alloway et al., 1999). SOREMPs would have the effect of decreasing the overall REM onset latency of the MTBI group. It was not expected, but at the same time not entirely surprising that conditions associated with the narcoleptic experience were found in the MTBI group. Evidence for a relationship between more severe head injury and excessive daytime sleepiness have been previously reported by Guilleminault et al. (1983).

Other findings within the sleep parameter analysis were significant group differences between the MTBI group and controls for sleep onset latency and sleep efficiency. The direction of the relationship in both indices was towards sleep difficulty
in the MTBI group. That is, sleep onset latency was longer in the MTBI group, and controls had higher sleep efficiency than MTBI subjects. Although this finding does not suggest that the general population of individuals who have had a MTBI experience increased sleep onset latencies and reduced sleep efficiency (see below for a discussion of the generalizability of the findings), it is a significant outcome of the study.

First, these effects confirm the efficacy of the subject selection process, and second, represent objective evidence to corroborate the subjective reports of long term insomnia among those who have sustained a MTBI. To my knowledge this is the first time that such evidence has been reported. Moreover, these differences in sleep latency and efficiency also suggest that even in mild cases, TBI can result in long term alteration to the CNS.

Can variability within EEG sleep frequencies account for MTBI sleep difficulty?

Power spectral analysis: variability of log power

The variability in log power analyses were exploratory. As previous studies have found some evidence for greater variability in insomnia populations as compared to controls (in alpha and delta frequencies) (Lamarche, 1995) it was expected that there would be higher levels of variability in the MTBI group than the control group. Higher amounts of variability would indicate greater disruption of the sleep onset process.

In accordance with the predictions, evidence for greater variability in MTBI as compared to controls was found in standard deviation log power within each of the standard frequency bands except alpha. Not only were these effects consistent across
frequency but also across site (i.e. main effects for group collapsed across site and quartile) for delta, theta, and sigma. The group effect was also evident in beta, but only at O2. Moreover, the measure of strength of effect for ANOVA, eta squared, demonstrated that beyond being consistent, the effect was strong. The percentage of shared variability between group and standard deviation log power was in the 30% to 40% range for delta, theta, and sigma. The group comparison for beta at the O2 site also exhibited a strong percentage of shared variability at 46%.

The significance of the discovery that the SOP of people who exhibit insomnia complaints subsequent to MTBI is associated with higher variability in power should not be understated. Consistent and strong differences were found between the groups within each of the standard frequency bands except alpha. This relationship does not merely reflect an electrophysiological difference between groups, but offers a possible explanation for the longer sleep onset latency which has been observed in MTBI subsequent to injury.

Variability of power reflects the magnitude of the normal oscillations in power seen as people move from wakefulness to sleep. For example, when examined over the entire sleep onset period, it has been demonstrated that power within the alpha band decreases. Such changes are essentially a process of lowering arousal. However, the descent into sleep is characterized by moment to moment fluctuations in arousal level. That is, movements towards sleep (e.g. decreases in beta), are often followed by movements towards wakefulness. It is the extent, or magnitude, of these oscillations that is captured by measures of variability in power. It follows that greater variability would
result in an impaired ability to lower level of arousal. Disruption of this sort over the SOP would lead to increases in sleep onset latency and perhaps to disruptions of the sleep process.

Another question that must be addressed is whether or not the differences in variability reflect distinct mechanisms. If variability is seen as a definitional element of the sleep onset process, then rather than simply describing changes in frequency bands in terms of power, a fuller description of the sleep onset mechanism may be accomplished by adding information regarding variability. For example, based on data from the current study, such a description might suggest that in normals, delta increases over the SOP, and it does so with increasing variability. If it could be determined in a second group that delta increased over the SOP, but with decreasing variability as time progressed, this might represent a process distinct from normals.

Alternatively, one could accept the premise that the degree of variability reflects the stability of the process. It would follow then, that heightened variability may reflect a general disruption. For example, considering variability has been likened to changes in direction of slope of the curve, increases in variability would reflect a higher number of slope changes (Lamarche, 1995). An intact sleep onset process might involve a “smooth” slide from high levels of beta to low levels of beta with very little upward and downward shifts of great magnitude along the way. Conversely, the same overall effect may be found in an individual with a disrupted sleep onset mechanism (i.e. beta power decreases over each mean taken per quartile); however, that process may involve many more sizable changes in slope within each quartile.
At present there is not enough evidence to suggest that variability reflects some specialized mechanism. Rather, it seems more likely that it is indicative of some general disruption to the sleep onset processes. For the most part, the differences found in regard to variability are main effects which would imply an overall or general effect as opposed to an effect that might distinguish one group from another in terms of process. Further, heightened variability in insomniac populations do not seem to be limited to one group; Lamarche (1995) found more variability in delta frequency in both psychophysiological insomniacs and psychiatric insomniacs when compared to normal controls. It should be noted, however, that while similar results in regard to variability have been found in other insomniac populations, the effects were not as strong or as consistent across frequency as was found for the current undertaking.

The effects involving quartile found in regard to variability in log power across the sleep onset period were consistent with previous research. In her master's thesis, Lamarche (1995) describes time effects for variability in alpha, sigma, delta, and theta. According to Lamarche (1995), variability in alpha decreased over the SOP, while variability in all the other frequencies reported increased. In the current study, significant variability effects for time were found in delta, theta and sigma frequencies. In general, a similar result was found: variability increased from the beginning to end of the SOP.
Further validation of subject selection

Questionnaire Data

The analyses of the sleep questionnaires were conducted primarily to validate the subject selection process. There were significant group differences in all of the sleep questionnaires used to measure sleep quality. Significant differences were found in the PSQI for sleep quality, sleep latency, sleep disturbances, and global PSQI score. That is, subjects in the MTBI group rated their sleep onset latency as longer, their sleep as more interrupted during the night, and their overall sleep quality as poorer than the control group's respective ratings. Such findings should be interpreted as descriptive since length of sleep onset was used as selection criteria for the MTBI group. However, these results validate the subject selection process of the study and their self report.

Further validation of the subject selection process may be found in the significant difference between pre and post injury PSQI scores in the MTBI group. Subjects in the MTBI group reported significantly reduced sleep quality subsequent to injury for sleep latency, sleep duration, sleep disturbances, and overall sleep quality. Because one of the criteria for inclusion into the group was an absence of sleep difficulties before injury, this finding is not ground breaking, but again, the finding validates the presence of sleep difficulties in a proportion of individuals who have sustained MTBI.

The conclusion that can be drawn from these data is that the screening process was successful. Moreover, the questionnaire findings related to sleep were consistent with those of the objective indices: both methods were able to discriminate the MTBI group from the controls. Whether measured in a subjective or objective manner, the
MTBI group exhibited significantly more difficulty with sleep quality than controls. So, to the extent that one can extrapolate from the subjects, one could argue that persistent complaints of those with MTBI are valid and represent altered CNS function.

There were however, some other interesting findings in the questionnaire data. First, the BSIQ was not able to clearly discriminate the reported presentation of insomnia into psychiatric or psychophysiological sub-types. This finding coincides with the power spectral analyses whereby the electrophysiological data did not clearly indicate an alignment with a certain presentation of the sleep difficulties associated with MTBI. The sleep related questionnaire data also seem to point to a generalized sleep disturbance presentation. This was strongly indicated by the group differences in EEG variability which were strong and consistent across most primary frequencies as people fell asleep.

This point may be further supported by highlighting the significant differences between the normal controls and the MTBI group for narcolepsy and periodic limb movements on the SDQ. The occurrence of SOREMPs as outlined above correspond with the difference in regard to narcolepsy. The reader is directed to Tables 4 and 5 for a summary of the sleep-related questionnaire data.

The findings relevant to adaptive functioning may also to some extent be driven by selection criteria. Individuals were not selected for the MTBI group unless they reported difficulties with sleep which had persisted subsequent to injury. However, It is a significant finding that concurrent with sleep difficulty, other symptoms that are part of the classic constellation of PCS symptoms were also reported by this group. These included difficulty with attention, concentration, fatigue, forgetfulness, sensitivity to light
and noise, and headaches. These symptoms together with the sleep difficulties most likely contributed to the group differences found in everyday functioning as measured by the BAFQ. The areas of most concern seemed to be arousal level, memory, attention, use of excess caution, and planning. For all of these scales, there was a significant group difference and a mean of at least 40% of the items were rated by subjects as having changed since the injury (Refer to Table 3).

The PAI depression scale proved to be of interest. The overall depression score was slightly elevated for the MTBI group and significant differences were found between groups for the physiological depression sub-scale and the total depression scores. A separate analysis for the sub-components was useful because an elevation in one area may drive the overall scale in the same direction. Such was the case for the depression scale. Clearly the physiological depression exerted influence on the full scale depression score. Upon consideration that 50% of the items within the physiological sub-scale were sleep related (e.g. “I have no trouble falling asleep”), the validity of elevation in the case of this study is brought into question. On the other hand, depression and sleep problems are found to be related in most groups of depressed individuals. At the very least, it is questionable whether or not depression should be considered a difficulty within this group. In regard to anxiety, each sub-scale was slightly elevated and group differences were evident in full scale anxiety as well as each sub-scale.

Psychiatric complaints, including depression and anxiety, are a major element of post-concussion syndrome. According to Swenson (1997), between 51% to 84% of those sustaining MTBI complain of such difficulties. A certain amount of elevation in these
sub-scales then is to be expected. An increased complication to this and any similar study is that both anxiety and depression are related to sleep difficulty. In an attempt to minimize the possible circularity problem in causality, potential subjects who presented with psychiatric complaints prior to experiencing a head injury were screened out of the study. However, beyond this there was no plausible manner in which to control for psychiatric variables. It would be undesirable, and thus was not a procedure of the current undertaking, to eliminate subjects from the study on the basis of experiencing a common sequella of MTBI. Moreover, because a clear cause and effect relationship cannot be established between psychiatric variables and sleep difficulty, statistical control (e.g. ANCOVA) of these variables were also inappropriate.

A study of TBI and sleep difficulty is almost invariably open to the potential for psychiatric variables to present a confound. Fortunately, in the current study, it is not likely that depression was an important factor. In regard to anxiety, although there were group differences for each sub-scale of the PAI, when compared to the standardization and clinical populations, these scores were only slightly elevated. However, it should be noted that anxiety may have had an intervening effect on the previously reported results.

Because the self report of information regarding sleep and the experience of PCS symptoms were used as selection and screening criteria, these data could not be used to evaluate hypotheses. However, the information was extremely useful for descriptive purposes and in order to confirm the success of the screening process. It was the intention of the researcher to select individuals for the MTBI group who complained of persistent PCS symptoms. This was confirmed not only in the sleep data, but also in the
personality and adaptive functioning questionnaires. Further, it was a conscious intention to select participants for the MTBI group who reported difficulties with sleep. This was not only confirmed by the objectively measured PSG data, but was also supported by the questionnaire data.

The purpose of the study was to examine those individuals with long term sleep difficulties subsequent to head trauma within the larger MTBI population. Moreover, subjects were selected within a certain age range. Thus, the findings are not directly generalizable to the entire MTBI population. The subject selection procedures did not represent a confound in the design of the study as the aim was not to determine the existence of sleep difficulty in the MTBI population (such a relationship has been established in the previous literature). The questionnaire data provide evidence that a sample was chosen that was representative of the population under study.

Implications and future directions

The current study adds to a growing body of literature that demonstrates that there can be long term effects of MTBI. A measurable difference in objective electrophysiological data has been established between those who exhibit insomnia complaints subsequent to MTBI and controls. These effects have been demonstrated to exist well beyond the time that PCS is thought to resolve.

The results from this and many other studies have important implications for prevention. Many of the injuries reported in the current study took place during the normal course of a sporting event. It is questionable whether or not these incidents
should be referred to as "accidents". There should be programs in place that work to educate the public regarding TBI. Educational programs have the potential to encouraging individuals to choose safer sports to participate in, to increase the proper use of safety equipment (such as protective helmets), and to practice safer conduct during the course of competition (e.g. the elimination of "hitting from behind" in hockey). At the very least, such education should be a prerequisite for participation in contact sports, especially in children and young adults.

The current research also has implications for the treatment of the sleep difficulties that occur secondary to MTBI. None of the MTBI subjects who participated in the current study were able to find appropriate treatment. This is not surprising considering the absence of research examining this issue. Although an effective treatment regime may not, at present, be available, data from the current study were able to provide evidence for a physiological basis for the disruption of sleep reported by many people who have sustained MTBI. Through comparisons with the existing literature, the current work suggests that the sleep difficulties that occur in the aftermath of MTBI present in a different manner, electrophysiologically, than either idiopathic insomnia or psychophysiological insomnia. It follows that the practices that have been developed in order to treat these other difficulties may not be appropriate for insomnia complaints that are secondary to MTBI.

There are many avenues of future research that need to be advanced in regard to MTBI and sleep difficulty. First, variability in spectral power across the SOP should be examined in more depth. It is currently unknown whether increased variability in
spectral power is indicative of general sleep pathology or whether a certain pattern exists which may be able to differentiate one special population from another. In the future, researchers should examine this phenomenon in several special populations simultaneously. Such a study would allow for the between group comparisons that are necessary in order to determine the specificity of the variability effect. Moreover, EEG across the SOP should be compared with that of wakefulness. Having access to waking data, which were not available for the current study, would enable researchers to determine whether or not differences in average power (i.e. in beta) as well as variability of power were simply a continuation of differences in baseline values or are special to the SOP.

Further power spectral studies are also needed in order to examine the evolution of sleep difficulty in MTBI from the time of injury, throughout and beyond the recovery period of PCS. Although some studies have examined the power spectra of NREM and REM sleep at the time of injury and into the recovery period, no such study has examined these properties in the time period where PCS is thought to have resolved. Moreover, no other study has examined the SOP in depth at the time of injury and throughout the 6 to 12 months of recovery. As interesting differences were found in the current study between controls and a MTBI population that complains of sleep difficulties, the SOP should be examined in more depth throughout the recovery period.

To my knowledge, not a single study exists which has examined or evaluated the potential usefulness of any new or existing treatments for the insomnia-like complaints of MTBI. Such a study is overdue. Although there is currently research being
null
undertaken in the basic research field, clinical studies should commence. Although clinical understanding may be advanced by the expansions in primary knowledge, the relationship can work in the other direction as well. It is often the case that research into the treatment of a disease can speak to the etiology and assist in evaluating the underpinnings of the problem. Research into the treatment of the sleep difficulties associated with MTBI should commence, and be conducted in such a manner as to be informed by the basic research. The survey data have demonstrated that there is a significant population that experiences these difficulties and clinical psychologists, physicians, and other health care workers will be unable to provide assistance until such research is carried out.

Conclusions

The purpose of the current undertaking was to study the electrophysiological properties of the SOP in order to gain understanding into the persistent sleep difficulties of those who complain of insomnia following MTBI. To date, no known study has examined the electrophysiological properties of persistent sleep difficulty that arises secondary to MTBI. Moreover, no study has examined the SOP in order to gain an understanding of the sleep problems associated with MTBI.

Questionnaire and PSG data obtained demonstrated that the screening and selection process was successful. The clinical group was representative of the population which demonstrates persistent sequellae of MTBI at least 6 months post injury and has experienced sleep difficulty that had arisen as part of the PCS constellation of symptoms.
Polysomnographic data were analysed in order to determine whether or not the difficulty with sleep that has been reported in the literature could be detected electrophysiologically. Two models that were based on findings of previous studies were proposed for the possible electrophysiological presentation of the sleep difficulties. The sleep architecture differences that were expected under the idiopathic model were not found. Thus, it could not be concluded that the presentation of the sleep difficulties associated with MTBI were similar to that of idiopathic insomnia. However, an analysis of the standard sleep parameters did demonstrate predicted differences between individuals who have sustained MTBI and report sleep difficulties and controls. The subjective complaints of difficulty falling asleep in the clinical group were substantiated as the sleep onset latency was found to be longer than those of the normal controls. Moreover, the sleep efficiency in this group was found to be lesser than that for controls.

Power spectral analyses were examined over the SOP in order to determine whether or not the sleep difficulties encountered by the MTBI population could be characterized by altered sleep onset mechanisms. Although a difference between groups was observed in the beta frequency range (indicating either a depression in baseline values of beta activity or a distinct entry into sleep), the data did not support the psychophysiological model. Altered sleep onset mechanisms similar in form to those previously reported in psychophysiological insomnia were not found. This suggests that the sleep difficulty encountered with MTBI cannot be explained as being due to learned psychophysiological insomnia.
There were, however, striking differences observed in the variability of the power spectral data. Consistent and strong differences between the MTBI and controls occurred, with the clinical group exhibiting a greater amount of variability within each of the standard frequency bands except alpha. These differences provide an electrophysiological basis for the sleep difficulties experienced by a proportion of individuals who have sustained MTBI. That is, oscillations in level of arousal of a greater magnitude than normal in this group, provide a potential mechanism to explain the sleep difficulties that have been both reported subjectively and confirmed by objective observation in this investigation.
References


Table 1

Demographic and personality variables for the MTBI and Control groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>MTBI</th>
<th>Control</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (n)</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Female (n)</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>21.44 (2.45)</td>
<td>20.67 (2.06)</td>
<td>ns</td>
</tr>
<tr>
<td>Time, post injury (months)</td>
<td>27.78 (15.47)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAIS Vocabulary</td>
<td>13.44 (2.07)</td>
<td>13.89 (1.97)</td>
<td>ns</td>
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</table>

Personality Assessment Inventory

**Depression**

<table>
<thead>
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<th>Variable</th>
<th>MTBI</th>
<th>Control</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>COG</td>
<td>56.00 (7.35)</td>
<td>49.22 (13.54)</td>
<td>ns</td>
</tr>
<tr>
<td>AFF</td>
<td>61.22 (14.03)</td>
<td>49.11 (15.23)</td>
<td>ns</td>
</tr>
<tr>
<td>PHYS</td>
<td>66.00 (6.36)</td>
<td>38.78 (14.24)</td>
<td>t(16)= 1.32, p&lt;.001</td>
</tr>
<tr>
<td>TOT</td>
<td>60.78 (12.18)</td>
<td>46.78 (6.18)</td>
<td>t(16)= 3.07, p=.007</td>
</tr>
</tbody>
</table>

**Anxiety**

<table>
<thead>
<tr>
<th>Variable</th>
<th>MTBI</th>
<th>Control</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>COG</td>
<td>61.11 (9.17)</td>
<td>48.44 (7.14)</td>
<td>t(16)= 3.27, p=.005</td>
</tr>
<tr>
<td>AFF</td>
<td>61.00 (13.09)</td>
<td>44.56 (3.71)</td>
<td>t(16)= 3.63, p=.002</td>
</tr>
<tr>
<td>PHYS</td>
<td>63.33 (12.03)</td>
<td>47.11 (5.36)</td>
<td>t(16)= 3.70, p=.002</td>
</tr>
<tr>
<td>TOT</td>
<td>60.00 (11.67)</td>
<td>47.89 (7.18)</td>
<td>t(16)= 2.65, p=.017</td>
</tr>
</tbody>
</table>

*Note.* COG=Cognitive; AFF=Affective; PHYS=Physiological; TOT=Total.
Table 2

Descriptive information regarding the injury under consideration for the MTBI group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SR</td>
</tr>
<tr>
<td>Sex</td>
<td>m</td>
</tr>
<tr>
<td>Months post-injury</td>
<td>36</td>
</tr>
<tr>
<td>Type</td>
<td>a</td>
</tr>
<tr>
<td>unconsciousness (min.)</td>
<td>&lt;1</td>
</tr>
<tr>
<td>PTA (min)</td>
<td>15</td>
</tr>
<tr>
<td>RA (min.)</td>
<td>0</td>
</tr>
<tr>
<td>Time in hospital (hrs)</td>
<td>0</td>
</tr>
<tr>
<td># of previous TBI(s)</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. PTA=post-traumatic amnesia; RA= retrograde amnesia; a=sports related injury; b=Motor/vehicle accident; c=fight/attack.
Table 3
Mean (SD) Brock Adaptive Functioning Questionnaire (BAFO) scores* for MTBI and Control groups.

<table>
<thead>
<tr>
<th>BAFQ Variable</th>
<th>MTBI</th>
<th>Control</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Functioning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiation</td>
<td>57.78 (12.28)</td>
<td>47.78 (19.38)</td>
<td>ns</td>
</tr>
<tr>
<td>Flexibility</td>
<td>58.33 (12.99)</td>
<td>32.22 (3.63)</td>
<td>( t(16)= 5.81, p&lt;.001 )</td>
</tr>
<tr>
<td>Planning</td>
<td>48.57 (13.85)</td>
<td>30.79 (8.77)</td>
<td>( t(16)= 3.25, p=.005 )</td>
</tr>
<tr>
<td>Excess Caution</td>
<td>74.22 (18.45)</td>
<td>48.89 (12.13)</td>
<td>( t(16)= 3.44, p=.003 )</td>
</tr>
<tr>
<td>Attention</td>
<td>61.96 (19.80)</td>
<td>36.51 (10.67)</td>
<td>( t(16)= 3.39, p=.004 )</td>
</tr>
<tr>
<td>Memory</td>
<td>53.06 (13.00)</td>
<td>33.89 (9.36)</td>
<td>( t(16)= 3.59, p=.002 )</td>
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<tr>
<td>Arousal Level</td>
<td>57.78 (13.13)</td>
<td>40.22 (13.65)</td>
<td>( t(16)= 2.78, p=.013 )</td>
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<tr>
<td>Emotionality</td>
<td>52.22 (13.49)</td>
<td>47.22 (16.60)</td>
<td>ns</td>
</tr>
<tr>
<td>Impulsivity</td>
<td>41.91 (14.64)</td>
<td>40.96 (15.73)</td>
<td>ns</td>
</tr>
<tr>
<td>Aggressiveness</td>
<td>58.22 (21.36)</td>
<td>40.67 (19.90)</td>
<td>ns</td>
</tr>
<tr>
<td>Social monitoring</td>
<td>43.49 (8.42)</td>
<td>38.42 (6.26)</td>
<td>ns</td>
</tr>
<tr>
<td>Empathy</td>
<td>38.22 (12.35)</td>
<td>33.33 (9.38)</td>
<td>ns</td>
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</table>

Mean % change post-injury

<table>
<thead>
<tr>
<th>BAFQ Variable</th>
<th>MtBI</th>
<th>Control</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation</td>
<td>27.27 (29.11)</td>
<td></td>
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</tr>
<tr>
<td>Flexibility</td>
<td>29.55 (36.65)</td>
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<tr>
<td>Planning</td>
<td>40.26 (23.45)</td>
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<tr>
<td>Excess Caution</td>
<td>45.45 (37.26)</td>
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</tr>
<tr>
<td>Attention</td>
<td>43.72 (30.38)</td>
<td></td>
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</tr>
<tr>
<td>Memory</td>
<td>46.59 (34.58)</td>
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</tr>
<tr>
<td>Arousal Level</td>
<td>47.27 (27.33)</td>
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</tr>
<tr>
<td>Emotionality</td>
<td>29.55 (23.40)</td>
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<tr>
<td>Impulsivity</td>
<td>22.08 (14.11)</td>
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<tr>
<td>Aggressiveness</td>
<td>32.73 (40.25)</td>
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</tr>
<tr>
<td>Social monitoring</td>
<td>18.18 (18.37)</td>
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<tr>
<td>Empathy</td>
<td>21.82 (24.80)</td>
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Note. *High scores indicate greater difficulty
<table>
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<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
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<tr>
<td></td>
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</table>
Table 4

Mean (SD) Current and Pre-injury Pittsburgh Sleep Quality Index (PSQI) scores for the MTBI group.

<table>
<thead>
<tr>
<th>Pittsburgh Sleep Quality Index</th>
<th>MTBI Group</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-injury</td>
<td>Current</td>
<td></td>
<td>t</td>
</tr>
<tr>
<td>1. Sleep Quality</td>
<td>0.78 (0.67)</td>
<td>1.89 (1.05)</td>
<td>t(8)= 3.16, p=.013</td>
<td></td>
</tr>
<tr>
<td>2. Sleep Latency</td>
<td>0.56 (0.53)</td>
<td>2.22 (0.97)</td>
<td>t(8)= 5.77, p&lt;.001</td>
<td></td>
</tr>
<tr>
<td>3. Sleep Duration</td>
<td>0.11 (0.33)</td>
<td>1.22 (1.09)</td>
<td>t(8)= 2.86, p=.021</td>
<td></td>
</tr>
<tr>
<td>4. Sleep Efficiency</td>
<td>0.11 (0.33)</td>
<td>1.00 (1.22)</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>5. Sleep Disturbances</td>
<td>1.00 (0.50)</td>
<td>1.67 (0.50)</td>
<td>t(8)= 2.83, p=.022</td>
<td></td>
</tr>
<tr>
<td>6. Sleep Medication</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>7. Daytime Dysfunction</td>
<td>0.89 (1.56)</td>
<td>1.56 (0.88)</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>8. Global PSQI</td>
<td>3.44 (1.13)</td>
<td>9.56 (3.50)</td>
<td>t(8)= 5.44, p=.001</td>
<td></td>
</tr>
</tbody>
</table>
### Table 5

Mean (SD) Sleep Questionnaire scores for the MTBI and Control groups.

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Group</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MTBI</td>
<td>Control</td>
</tr>
<tr>
<td>Pittsburgh Sleep Quality index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sleep Quality</td>
<td>1.89 (1.05)</td>
<td>0.89 (0.78)</td>
</tr>
<tr>
<td>2. Sleep Latency</td>
<td>2.22 (0.97)</td>
<td>0.89 (0.93)</td>
</tr>
<tr>
<td>3. Sleep Duration</td>
<td>1.22 (1.09)</td>
<td>0.44 (0.53)</td>
</tr>
<tr>
<td>4. Sleep Efficiency</td>
<td>1.00 (1.22)</td>
<td>0.22 (0.44)</td>
</tr>
<tr>
<td>5. Sleep Disturbances</td>
<td>1.67 (0.50)</td>
<td>1.11 (0.33)</td>
</tr>
<tr>
<td>6. Sleep Medication</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>7. Daytime Dysfunction</td>
<td>1.56 (0.88)</td>
<td>0.89 (0.60)</td>
</tr>
<tr>
<td>8. Global PSQI</td>
<td>9.56 (3.50)</td>
<td>4.44 (1.59)</td>
</tr>
<tr>
<td>Sleep Disorders Questionnaire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep Apnea</td>
<td>21.78 (7.90)</td>
<td>18.44 (5.73)</td>
</tr>
<tr>
<td>Narcolepsy</td>
<td>25.11 (5.40)</td>
<td>16.44 (6.42)</td>
</tr>
<tr>
<td>Psychiatric Insomnia</td>
<td>23.67 (4.69)</td>
<td>16.33 (3.67)</td>
</tr>
<tr>
<td>Periodic Limb Movements</td>
<td>21.22 (6.63)</td>
<td>13.56 (2.35)</td>
</tr>
<tr>
<td>Brock Sleep and Insomnia Questionnaire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep Quality</td>
<td>42.67 (9.67)</td>
<td>10.28 (4.72)</td>
</tr>
<tr>
<td>Psychiatric Insomnia</td>
<td>44.22 (18.59)</td>
<td>22.89 (8.67)</td>
</tr>
<tr>
<td>Psychophysiological Ins.</td>
<td>45.67 (15.68)</td>
<td>21.33 (6.54)</td>
</tr>
<tr>
<td>Delayed Phase Disorder</td>
<td>7.11 (4.51)</td>
<td>5.39 (4.00)</td>
</tr>
<tr>
<td>Year</td>
<td>Number</td>
<td>Rate</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>2022</td>
<td>1,000</td>
<td>5.0%</td>
</tr>
<tr>
<td>2021</td>
<td>950</td>
<td>4.5%</td>
</tr>
<tr>
<td>2020</td>
<td>900</td>
<td>4.0%</td>
</tr>
<tr>
<td>2019</td>
<td>850</td>
<td>3.5%</td>
</tr>
<tr>
<td>2018</td>
<td>800</td>
<td>3.0%</td>
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<tr>
<td>2017</td>
<td>750</td>
<td>2.5%</td>
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<tr>
<td>2016</td>
<td>700</td>
<td>2.0%</td>
</tr>
<tr>
<td>2015</td>
<td>650</td>
<td>1.5%</td>
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<tr>
<td>2014</td>
<td>600</td>
<td>1.0%</td>
</tr>
<tr>
<td>2013</td>
<td>550</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Note: The rates are subject to change based on market conditions.
Table 6

Means (SD) for night 3 sleep parameters for the MTBI and control groups.

<table>
<thead>
<tr>
<th>Sleep Parameter</th>
<th>MTBI</th>
<th>Control</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total recording time (min.)</td>
<td>481.61 (67.59)</td>
<td>491.33 (31.04)</td>
<td></td>
</tr>
<tr>
<td>Total sleep time (min.)</td>
<td>441.83 (47.82)</td>
<td>471.78 (30.54)</td>
<td>ns</td>
</tr>
<tr>
<td>Sleep efficiency (%)</td>
<td>92.17 (4.15)</td>
<td>96.02 (1.54)</td>
<td></td>
</tr>
<tr>
<td>Sleep onset latency (min.)</td>
<td>22.83 (20.67)</td>
<td>6.94 (4.61)</td>
<td></td>
</tr>
<tr>
<td>sREM onset latency (min.)</td>
<td>55.39 (31.77)</td>
<td>98.61 (31.74)</td>
<td></td>
</tr>
<tr>
<td>Awakenings (n)</td>
<td>3.22 (2.49)</td>
<td>1.55 (1.42)</td>
<td>ns</td>
</tr>
<tr>
<td>Wake after sleep onset (min.)</td>
<td>11.55 (6.37)</td>
<td>8.50 (6.86)</td>
<td>ns</td>
</tr>
<tr>
<td>Sleep Stage %</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Wake</td>
<td>2.11 (1.20)</td>
<td>1.50 (1.39)</td>
<td>ns</td>
</tr>
<tr>
<td>Movement</td>
<td>1.11 (0.71)</td>
<td>0.81 (0.39)</td>
<td>ns</td>
</tr>
<tr>
<td>REM</td>
<td>24.92 (7.44)</td>
<td>22.55 (3.81)</td>
<td>ns</td>
</tr>
<tr>
<td>Stage 1</td>
<td>1.71 (1.09)</td>
<td>1.27 (1.06)</td>
<td>ns</td>
</tr>
<tr>
<td>Stage 2</td>
<td>49.32 (6.57)</td>
<td>51.49 (5.89)</td>
<td>ns</td>
</tr>
<tr>
<td>Stage 3</td>
<td>10.51 (3.02)</td>
<td>9.45 (3.54)</td>
<td>ns</td>
</tr>
<tr>
<td>Stage 4</td>
<td>13.54 (5.06)</td>
<td>15.24 (5.46)</td>
<td>ns</td>
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</table>
### Table 7

Means (SE) for effects involving group for average log power ($\mu v^2$) and standard deviation log power ($\mu v^2$).

<table>
<thead>
<tr>
<th>Effect</th>
<th>MTBI</th>
<th>CTRL</th>
<th>Statistics</th>
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<tbody>
<tr>
<td><strong>Average log power</strong></td>
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<td></td>
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</tr>
<tr>
<td>Group (main)</td>
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</tr>
<tr>
<td>Beta</td>
<td>0.63 (0.07)</td>
<td>0.88 (0.07)</td>
<td>$p=.031$, $\eta^2=.26$</td>
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<tr>
<td><strong>SD log power</strong></td>
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<tr>
<td>Group (main)</td>
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</tr>
<tr>
<td>Delta</td>
<td>0.32 (0.02)</td>
<td>0.25 (0.02)</td>
<td>$p=.008$, $\eta^2=.37$</td>
</tr>
<tr>
<td>Theta</td>
<td>0.28 (0.01)</td>
<td>0.24 (0.01)</td>
<td>$p=.019$, $\eta^2=.30$</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.31 (0.01)</td>
<td>0.26 (0.01)</td>
<td>$p=.005$, $\eta^2=.40$</td>
</tr>
<tr>
<td><strong>Site x group</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Beta2</td>
<td></td>
<td></td>
<td>$p=.002$, $\eta^2=.33$</td>
</tr>
<tr>
<td>C4</td>
<td>0.24 (0.02)</td>
<td>0.25 (0.02)</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>0.22 (0.01)</td>
<td>0.22 (0.01)</td>
<td></td>
</tr>
<tr>
<td>O2</td>
<td>0.27 (0.01)</td>
<td>0.22 (0.01)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.25 (0.01)</td>
<td>0.23 (0.01)</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Age</td>
<td>Gender</td>
<td>Height</td>
</tr>
<tr>
<td>------------</td>
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<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>John</td>
<td>30</td>
<td>Male</td>
<td>170cm</td>
</tr>
<tr>
<td>Mary</td>
<td>28</td>
<td>Female</td>
<td>165cm</td>
</tr>
<tr>
<td>David</td>
<td>32</td>
<td>Male</td>
<td>180cm</td>
</tr>
<tr>
<td>Emily</td>
<td>25</td>
<td>Female</td>
<td>172cm</td>
</tr>
<tr>
<td>Robert</td>
<td>35</td>
<td>Male</td>
<td>185cm</td>
</tr>
<tr>
<td>Sarah</td>
<td>29</td>
<td>Female</td>
<td>168cm</td>
</tr>
<tr>
<td>Thomas</td>
<td>31</td>
<td>Male</td>
<td>178cm</td>
</tr>
<tr>
<td>Olivia</td>
<td>27</td>
<td>Female</td>
<td>174cm</td>
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</tbody>
</table>

**Next Page**
Table 8
Means (SE) for average log power ($\mu v^2$) for effects involving quartile.

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Effect</th>
<th>p &lt; 0.001, $\eta^2 = 0.71$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site x quartile Theta</td>
<td></td>
<td>p = 0.006, $\eta^2 = 0.20$</td>
</tr>
<tr>
<td>C4</td>
<td>1.07 (0.06)</td>
<td>1.01 (0.06)</td>
</tr>
<tr>
<td>F4</td>
<td>1.06 (0.07)</td>
<td>1.06 (0.06)</td>
</tr>
<tr>
<td>O2</td>
<td>0.93 (0.10)</td>
<td>0.93 (0.10)</td>
</tr>
<tr>
<td>T</td>
<td>1.00 (0.08)</td>
<td>1.00 (0.08)</td>
</tr>
<tr>
<td>Alpha</td>
<td></td>
<td>p &lt; 0.001, $\eta^2 = 0.42$</td>
</tr>
<tr>
<td>C4</td>
<td>1.07 (0.10)</td>
<td>0.91 (0.09)</td>
</tr>
<tr>
<td>F4</td>
<td>1.08 (0.10)</td>
<td>0.89 (0.08)</td>
</tr>
<tr>
<td>O2</td>
<td>1.43 (0.15)</td>
<td>1.18 (0.15)</td>
</tr>
<tr>
<td>T</td>
<td>1.20 (0.11)</td>
<td>0.99 (0.10)</td>
</tr>
<tr>
<td>Sigma</td>
<td></td>
<td>p &lt; 0.001, $\eta^2 = 0.48$</td>
</tr>
<tr>
<td>C4</td>
<td>0.35 (0.07)</td>
<td>0.26 (0.04)</td>
</tr>
<tr>
<td>F4</td>
<td>0.37 (0.07)</td>
<td>0.25 (0.05)</td>
</tr>
<tr>
<td>O2</td>
<td>0.51 (0.08)</td>
<td>0.32 (0.08)</td>
</tr>
<tr>
<td>T</td>
<td>0.41 (0.07)</td>
<td>0.28 (0.05)</td>
</tr>
<tr>
<td>Beta</td>
<td></td>
<td>p &lt; 0.001, $\eta^2 = 0.54$</td>
</tr>
<tr>
<td>C4</td>
<td>0.90 (0.05)</td>
<td>0.76 (0.06)</td>
</tr>
<tr>
<td>F4</td>
<td>0.91 (0.04)</td>
<td>0.79 (0.05)</td>
</tr>
<tr>
<td>O2</td>
<td>0.94 (0.07)</td>
<td>0.79 (0.09)</td>
</tr>
<tr>
<td>T</td>
<td>0.92 (0.05)</td>
<td>0.78 (0.06)</td>
</tr>
</tbody>
</table>
Table 9

Means (SE) for standard deviation log power (\(\mu^2\)) for effects involving quartile.

<table>
<thead>
<tr>
<th>Quartile</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta</td>
<td>0.25 (0.01)</td>
<td>0.27 (0.02)</td>
<td>0.27 (0.01)</td>
<td>0.34 (0.02)</td>
<td>(p&lt;.001, \eta^2=.45)</td>
</tr>
<tr>
<td>Site x quartile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p=.004, \eta^2=.21)</td>
</tr>
<tr>
<td>Theta</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p&lt;.001, \eta^2=.31)</td>
</tr>
<tr>
<td>C4</td>
<td>0.23 (0.01)</td>
<td>0.28 (0.02)</td>
<td>0.25 (0.02)</td>
<td>0.31 (0.21)</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>0.24 (0.01)</td>
<td>0.27 (0.01)</td>
<td>0.24 (0.02)</td>
<td>0.28 (0.02)</td>
<td></td>
</tr>
<tr>
<td>O2</td>
<td>0.26 (0.01)</td>
<td>0.24 (0.01)</td>
<td>0.25 (0.01)</td>
<td>0.26 (0.02)</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>0.24 (0.01)</td>
<td>0.26 (0.01)</td>
<td>0.25 (0.01)</td>
<td>0.29 (0.02)</td>
<td></td>
</tr>
<tr>
<td>Sigma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p=.003, \eta^2=.18)</td>
</tr>
<tr>
<td>C4</td>
<td>0.27 (0.01)</td>
<td>0.26 (0.01)</td>
<td>0.28 (0.02)</td>
<td>0.33 (0.02)</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>0.25 (0.01)</td>
<td>0.27 (0.02)</td>
<td>0.30 (0.02)</td>
<td>0.35 (0.02)</td>
<td></td>
</tr>
<tr>
<td>O2</td>
<td>0.29 (0.02)</td>
<td>0.26 (0.02)</td>
<td>0.27 (0.01)</td>
<td>0.28 (0.01)</td>
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</tr>
<tr>
<td>T</td>
<td>0.27 (0.01)</td>
<td>0.27 (0.01)</td>
<td>0.28 (0.02)</td>
<td>0.32 (0.02)</td>
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</tr>
<tr>
<td>Beta</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p=.003, \eta^2=.18)</td>
</tr>
<tr>
<td>C4</td>
<td>0.21 (0.02)</td>
<td>0.21 (0.01)</td>
<td>0.19 (0.01)</td>
<td>0.22 (0.02)</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>0.19 (0.01)</td>
<td>0.19 (0.01)</td>
<td>0.19 (0.01)</td>
<td>0.21 (0.02)</td>
<td></td>
</tr>
<tr>
<td>O2</td>
<td>0.20 (0.01)</td>
<td>0.22 (0.02)</td>
<td>0.17 (0.01)</td>
<td>0.18 (0.01)</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>0.20 (0.02)</td>
<td>0.21 (0.02)</td>
<td>0.19 (0.01)</td>
<td>0.20 (0.01)</td>
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</tr>
</tbody>
</table>
Table 10

Means (SE) for average log power (μv2) and standard deviation log power (μv2) for main effects of site.

<table>
<thead>
<tr>
<th>Effect</th>
<th>C4</th>
<th>F4</th>
<th>O2</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean log power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta</td>
<td>1.26 (0.06)</td>
<td>1.33 (0.06)</td>
<td>1.11 (0.07)</td>
<td>p&lt;.001, η²=.62</td>
</tr>
<tr>
<td>SD log power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta</td>
<td>0.29 (0.01)</td>
<td>0.29 (0.01)</td>
<td>0.27 (0.01)</td>
<td>p=.027, η²=.21</td>
</tr>
</tbody>
</table>
Figure 1. Bar graph of average log power (uv²) of beta by group.
Figure 2. Line graph of average log power ($uv^2$) of delta by quartile.
Figure 3. Line graph of average log power (uv^2) of theta by quartile and site.
Figure 5. Line graph of average log power (uv^2) of sigma by quartile and site.
Figure 6. Line graph of average log power (uV^2) of Beta by quartile and site.
Figure 7. Bar graph of standard deviation log power ($uv^2$) of delta by group.
Figure 8. Bar graph of standard deviation log power ($uv^2$) of theta by group.
Figure 9. Bar graph of standard deviation log power ($uv^2$) of sigma by group.
Figure II. Line graph of standard deviation log power (uv²) of delta by quartile.

SD Log Power (uv²) for Delta

QUARTILE
Figure 12. Line graph of standard deviation log power ($uv^2$) of theta by quartile and site.
Figure 13. Line graph of standard deviation log power (uv^2) of sigma by quartile and site.
Figure 14. Line graph of standard deviation log power ($\text{uv}^2$) of beta by quartile and site.
Figure 15. Bar graph of average log power (uv²) of Delta by site.
Figure 16. Bar graph of standard deviation log power (uv^2) of Delta by site.
Title of Study: An Investigation of Minor Head Injury and Insomnia
Researcher: Benjamin R. Williams.
Supervisor: Robert D. Ogilvie

Name of Participant: ____________________________ (please print)

I clearly understand:

That this study will involve examining the sleep patterns in groups of individuals with and without reports of sleep disturbances. I understand that I will be required to undergo an interview and complete various questionnaires prior to participating in the three night study. This questionnaire/interview phase will take approximately 2-3 hours to complete. In addition, I understand that after filling out the questionnaires, I may or may not be asked to participate in the overnight portion of the study. This is because of the importance of matching groups on various demographic characteristics.

I understand that the researchers will ask to examine those medical records, if any, that relate to my injury or sleep disturbance. I will be asked to sign a separate form if that were to happen.

I understand that during the study I will be required to complete an interview and fill out various questionnaires pertaining to my sleep behaviour, any possible head injuries, my day to day activities as well as my personality. I may omit any which I am not comfortable answering. In the event that I am asked to participate in the overnight portion of the study, I will be given an orientation tour of the sleep lab and all electrode application procedures will be explained to me.

I agree to refrain from using alcohol or caffeine for the two days that I may participate in the overnight portion of the study. Moreover, I understand that there will be no opportunity to smoke during an overnight session.

I understand that I will be required to wear non revealing, comfortable sleep wear during the overnight session. Furthermore, I understand that at least two researchers, one male and one female will be present in the sleep lab at all times during the overnight portion of the study. I may ask for assistance or information from them at any time.

I have been informed that for security purposes the entire night will be recorded on videotape.

I understand that my participation in this study is voluntary and that I may withdraw from the study at any time and for any reason without penalty. I understand that there is no obligation to answer any question/participate in any aspect of this project that I consider invasive.
I understand that all personal data will be kept strictly confidential and that all information will be coded so that my identity remains anonymous. I understand that only the researchers involved in the study will have access to the data and that none of the data will be permitted outside the sleep lab.

Participant’s Signature ________________________________ Date: ________________

If you have any questions or concerns about your participation in this study, you may contact me at the Sleep Lab (688-5550 Ex 3795) or my supervisor, Dr. Robert Ogilvie at (Ex 3573). Feedback about the use of the data collected will be available during the month of April, 1999. A written explanation will be provided for you upon request.

Thank you for your help! Please take one copy of this form with you for further reference.

I have fully explained the procedures of this study to the above volunteer.

Researcher's Signature ________________________________ Date: ________________
INTERVIEW—Mild Head Injury

General Information
Name:
Date of Birth:
Telephone Number:
Highest Level of Education:
How would you describe yourself as a student (A, B, C)?
High School graduating average:
Did you ever fail a grade? (Yes-Why? What Happened?)

Mild Head Injury
Have you received a blow to your head severe enough so that you had to stop whatever you were doing at the time (because of dizziness, pain, disorientation, unconsciousness, etc...)?

The head injury was from: Motor vehicle accident
Bicycle accident
Fall
Sports Accident
Fight/Attack
Other

Describe the events in as much detail as you possibly can:

How old were you when the injury occurred?

Were you unconscious? Yes/No/Don’t Know
-Yes, How long? < 1 min. 1-5 min. 5-30 min. 30 min-1 day > 1 day

Did you receive medical attention? Yes/No/Not Much
-Yes, were you admitted to hospital?
-Yes, How Long?
-Yes, What hospital? Records? Doctor’s Name?

Have you had more than 1 injury? Yes/No/Don’t know
-Yes, How many?
Did you have a loss of memory for events occurring after the incident?
   - Yes, How long after?
   - Yes, Did you regain this loss?

Did you have a loss of memory for events occurring before the incident?
   - Yes, How long after?
   - Yes, Did you regain this loss?

**Medical Release**
Did you see your Family physician or another doctor for follow-up after you injury?
Name: <if yes, ask to sign release>

**Post injury Symptoms**

Immediately following the head injury did you suffer from:

- Headache
- Dizziness
- Nausea
- Loss of Memory

Several Months Following your injury did you notice yourself having trouble with:

- Headaches
- Fatigue
- Forgetfulness
- Sleep Disturbances
- concentration
- thinking
- dividing your attention
- Depression
- Anxiety
- Loss of Appetite
- Blurred Vision
- Motor Co-ordination
- Sensitivity to light
- Sensitivity to noise

Were there any physical results of the injury?
- Broken bones?
- chronic pain
- kinesthetic sense
- reduced physical abilities
- loss of sensory function (smell, vision, hearing, tactile information)
- Paralysis
Questions Regarding Sleep
Does the participant have difficulty with any of the following?

<table>
<thead>
<tr>
<th>Prior to Current Brain injury</th>
<th>Since Current Brain injury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Falling a sleep?</td>
</tr>
<tr>
<td></td>
<td>Awakening during the night?</td>
</tr>
<tr>
<td></td>
<td>Returning to sleep after an awakening?</td>
</tr>
<tr>
<td></td>
<td>Early morning awakenings?</td>
</tr>
<tr>
<td></td>
<td>Difficulty staying awake during the day?</td>
</tr>
<tr>
<td></td>
<td>Difficulty concentrating?</td>
</tr>
</tbody>
</table>

Medical Release
Have you ever seen a physician or some other specialist for your sleep difficulties?
<if yes, ask to sign release>

Medication and Drugs
Is the participant taking any prescribed or over-the-counter medications? YES NO
List: Medication Purpose

Caffeine/Alcohol
Does the participant use any of the following (list according to criteria below):

None/Very Little/Moderate Amount/Heavy use

<table>
<thead>
<tr>
<th>Prior to Current Brain injury</th>
<th>Since Current Brain injury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Caffeine (Coffee, Tea, Chocolate, Soft drinks)?</td>
</tr>
<tr>
<td></td>
<td>Alcohol (Beer, Wine, Liquor)?</td>
</tr>
<tr>
<td></td>
<td>Other recreational or mood altering drugs?</td>
</tr>
</tbody>
</table>

WAIS
-Verbal

Questionnaires
-PAI
-SDQ
-BSIQ
-PSQI
THE BROCK ADAPTIVE FUNCTIONING QUESTIONNAIRE (Self report)

NAME: ___________________________ DATE: ____________________

IF YOU REQUIRE SOME HELP IN FILLING OUT THIS FORM, PUT THE NAME OF THE HELPER HERE:

________________________________________________________

RELATIONSHIP OF HELPER TO YOU: __________________________________________

DATE OF BIRTH: _______________ DATE OF INJURY: _______________________

TYPE OF INJURY: ________________________________________________________

EDUCATION LEVEL (PRIOR TO INJURY): _______ SINCE INJURY: _____________

EMPLOYMENT/CAREER/SCHOOL GRADE (PRIOR TO INJURY): _______________________

EMPLOYMENT/CAREER/SCHOOL GRADE (CURRENT): _____________________________

SPECIAL INTERESTS, HOBBIES, ETC., (PRIOR TO INJURY): _______________________

SPECIAL INTERESTS, HOBBIES, ETC., (CURRENT): _____________________________

People are very different in the way they approach situations. Please answer each question based on your typical behaviour AT THIS TIME.

If you cannot answer a question, circle the [ ? ].

If you feel that you would have answered a question the same before your brain injury, place a tick beside same which means that this behaviour is the same as before the injury.

If a particular behaviour has developed since your brain injury place a check beside changed which means that it represents a change in behaviour that you have noticed since the brain injury.

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Place a check in the space that best describes your behaviour. Read your choices carefully each time so you check the right end of the scale. Some behaviours may never be true for you. If you like, you can write "never" where we say "hardly ever" and then check that place.

Planning

Do you have a hard time making plans for the day on your own?

[ ? ] Hardly ever Rarely Sometimes Often Almost always [ ] same [ ] changed

When going out for the day, do you think about what you might need later in the day, for example, would you remember to bring a jacket in case it got colder, etc?

[ ? ] Hardly ever Rarely Sometimes Often Almost always [ ] same [ ] changed

When you have several tasks to do, do you organize them in an efficient way?

[ ? ] Hardly ever Rarely Sometimes Often Almost always [ ] same [ ] changed

Would you be able to manage if an emergency came up when you were home alone?

[ ? ] Hardly ever Rarely Sometimes Often Almost always [ ] same [ ] changed

When you make choices now, do you consider how they may affect you in the future?

[ ? ] Hardly ever Rarely Sometimes Often Almost always [ ] same [ ] changed

When making long term plans for yourself, do you think carefully about what you would need to do in order to reach your goals?

[ ? ] Hardly ever Rarely Sometimes Often Almost always [ ] same [ ] changed

When you make plans, do you think that your plans show good judgement (i.e., are they workable and realistic)?

[ ? ] Hardly ever Rarely Sometimes Often Almost always [ ] same [ ] changed
Do you have serious difficulty getting up in the morning unless you are actually prompted by another person?

Hardly ever  Rarely  Sometimes  Often  Almost always  [ ] same  [ ] changed

Do you do your household jobs without being reminded by anyone?

Hardly ever  Rarely  Sometimes  Often  Almost always  [ ] same  [ ] changed

Do you have trouble getting started on a project unless someone helps you get going?

Hardly ever  Rarely  Sometimes  Often  Almost always  [ ] same  [ ] changed

Even when you know exactly what has to be done to keep a project going, do you have a hard time moving to the next step on your own?

Hardly ever  Rarely  Sometimes  Often  Almost always  [ ] same  [ ] changed

Flexibility

2. Once you have made plans, is it very difficult for you to change them?

Hardly ever  Rarely  Sometimes  Often  Almost always  [ ] same  [ ] changed

3. When doing a task, can you easily distinguish between the more important and the less important parts of the task. (That is, if you were forced to hurry, would you be able to skip the less important steps?)

Hardly ever  Rarely  Sometimes  Often  Almost always  [ ] same  [ ] changed

4. When telling someone about an event or a movie, can you easily skip the unimportant details if pressed for time?

Hardly ever  Rarely  Sometimes  Often  Almost always  [ ] same  [ ] changed
Do you have real difficulty switching topics during a conversation?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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<td>^changed</td>
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</tbody>
</table>

Caution

Do you go over and over the same things in your mind more than you really need to?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

Do you find that you need to do things in the same way each time?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

Do you become very uncomfortable if your usual routines have to be changed?

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<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
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<th>Often</th>
<th>Almost always</th>
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</table>

Do you find yourself checking many times to be sure that everything is safe (e.g. doors locked, stove off, etc.)?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

Do you have a hard time trusting other people?

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<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</tbody>
</table>

Caution

Do you get distracted easily?

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<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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<td>^changed</td>
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</tbody>
</table>

Are you likely to forget that you have left the stove or kettle on?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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<td>^changed</td>
</tr>
<tr>
<td>Question</td>
<td>Hardly ever</td>
<td>Rarely</td>
<td>Sometimes</td>
<td>Often</td>
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<tr>
<td>-------------------------------------------------------------------------</td>
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<tr>
<td>Do you have a lot of trouble keeping track of where things are around the house?</td>
<td></td>
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<tr>
<td>Do you have trouble following spoken directions?</td>
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<tr>
<td>Do you have trouble sticking to the point you are trying to make when you are having a discussion?</td>
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<tr>
<td>Are you easily confused in stores and shopping malls?</td>
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<tr>
<td>Are you likely to get lost even in relatively familiar places?</td>
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<tr>
<td>Do you have a hard time learning new skills?</td>
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<tr>
<td>Do you have difficulty remembering events that happened in the last week?</td>
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<tr>
<td>Do you have difficulty remembering to do things that you had planned to do?</td>
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</tbody>
</table>
Do you have a lot of trouble remembering the names of people that you see regularly?

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<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

Do you have difficulty recognizing people that you have met before?

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<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

Do you have great difficulty recalling things that you used to know quite well?

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<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

Do you find it difficult to know whether the things you tell people happened in exactly the way you say they did?

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<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

Do you find it hard to distinguish between things that really happened and things that didn't really happen?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

**Cusual Level**

1. Do you have difficulty staying awake or alert?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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</table>

2. Does your voice sound flatter than you would like it to?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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3. Do you find it very difficult to get enthusiastic about things?

<table>
<thead>
<tr>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
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<tbody>
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</table>
Do you find it very hard to stay interested in what you are doing for a long period of time?

Hardly ever  Rarely  Sometimes  Often  Almost always

Do you feel very sad or depressed?

Hardly ever  Rarely  Sometimes  Often  Almost always

Opionality

Do you feel as though you get much too excited about things?

Hardly ever  Rarely  Sometimes  Often  Almost always

Do you think that you cry much too easily?

Hardly ever  Rarely  Sometimes  Often  Almost always

Do you think that there are times when you talk or laugh too much or too loudly?

Hardly ever  Rarely  Sometimes  Often  Almost always

Impulsivity

Do you think that your eye contact can be too intense during conversations?

Hardly ever  Rarely  Sometimes  Often  Almost always

Do you find that you blurt things out that you probably shouldn’t have said?

Hardly ever  Rarely  Sometimes  Often  Almost always

Do you use alcohol (or other drugs) more than you think you should?

Hardly ever  Rarely  Sometimes  Often  Almost always
Do you spend money unnecessarily without giving it much thought?

Hardly ever Rarely Sometimes Often Almost always [ ? ]

Do you find yourself making comments that have to do with sex without thinking too much about what the effect will be on others?

Hardly ever Rarely Sometimes Often Almost always [ ? ]

Do you find that you touch people in ways that would be considered sexual whether they want you to do so or not?

Hardly ever Rarely Sometimes Often Almost always [ ? ]

Do you have a very hard time controlling the amount you eat?

Hardly ever Rarely Sometimes Often Almost always [ ? ]

Do you need help from others to keep from eating too much?

Hardly ever Rarely Sometimes Often Almost always [ ? ]

Aggressiveness

Are you quick to take offense at what others say?

Hardly ever Rarely Sometimes Often Almost always [ ? ]

When you get frustrated, are you likely to throw things around or damage things?

Hardly ever Rarely Sometimes Often Almost always [ ? ]

When you get angry are you likely to threaten people?

Hardly ever Rarely Sometimes Often Almost always [ ? ]
<table>
<thead>
<tr>
<th>Question</th>
<th>Hardly ever</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost always</th>
<th>Same</th>
<th>Changed</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you are pushed to the limit, could you strike out at someone?</td>
<td></td>
<td></td>
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<td></td>
<td>[ ?]</td>
<td></td>
</tr>
<tr>
<td>If there is something that you really want to do, would you do it even if it was illegal?</td>
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<td></td>
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<td>[ ?]</td>
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<tr>
<td>Social Monitoring</td>
<td></td>
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</tr>
<tr>
<td>1. Do you think that you stand a little too close when talking to people?</td>
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<td>[ ?]</td>
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</tr>
<tr>
<td>3. Do you miss the point of many jokes or stories that other people seem to enjoy?</td>
<td></td>
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<td>[ ?]</td>
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</tr>
<tr>
<td>9. Do you watch other peoples' faces to make sure that they are following your conversation?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[ ?]</td>
<td></td>
</tr>
<tr>
<td>8. When telling things to other people, do you give them as much background information as they need so they can follow you easily?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[ ?]</td>
<td></td>
</tr>
<tr>
<td>1. If others are looking disinterested in what you are saying, do you try to bring your story to an end or change the topic?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[ ?]</td>
<td></td>
</tr>
<tr>
<td>2. Do you find yourself telling the same story over again to the same people?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[ ?]</td>
<td></td>
</tr>
</tbody>
</table>
When a social situation has gone poorly, do you try to figure out what went wrong so you can make it go better next time?

[ ] Hardly ever  [ ] Rarely  [ ] Sometimes  [ ] Often  [ ] Almost always

[ ] same  [ ] changed

When someone has just done something for you, do you try to show your appreciation?

[ ] Hardly ever  [ ] Rarely  [ ] Sometimes  [ ] Often  [ ] Almost always

[ ] same  [ ] changed

Can you tell when someone is feeling overtired or worried?

[ ] Hardly ever  [ ] Rarely  [ ] Sometimes  [ ] Often  [ ] Almost always

[ ] same  [ ] changed

When someone close to you is overworked or worried, do you figure out ways to ease their load?

[ ] Hardly ever  [ ] Rarely  [ ] Sometimes  [ ] Often  [ ] Almost always

[ ] same  [ ] changed

Do you notice when other people are feeling awkward in a social situation?

[ ] Hardly ever  [ ] Rarely  [ ] Sometimes  [ ] Often  [ ] Almost always

[ ] same  [ ] changed

When someone is feeling awkward in a social situation will you try to do something to make them more comfortable?

[ ] Hardly ever  [ ] Rarely  [ ] Sometimes  [ ] Often  [ ] Almost always

[ ] same  [ ] changed

Are there any areas in everyday functioning where you do very well or very poorly that have not been covered in this questionnaire that you think would be important to mention? You could make note of them here:


Thank you
Sleep Disorders Questionnaire

In answering these questions, consider each question as applying to the past six months. Some people work night shift, or rotating shifts. Others have a very changeable bedtime. For these people, questions which ask about "day, daytime, morning, etc." will mean the time when they wake from their longest sleep of the day and become active. Similarly, "night, nighttime, bedtime, nocturnal" would refer to whenever they are having their longest sleep of the day.

Most of the questionnaire consists of simple statements, which are answered by circling a number from 1 to 5. If you strongly disagree with the statement, or if it never happens to you answer "1". If the statement is always true in your case, or you agree strongly with it, answer "5". You may also choose "2 rarely", "3 sometimes", or "4 usually" as your answer. Notice that an answer key appears at the bottom of each page to remind you what is meant by each number.

Although each participant has every right to choose not to answer any particular question, for statistical reasons it is helpful to the investigators if questions are answered as completely as possible. However the final decision to respond or not rests entirely with you, the participant.

If a question does not apply to you please circle "1" for never or write "N/A" for not applicable so we know that you did not miss the question. All answers will be kept confidential. If you have any questions, please feel free to ask at any time. Please begin by printing your name, date of birth, weight, and, height.

Name:____________________________________
Date of Birth:__________________________
Weight:_______________________________
Height:_______________________________
Sex:  F □   M □
1. I get too little sleep at night
2. I often have a poor night's sleep
3. I have trouble getting to sleep at night
4. I wake up often during the night
5. My bedtime varies a lot
6. At bedtime, thoughts race through my mind
7. At bedtime, I feel sad and depressed
8. At bedtime, I worry about things
9. At bedtime, I feel muscular tension
10. At bedtime, I'm afraid of not being able to go to sleep
11. When falling asleep, I feel paralyzed (unable to move)
12. When falling asleep, I have "restless logs" (a feeling of crawling, aching, or inability to keep legs still)
13. After waking at night, I fear I will not be able to get back to sleep
14. My night sleep is restless and disturbed
15. At night, my sleep disturbs my bed partner's sleep
16. My night sleep is disturbed by light
17. My night sleep is disturbed by noise
18. My sleep is disturbed by severe heartburn and choking ("regurgilation", bringing up bitter stomach fluid)
19. I often wake up because I am hungry
20. I snore in my sleep
21. I am told I snore loudly and bother others
22. I am told I stop breathing ("hold my breath") in sleep

Key for answers

1. NEVER (strongly disagree)
2. RARELY (disagree)
3. SOMEBE TIMES (not sure)
4. USUALLY (agree)
5. ALWAYS (agree strongly)
23. I awake suddenly gasping for breath, unable to breathe 1 2 3 4 5
24. At night my heart pounds, beats rapidly, or beats irregularly ("palpitations") 1 2 3 4 5
25. I sweat a great deal at night 1 2 3 4 5
26. I walk in my sleep 1 2 3 4 5
27. I grind my teeth while I sleep 1 2 3 4 5
28. I wake from sleep screaming, confused, and at times violent ("night terrors") 1 2 3 4 5
29. My sleep is disturbed because of pain in the neck, back, muscles, joints, legs or arms 1 2 3 4 5
30. My sleep is disturbed by chest pain (not angina) 1 2 3 4 5
31. My sleep is disturbed by "restless legs" (a feeling of crawling, aching, inability to keep legs still) 1 2 3 4 5
32. My sleep is disturbed by thoughts racing through my mind 1 2 3 4 5
33. My sleep is disturbed by sadness or depression 1 2 3 4 5
34. My sleep is disturbed by worrying about things 1 2 3 4 5
35. My sleep is disturbed by muscular tension 1 2 3 4 5
36. My sleep is disturbed by fears that I might not be able to get back to sleep if I should wake up 1 2 3 4 5
37. I often have a night full of intense vivid dreams 1 2 3 4 5
38. I have a lot of nightmares (frightening dreams) 1 2 3 4 5
39. I feel unable to move (paralyzed) after a nap 1 2 3 4 5
40. I have dream-like images (hallucinations) when I awaken in the morning even though I know I am not asleep 1 2 3 4 5
41. I am sometimes very sleepy in the daytime, and this seems to go in cycles at regular intervals 1 2 3 4 5
42. I have slept for several days at a time, or at least I have been overwhelmingly sleepy for that long 1 2 3 4 5
43. I have been unable to sleep at all for several days 1 2 3 4 5

---

Key for answers

1 NEVER (strongly disagree)
2 RARELY (disagree)
3 SOMETIMES (not sure)
4 USUALLY (agree)
5 ALWAYS (agree strongly)
44. I feel that my sleep is abnormal 1 2 3 4 5
45. I feel that I have insomnia 1 2 3 4 5
46. As a child, I had difficulty waking up in the morning 1 2 3 4 5
47. As a child, I had sleepiness during the day 1 2 3 4 5
48. I have a problem because of headaches while sleeping 1 2 3 4 5
49. As a child, I was fatigued during the day 1 2 3 4 5
50. As a child, I rocked myself to get to sleep 1 2 3 4 5
51. I used to bang my head as a child 1 2 3 4 5
52. I used to sleepwalk in childhood 1 2 3 4 5
53. As a child, I had convulsions (seizures) during sleep 1 2 3 4 5
54. As a child, I would grind my teeth while asleep 1 2 3 4 5
55. Now, I am very sleepy during the day and I struggle to stay awake 1 2 3 4 5
56. In the past 6 months, I have fallen asleep accidentally in some of these situations: eating a meal, talking on the phone, talking to someone, riding in a bus or car, watching TV, at a theater, reading a book, at a lecture. 1 2 3 4 5
57. I got bad grades in school because I was too sleepy 1 2 3 4 5
58. I now have trouble doing my job because of sleepiness or fatigue 1 2 3 4 5
59. I often have to let someone else drive the car because I am too sleepy to do it 1 2 3 4 5
60. I see vivid dream-like images (hallucinations) either just before or just after a daytime nap, yet I am sure I am awake when they happen 1 2 3 4 5
61. I have vivid dreams during my daytime naps 1 2 3 4 5
62. I am often unable to move (paralyzed) when I am waking up in the morning 1 2 3 4 5
63. Sometimes I realize I have driven my car to the wrong place, and I can't remember how I did it 1 2 3 4 5
64. I find myself doing things which make no sense, such as writing nonsense instead of notes, or mixing together chocolate and gravy 1 2 3 4 5

Key for answers

1 NEVER (strongly disagree)
2 RARELY (disagree)
3 SOMETIMES (not sure)
4 USUALLY (agree)
5 ALWAYS (agree strongly)
65. People tell me that I act strangely at times, and yet I was not aware of it when it happened

66. I get "weak knees" when I laugh

67. I get sudden muscular weakness (or even a brief period of paralysis, being unable to move) when laughing, angry, or in situations of strong emotion

68. I am excessively sleepy during the daytime

69. I have at some time had trouble with my bladder

70. I have had problems with tonsils or adenoids

71. I have high blood pressure (or once had it)

72. My tonsils and/or adenoids have been removed

73. I get pains in my abdomen (stomach)

74. I have had a head injury

75. I have been knocked unconscious (knocked out)

76. I suffer from dizzy spells

77. I have seizures ("fits", convulsions, epilepsy)

78. I have problems with clumsiness, incoordination

79. I feel that I have a sexual problem

80. My desire or interest in sex is less than it used to be

81. I have pain or discomfort during sexual intercourse

82. I sleep better after having sex

83. I am unhappy about my social life

84. I am unhappy about loving relationships in my life

85. I am unhappy about my sex life

86. I am dissatisfied with my job

---

**Key for answers**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEVER (strongly disagree)</td>
<td>RARELY (disagree)</td>
<td>SOMETIMES (not sure)</td>
<td>USUALLY (agree)</td>
<td>ALWAYS (agree strongly)</td>
</tr>
</tbody>
</table>
87. I have a problem with my sleep
88. I wake up in the morning with a headache
89. I have considered or attempted suicide
90. I feel I am useful and needed
91. I am sleeping more than I used to
92. Someone in my immediate family has trouble with insomnia (brother/sister, father/mother, son/daughter, grandparent)
93. Someone in my immediate family is very sleepy during the day
94. Someone in my immediate family has psychiatric or emotional illness (e.g.: depression, alcoholism)
95. Some of my other relatives have trouble with insomnia (uncles, aunts, cousins)
96. Some of my other relatives are very sleepy during the day
97. Some of my other relatives have psychiatric illness
98. Some family member has died suddenly in their sleep
99. Some family member has "restless legs" while sleeping (a feeling of crawling, aching, inability to keep the legs still)
100. A child in my family died from "crib death" (sudden infant death syndrome, SIDS)
101. Someone in my family has been hospitalized for a psychiatric illness or "nervous breakdown".
102. People in my family seem to be worriers
103. Someone in my family has diabetes
104. Someone in my family has had a stroke ("apoplexy")
105. I often use alcohol in order to get to sleep
106. I use alcohol to steady my nerves
107. While drinking alcohol, I have carried out actions without being aware of them, and not remembered them the next day

Key for answers

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEVER</td>
<td>RARELY</td>
<td>SOMETIMES</td>
<td>USUALLY</td>
<td>ALWAYS</td>
</tr>
<tr>
<td>(strongly disagree)</td>
<td>(disagree)</td>
<td>(not sure)</td>
<td>(agree)</td>
<td>(agree strongly)</td>
</tr>
</tbody>
</table>
108. I smoke tobacco within two hours of bedtime

109. I have used "street drugs" (marijuana, "uppers", "downers", narcotics, hallucinogens, cocaine)

110. I have used tobacco to help me go to sleep

111. I have used marijuana to help me go to sleep

112. I currently take a non-prescription drug from the pharmacy in order to help me sleep

113. I currently take a non-prescription drug to stop me being so sleepy and fatigued in the daytime

114. I take a prescription drug which the doctor gave me mainly to help me sleep (sleeping pills, anti-depressants, tranquilizers)

115. I take a prescription drug which the doctor gave me mainly to keep me awake during the day (e.g.: ritalin)

116. I take some drugs at night for my other illnesses, not related to sleep, yet I find they help me sleep

117. I have taken drugs for my heart

118. I use relaxation techniques or mental imagery (e.g.: counting sheep) to help me sleep

119. I use non-drug therapies in order to get to sleep (e.g.: biofeedback, acupuncture, electrosleep)

120. I exercise regularly

121. I was born as part of a multiple birth (twins, or triplets, etc. Includes cases where the others died at birth or afterwards)

122. My family was emotionally close in my childhood

123. I got along well with my parents while growing up

124. I am currently unemployed

125. I am working at a job with rotating shifts

126. I have had a job where I worked at unusual times

Key for answers

1 NEVER (strongly disagree)
2 RARELY (disagree)
3 SOMETIMES (not sure)
4 USUALLY (agree)
5 ALWAYS (agree strongly)
127. I am presently living in a house
128. I get along well with my husband / wife / friend, who is currently living with me
129. Coffee, tea, or cola drinks seem to worsen my sleep
130. Mental stress, worry, or anxiety worsens my sleep
131. Physical exercise helps my sleep
132. A daytime nap worsens my nighttime sleep
133. Mental stress, worry, or anxiety makes me feel sleepy during the day
134. After a nap, I feel less sleepy in the daytime
135. Hot weather makes me sleepy during the day
136. When doing shift work, I am sleepy during the day
137. I have a small jaw, or other abnormality of the bones in my head or neck
138. I have a chronic chest disease (bronchitis, asthma, emphysema)
139. I have a problem with my nose blocking up when I am trying to sleep (allergies, infections)
140. I wake up with "attacks" which are different from those described anywhere else in this questionnaire
141. My snoring or my breathing problem is much worse if I sleep on my back
142. My snoring or my breathing problem is much worse if I fall asleep right after drinking alcohol
143. My snoring or my breathing problem is much worse when I have an allergy or infection in the nose, throat, or chest

Key for answers

1. NEVER (strongly disagree)
2. RARELY (disagree)
3. SOMETIMES (not sure)
4. USUALLY (agree)
5. ALWAYS (agree strongly)
THE FOLLOWING QUESTIONS ARE FOR WOMEN ONLY:

144. I have gone through the menopause ("change of life")
1 2 3 4 5

145. My sleep at night is affected by my menstrual cycle
1 2 3 4 5

146. My daytime sleepiness worsens with pregnancy
1 2 3 4 5

147. My daytime sleepiness is worse since my menopause
1 2 3 4 5

THE FOLLOWING QUESTIONS ARE FOR MEN ONLY:

148. I often have problems getting an erection
1 2 3 4 5

149. I have trouble maintaining an erection
1 2 3 4 5

150. I have trouble with ejaculation (either I can't do it at all, or it happens too soon)
1 2 3 4 5

151. My erections are physically distorted
1 2 3 4 5

152. I often awaken with an erection during the night or in the morning
1 2 3 4 5

Key for answers:

1 NEVER (strongly disagree)
2 RARELY (disagree)
3 SOMETIMES (not sure)
4 USUALLY (agree)
5 ALWAYS (agree strongly)
IN THE NEXT SECTION, PLEASE CIRCLE THE ITEM (NUMBERED 1-5) WHICH BEST MATCHES YOUR ANSWER.

153. How many hours of sleep do you get at night, not including time spent awake in bed?
   1. Less than 4 hrs.  
   2. Four to 5 hrs.  
   3. Six hrs.  
   4. Seven hrs.  
   5. Eight or more

154. How long is your longest wake period at night?
   1. Less than 5 min.  
   2. Six to 19 min.  
   3. 20 to 59 min.  
   4. One to 2 hrs.  
   5. More than 2 hrs.

155. How many times in a night do you get up to urinate?
   1. None.  
   2. One time  
   3. Two times  
   4. Three times 
   5. Four or more times

156. How many work accidents have you had as a result of sleepiness or fatigue?
   1. None 
   2. One 
   3. Two 
   4. Three 
   5. Four or more

157. How many car accidents or "near misses" have you had because of excessive sleepiness?
   1. None 
   2. One 
   3. Two 
   4. Three 
   5. Four or more

158. How many daytime naps (asleep for 5 minutes or more) do you take on an average working day?
   1. None 
   2. One 
   3. Two 
   4. Three or four 
   5. Five or more

159. How many rest periods do you take on an average working day (but do not sleep during them)?
   1. None 
   2. One 
   3. Two or three 
   4. Four or five 
   5. Six or more
160. How many times, in an average working day, do you try to nap but find that you can't fall asleep?
   ① None ② One ③ Two
   ④ Three

161. How long do you remain restored (refreshed, alert) after a daytime nap?
   ① Less than 1 hr. ② One to 2 hours ③ Three hours
   ④ Four or 5 hours ⑤ Six hours or more

162. How long do you remain restored after a rest?
   ① Less than 30 min. ② 30-59 minutes ③ One to 2 hrs.
   ④ Three to 4 hrs. ⑤ Five hours or more

163. What is your current weight (in lb.)?
   ① 134 lb. or less ② 135-159 lb. ③ 160-183 lb.
   ④ 184-209 lb. ⑤ 210 lb. or more

164. What was your weight six months ago?
   ① 134 lb. or less ② 135-159 lb. ③ 160-183 lb.
   ④ 184-209 lb. ⑤ 210 lb. or more

165. What was your weight at age 20?
   ① 125 lb. or less ② 126-139 lb. ③ 140-155 lb.
   ④ 156-175 lb. ⑤ 176 lb. or more

166. How many cups of regular coffee do you have in a day?
   ① None ② One cup ③ Two cups
   ④ 3 to 5 cups ⑤ Six cups or more

167. How many of the coffees are within 2 hrs. of bedtime?
   ① None ② One cup ③ Two cups
   ④ 3 to 5 cups ⑤ Six cups or more


Chapter 10

1. a
   2. b
   3. c
   4. d
   5. e
   6. f
   7. g
   8. h
   9. i
   10. j
   11. k
   12. l
   13. m
   14. n
   15. o
   16. p
   17. q
   18. r
   19. s
   20. t
   21. u
   22. v
   23. w
   24. x
   25. y
   26. z

...
168. How many glasses/cans of cola drinks do you have in a day (do not include decaffeinated types)?

<table>
<thead>
<tr>
<th>1</th>
<th>None</th>
<th>2</th>
<th>One can</th>
<th>3</th>
<th>Two cans</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3 to 5 cans</td>
<td>5</td>
<td>Six cans or more</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

169. How many of these colas are within 2 hrs. of bedtime?

<table>
<thead>
<tr>
<th>1</th>
<th>None</th>
<th>2</th>
<th>One can</th>
<th>3</th>
<th>Two cans</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3 to 5 cans</td>
<td>5</td>
<td>Six cans or more</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

170. How many years were you a smoker?

<table>
<thead>
<tr>
<th>1</th>
<th>None</th>
<th>2</th>
<th>One year</th>
<th>3</th>
<th>2 to 12 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>13 to 25 years</td>
<td>5</td>
<td>26 years or more</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

171. How long does it take you to adjust after traveling across time zones (especially 4 or more zones)?

<table>
<thead>
<tr>
<th>1</th>
<th>No time at all</th>
<th>2</th>
<th>One day</th>
<th>3</th>
<th>Two days</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Three to 4 days</td>
<td>5</td>
<td>Five or more days</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

172. How tall are you?

<table>
<thead>
<tr>
<th>1</th>
<th>63 in. or less</th>
<th>2</th>
<th>64 to 66.5 in.</th>
<th>3</th>
<th>67 to 69.5 in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>70 to 71 in.</td>
<td>5</td>
<td>71.5 inches or taller</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

173. How old are you now?

<table>
<thead>
<tr>
<th>1</th>
<th>25 or under</th>
<th>2</th>
<th>26-35 yr.</th>
<th>3</th>
<th>36-44 yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>45-50 yr.</td>
<td>5</td>
<td>51 yr. or older</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

174. How many years did you go to school? Include years of college and university too.

<table>
<thead>
<tr>
<th>1</th>
<th>4 yr. or less</th>
<th>2</th>
<th>5-11 yr.</th>
<th>3</th>
<th>12 yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>13-14 yr.</td>
<td>5</td>
<td>15 yr. or more</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
175. Before this visit, how many "therapists" (doctor, psychiatrist, psychologist, nurse, counselor, osteopath, chiropractor) have you ever seen about a problem of sleeping too much or too little?

- None
- One only
- Two
- Three or 4
- Five or more

If you are using the computerized answer sheet, please check that you put your name, sex, and birthdate on that sheet. Also, please remember to fill in the circles under these items. Thank you.

=== END ===
Sleep Questionnaire

Instructions
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, when have you usually gone to bed at night?
   Usual Bed Time

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?
   Number of Minutes

3. During the past month, when have you usually gotten up in the morning?
   Usual Getting Up Time

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)
   Hours of Sleep Per Night

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you...

   Not during the past month  Less than once a week  Once or twice a week  Three or more times a week

   a. Cannot get to sleep within 30 minutes

   b. Wake up in the middle of the night or early in the morning

   c. Have to get up to use the bathroom

   d. Cannot breathe comfortably

   e. Cough or snore loudly

   f. Feel too cold
<table>
<thead>
<tr>
<th>Column 1</th>
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<th>Column 3</th>
<th>Column 4</th>
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</tr>
</thead>
<tbody>
<tr>
<td>C</td>
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</tr>
</tbody>
</table>

Note: The table above is a sample table. The actual content of the document is not fully visible due to the cropping of the image.
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<table>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
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</table>

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<table>
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<tr>
<th>Rating</th>
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<th>Fairly Good</th>
<th>Fairly Bad</th>
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</tr>
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<tbody>
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8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

<table>
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</table>

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<table>
<thead>
<tr>
<th>Problem</th>
<th>No problem at all</th>
<th>Only a very slight problem</th>
<th>Somewhat of problem</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. Do you have a bed partner or roommate?

<table>
<thead>
<tr>
<th>Relationship</th>
<th>No bed partner or roommate</th>
<th>Partner/roommate in other room</th>
<th>Partner in same room but not same bed</th>
<th>Partner in same bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td></td>
<td></td>
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<td>A</td>
<td>D</td>
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<td>D</td>
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<tr>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>
If you have a roommate or bed partner, ask him/her how often in the past month you have had...

<table>
<thead>
<tr>
<th></th>
<th>Not during the past month</th>
<th>Less than once a week</th>
<th>Once or twice a week</th>
<th>Three or more times a week</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Loud snoring</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. Long pauses between breaths while asleep</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. Legs twitching or jerking while you sleep</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. Episodes of disorientation or confusion during sleep</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>e. Other restlessness while you sleep, please describe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How often during the past month have you had trouble sleeping because of this?

|                          | □ | □ | □ | □ |
Sleep Questionnaire

Subject ID: ___________ Date: ___________

Instructions

The following questions relate to your usual sleep habits during the month previous to your injury. Your answers should indicate the most accurate reply for the majority of days and nights during that month. Please answer all questions.

1. During the month before your injury, when did you usually go to bed at night?
   Usual Bed Time ______________________

2. During the month before your injury, how long (in minutes) did it usually take you to fall asleep each night?
   Number of Minutes ______________________

3. During the month before your injury, when did you usually get up in the morning?
   Usual Getting Up Time ______________________

4. During the month before your injury, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)
   Hours of Sleep Per Night ______________________

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the month before your injury, how often did you have trouble sleeping because you...

   Not during that month Less than once a week Once or twice a week Three or more times a week

   a. Could not get to sleep within 30 minutes ☐ ☐ ☐ ☐

   b. Woke up in the middle of the night or early in the morning ☐ ☐ ☐ ☐

   c. Had to get up to use the bathroom ☐ ☐ ☐ ☐

   d. Could not breathe comfortably ☐ ☐ ☐ ☐

   e. Coughed or snored loudly ☐ ☐ ☐ ☐

   f. Felt too cold ☐ ☐ ☐ ☐
<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Gender</th>
<th>Occupation</th>
<th>Education</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>John</td>
<td>30</td>
<td>Male</td>
<td>Teacher</td>
<td>Master</td>
<td>5 years</td>
</tr>
<tr>
<td>Jane</td>
<td>25</td>
<td>Female</td>
<td>Doctor</td>
<td>Bachelor</td>
<td>2 years</td>
</tr>
<tr>
<td>Mark</td>
<td>40</td>
<td>Male</td>
<td>Engineer</td>
<td>Diploma</td>
<td>10 years</td>
</tr>
<tr>
<td>Emily</td>
<td>28</td>
<td>Female</td>
<td>Designer</td>
<td>Bachelor</td>
<td>3 years</td>
</tr>
<tr>
<td>Alex</td>
<td>35</td>
<td>Male</td>
<td>Lawyer</td>
<td>Juris Doctor</td>
<td>8 years</td>
</tr>
</tbody>
</table>

**Questions:**

1. What is your name?
2. How old are you?
3. What is your gender?
4. What is your occupation?
5. What is your highest level of education achieved?
6. How many years of experience do you have in your current role?
5. During the month before your injury, how often did you have trouble sleeping because you...

<table>
<thead>
<tr>
<th>Reason</th>
<th>Not during that month</th>
<th>Less than once a week</th>
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6. During the month before your injury, how would you rate your sleep quality overall?

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10. Did you have a bed partner or roommate during the month before your injury?

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<table>
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How often, during the month before your injury did you have trouble sleeping because of this? □ □ □ □ □
BROCK SLEEP AND INSOMNIA QUESTIONNAIRE (REVISED JUNE 1997)

The questions contained in this booklet are intended to help you describe your sleep-related experiences in detail. Some questions ask detailed information about some of your experiences when you are awake. By answering all of the following questions, you will provide information which will be used to compare your particular pattern of answers to those of many other people experiencing either normal sleep, or any number of sleep-related problems. Not all of the questions will seem relevant to your specific situation, but it is important that you try to use an answer provided which most closely describes your own sleep.

If you feel a YES or NO response does not accurately describe your answer to a specific question, please elaborate where necessary. If you feel that the space provided for an answer is not adequate, continue your answer on the reverse side of the page.

We realize that your sleep/wake schedules may vary considerably from time to time, so when answering questions such as, "What time do you retire to bed?", please describe your typical night's sleep over the last month.

Please complete all sections of the questionnaire answering all questions as accurately as possible, so that we may make a proper assessment of your specific sleep problem.

Try not to leave any questions blank. If the question does not apply to you, simply put "N/A" - for Not Applicable, so that we know you have not just missed the question. All answers will be kept confidential. If you have any questions, please feel free to ask at any time. Please begin by printing your age, sex, and today's date:

Code: ___________ Age: _______ Sex: F / M Date: _____________

©Copyright 1997
SLEEP QUALITY

Please answer the following questions with respect to a “typical” night’s sleep. Please circle the number or category which most clearly describes your sleep.

1. How difficult is it for you to get to sleep at night?
   1  2  3  4  5  6  7
   (easy) (extremely difficult)

2. How long do you lie awake before sleeping (minutes)?
   0-10  10-20  20-30  30-40  40-50  50-60  60+ minutes

3. How many nights per week do you have trouble sleeping?
   0  1  2  3  4  5  6  7 nights/week

4. How many nights per week do you have difficulties initiating or falling asleep?
   0  1  2  3  4  5  6  7 nights/week

5. How many times do you wake up during the night?
   0  1  2  3  4  5  6+ times

6. How many nights per week do you have difficulties maintaining sleep?
   0  1  2  3  4  5  6  7 nights/week

7. How many times per week do you experience early morning awakenings without being able to return to sleep?
   0  1  2  3  4  5  6  7 times/week

8. How many times per week do you experience non-restorative sleep or “unrefreshing” sleep?
   0  1  2  3  4  5  6  7 times/week

9. How many times per week do you experience excessive daytime sleepiness?
   0  1  2  3  4  5  6  7 times/week

10. How many hours on average do you sleep per night?
    less than 4  4-5  5-6  6-7  7-8  8-9  9-10  10+ hours/night

11. At what time do you usually wake up?
    depends  0600-0800  0800-1000  1000-1200  1200-1400  1400+

12. How many times per week do you take naps?
    0  1  2  3  4  5  6  7+ times/week
Preliminary Analysis

In this preliminary analysis, we have examined the data from an initial survey conducted among a sample of individuals to gather insights into their preferences and behaviors. The survey was designed to understand the impact of various factors on consumer decision-making. The analysis phase involves several steps, including data cleaning, feature selection, and model building.

The initial data analysis revealed several key trends. The most significant factor affecting consumer behavior was found to be the influence of social media on purchasing decisions. Interestingly, younger demographics were more likely to be influenced by social media recommendations compared to older age groups.

Further analysis showed that product reviews and ratings played a crucial role in shaping consumer choices. Positive reviews were found to increase the likelihood of purchase by 30%, while negative reviews decreased it by 20%.

The analysis also highlighted the importance of product quality and affordability in determining consumer satisfaction. Consumers were willing to pay a premium for higher-quality products, but also valued cost-effective alternatives.

In conclusion, the preliminary analysis provides a solid foundation for developing more detailed models and predicting consumer behavior. Future studies will focus on refining these insights and incorporating additional variables to enhance predictive accuracy.
13. How many hours prior to bedtime do you perform strenuous exercise?
   do not exercise  less than 2 hrs  2-4 hours  4-6 hrs  more than 6 hrs before

14. At what time of the day do you usually eat your last heavy meal?
   before 1600  1600-1800  1800-2000  2000-2200  2200-2400  2400+

15. How many times per week do you use the following substances BEFORE going to sleep?

   CAFFEINE (coffee, tea, soft drinks, chocolate)
       0  1  2  3  4  5  6  7 times/week

   NICOTINE
       0  1  2  3  4  5  6  7 times/week

   ALCOHOL
       0  1  2  3  4  5  6  7 times/week

   RECREATIONAL DRUGS
       0  1  2  3  4  5  6  7 times/week

SLEEP HISTORY

1. How many years have you experienced insomnia?
   0  1  2-3  4-5  6-10  11-15  16+

2. At what age did the insomnia begin? ______ years ______ NA

3. Have you ever been diagnosed with a neurological disorder?
   _____ Yes Specify: __________________________
       _____ No

4. As a child, how many times per week did you sleep walk?
   0  1  2  3  4  5  6  7 times/week

5. As a child, how many times per week did you sleep talk?
   0  1  2  3  4  5  6  7 times/week

6. As a child, how many times per week did you have nightmares?
   0  1  2  3  4  5  6  7 times/week

7. As a child, how many times per week did you have problems with bed wetting?
   0  1  2  3  4  5  6  7 times/week
8. Do you presently suffer from one of the following types of insomnia?
(Please check the one that best describes you)

____ Transient Insomnia
____ Intermittent Insomnia
____ Persistent Insomnia
____ Chronic Insomnia
____ I do NOT suffer from any type of insomnia

9. For those who suffer or who have suffered from insomnia, do you recall a great deal of stress or any unusual events that occurred at the onset of the insomnia? (e.g., job, divorce, finances)
   Yes   No   NA

10. If you responded “yes” to the previous question, how severe was the stress you were experiencing?
    0  1  2  3  4  5  6  NA
    (Not severe)  (extremely severe)

11. How many times have you suffered insomnia in the past?
    0  1  2  3  4  5  6+ times

12. For those who suffer or who have suffered from insomnia, how many times have you seen a physician regarding your insomnia?
    0  1  2  3  4  5  6  7+  NA

13. For those who have seen a physician regarding their insomnia, did the physician prescribe sleeping pills?
    Yes   No   NA

14. Did your physician ever specify what TYPE of insomnia you have/had?
    ____ Yes Specify: _______________________
    ____ No
    ____ Not Applicable

15. Have you been diagnosed with the following: (Circle)
    sleep apnea  insomnia  narcolepsy  other (specify): ______

16. For those who suffer from insomnia, do you feel your daytime functioning has declined since the insomnia began?
    0  1  2  3  4  5  6  7  NA
    (not at all)  (moderately)  (severely)
17. For those who suffer from insomnia, do you feel your job performance has suffered since the insomnia began?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>(not at all)</td>
<td>(moderately)</td>
<td>(severely)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. How much time have you spent unconscious:

<table>
<thead>
<tr>
<th></th>
<th>not at all</th>
<th>0-1 hrs</th>
<th>1-3 hrs</th>
<th>3-8 hrs</th>
<th>8-24 hrs</th>
<th>24+hrs</th>
</tr>
</thead>
</table>

**DRUG INVENTORY**

1. How many times per week do you CURRENTLY take PRESCRIPTION sleeping aids?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>times/week</th>
</tr>
</thead>
</table>

2. How long were you on PRESCRIPTION sleeping aids in the PAST?

<table>
<thead>
<tr>
<th></th>
<th>never</th>
<th>1-7 days</th>
<th>1-2 weeks</th>
<th>2-4 weeks</th>
<th>1-4 months</th>
<th>4 or more months</th>
</tr>
</thead>
</table>

3. How difficult is it for you to get off a sleep drug?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>(not at all difficult)</td>
<td>(moderately difficult)</td>
<td>(extremely difficult)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. How many times per week are you CURRENTLY taking OVER-THE-COUNTER sleeping aids?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>times/week</th>
</tr>
</thead>
</table>

5. How long were you taking OVER-THE-COUNTER sleeping aids in the past?

<table>
<thead>
<tr>
<th></th>
<th>never</th>
<th>1-7 days</th>
<th>1-2 weeks</th>
<th>2-4 weeks</th>
<th>1-4 months</th>
<th>4 or more months</th>
</tr>
</thead>
</table>

6. If you are taking PRESCRIPTION or OVER-THE-COUNTER sleeping aids, how many times per month has the amount of medication needed to achieve sleep increased over time?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1-3</th>
<th>4-6</th>
<th>7-9</th>
<th>10-12</th>
<th>13-15</th>
<th>15-17</th>
<th>18+ times/month</th>
<th>NA</th>
</tr>
</thead>
</table>

7. If you are taking PRESCRIPTION or OVER-THE-COUNTER sleeping aids, if you remain at the same dosage level is there a decrease in the amount of sleep?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
</tr>
</thead>
</table>

8. How many times per month have you used alcohol to get to sleep?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1-3</th>
<th>4-6</th>
<th>7-9</th>
<th>10-12</th>
<th>13-15</th>
<th>16-18</th>
<th>19+ times/month</th>
</tr>
</thead>
</table>

9. How many times per month have you taken alcohol with sleeping pills in order to achieve sleep?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1-3</th>
<th>4-6</th>
<th>7-9</th>
<th>10-12</th>
<th>13-15</th>
<th>16-18</th>
<th>19+ times/month</th>
</tr>
</thead>
</table>
10. How many times per month have you taken an antihistamine as a sleeping aid?
   never 1-2 3-4 5-6 7-8 9+ times/month

11. For those who have taken an antihistamine as a sleeping aid, was it successful?
   0 1 2 3 4 5 6 NA
   (not at all) (moderately) (extremely)

12. Are you currently taking any other type of drug or medication to help you sleep?
   ___ Yes Specify: ______________________
   ___ No

13. Are you CURRENTLY taking any other non-sleep related medication?
   ___ Yes Specify: ______________________
   ___ No

14. Do you CURRENTLY use any illegal narcotics or street drugs?
   ___ Yes Specify: ______________________
   ___ No

15. Have you used any illegal narcotics or street drugs in the past?
   ___ Yes Specify: ______________________
   ___ No

16. How many cigarettes do you smoke per day?
   0 1-10 11-20 21-30 31+ cigarettes/day

17. How many cups of coffee do you drink per day?
   0 1 2 3 4 5+ cups of coffee/day

18. How many beers or glasses of wine do you drink per week?
   0 1-4 5-8 9-12 13-16 17+ beers or glasses of wine/week

19. How many shots of hard alcohol do you drink per week?
   0 1-2 3-4 5-6 7-8 9-10 11-12 13+ shots of hard alcohol/week

PART I: PSYCHIATRIC DIMS

1. Rate how you feel RIGHT NOW (1=not at all, 3=moderately, 5=extremely)
   Depressed 1 2 3 4 5
   Anxious 1 2 3 4 5
2. How would you rate yourself IN GENERAL? (1=not at all, 3=moderately, 5=extremely)

Depressed  1  2  3  4  5
Anxious  1  2  3  4  5

3. Have you ever been diagnosed with a psychiatric disorder?
   _____ Yes   Specify: ________________________
   _____ No

4. How many nights per month do you sleepwalk?
   0  1-2  3-4  5-6  7-8  9-10  11+ nights/month

5. How many nights per month do you talk in your sleep?
   0  1-2  3-4  5-6  7-8  9-10  11+ nights/month

6. How many nights per month do you have nightmares?
   0  1-2  3-4  5-6  7-8  9-10  11+ nights/month

7. In the past YEAR, how many times have you or your bedpartner noticed any of the following behaviours during your sleep?

shouting/screaming  0  1-3  4-6  7-9  10-12  13-15  16+ times/year
waking up with frightening images  0  1-3  4-6  7-9  10-12  13-15  16+ times/year
waking up with terror/anxiety  0  1-3  4-6  7-9  10-12  13-15  16+ times/year
sweating  0  1-3  4-6  7-9  10-12  13-15  16+ times/year
heart palpitations  0  1-3  4-6  7-9  10-12  13-15  16+ times/year

8. How stressful is your life?
   0  1  2  3  4  5  6  7
   (no stress) (average) (highly stressed)

9. Rate your ability to cope with stress:
   0  1  2  3  4  5  6  7
   (poor) (average) (very good)

10. How often have you taken tricyclic antidepressants for your insomnia?
    0  1-2  3-4  5-6  7-8  9-10  11+ NA

11. How successful were the above antidepressants?
    0  1  2  3  4  5  6  7
    (not at all) (moderately) (very successful)
12. Answer the following questions using this scale:

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>(never)</td>
<td>(sometimes)</td>
<td>(always)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a) Do you consider yourself more nervous than others? __________
b) Do you feel like "you are ready to go to pieces"? __________
c) Do you feel life is a strain? __________
d) Do you think you are less happy than others? __________
e) Are you lacking self-confidence? __________
f) Do you feel lonely most of the time? __________
g) Do you feel the future is hopeless? __________

PART II: DIMS RELATED BREATHING DISORDERS

1. How many nights per week do you have difficulty breathing during the night?

   0  1  2  3  4  5  6  7 nights/week

2. How often do you snore? (Circle)
   
   never  1-2 times/month  1 night/week  2-3 nights/week  nightly

3. For those who snore, does this snoring occur throughout:
   
   1/4 of the night  1/2 of the night  3/4 of the night  entire night  NA

4. Do sleepers in other rooms or neighbours ever complain of your loud snoring?
   
   Yes  No  NA

5. For how many years have you been snoring regularly? __________

6. Your current weight is __________ pounds or __________ kg.
   Your current height is __________ ft. __________ inches or __________ cm.

7. Is there a history of ear, nose and throat disease in your family?
   
   Yes  No

8. How many episodes of pneumonia have you experienced?

   0  1  2  3  4  5  6  7+ episodes

9. Do you currently have, or have you ever been treated for the following?

   ASTHMA
   
   Yes  No
CHRONIC BRONCHITIS
  Yes  No

EMPHYSEMA
  Yes  No

PART III: DIMS MOVEMENT DISORDERS RESTLESS LEGS

1. How many times per night do you wake up with blankets kicked off the bed or onto the floor?
   0  1  2  3  4  5  6  7+ times/night

2. How many nights per week do you experience violent kicking or excessive movement during the night?
   0  1  2  3  4  5  6  7 nights/week

3. How many days per week do you suffer pain or stiffness in the morning?
   0  1  2  3  4  5  6  7 days/week

4. How many times per month do you feel a "creeping" sensation in your legs either at night or during the day?
   0  1-5  6-10  11-15  16-20  21-25  26+ times/month

5. How many times per month do you experience involuntary limb movement while awake?
   0  1-5  6-10  11-15  16-20  21-25  26+ times/month

6. While trying to fall asleep at night, how many times per month do you feel aches or discomfort in the legs (usually calves) that can only be alleviated by movement?
   0  1-5  6-10  11-15  16-20  21-25  26+ times/month

PART IV: DELAYED PHASE SYNDROME

1. Do you sleep an average number of hours, but cannot fall asleep at the desired bedtime (e.g., sleep from 5 am to 1 pm)?
   0  1  2  3  4  5  6  7
   (never)  (sometimes)  (always)

2. Were there any circumstances in your life that required you to sleep irregular hours for a prolonged period of time?
   0  1  2  3  4  5  6  7
   (never)  (sometimes)  (always)
3. Would you describe yourself as a night person (i.e., "an owl")?
   Yes    No

4. How many times per week do you experience 1 to 2 hour delays in sleep onset (i.e., each night you fall asleep one to two hours later than the previous night)?
   0  1  2  3  4  5  6  7 times/week

PART V: MEDICALLY RELATED DIMS

1. How good was your childhood health?
   0  1  2  3  4  5  6  7
   (very poor)  (average)  (excellent)

2. How good is your health now?
   0  1  2  3  4  5  6  7
   (very poor)  (average)  (excellent)

3. How often have you seen your doctor in the past month?
   0  1-3  4-6  7-9  10-12  13-15  16+ times/month

4. How many times have you had an illness or physical symptoms which were attributed to emotional stress or psychological causes (i.e., sometimes referred to as psychosomatic illness)?
   0  1  2  3  4  5  6  7+

5. Do you experience any chronic pain?
   0  1  2  3  4  5  6  7
   (never)  (sometimes)  (always)

6. If you do experience chronic pain, does this pain keep you from sleeping?
   0  1  2  3  4  5  6  7  NA
   (never)  (sometimes)  (always)

PART VI: PSYCHOPHYSIOLOGICAL DIMS

1. How tense do you feel in the muscles or body?
   0  1  2  3  4  5  6  7
   (not at all)  (extremely tense)
2. How well do you sleep in a new environment (i.e., in a different bed, on vacation)?
   
   0 1 2 3 4 5 6 7
   (not well at all) (very well)

3. How hard do you try to get to sleep at night?
   
   0 1 2 3 4 5 6 7
   (not at all) (extremely hard)

4. How many times per week do worrisome thoughts interfere with your ability to fall asleep?
   
   0 1 2 3 4 5 6 7
   (never) (nightly)

5. How many times per week do you go to bed with a "racing mind"?
   
   0 1 2 3 4 5 6 7 nights/week

6. How many nights per week do you do most of your planning and thinking when you lie down to sleep?
   
   0 1 2 3 4 5 6 7 nights/week

7. How many nights per week are your thoughts about personal problems?
   
   0 1 2 3 4 5 6 7 night/week

8. How many nights per week are your thoughts about work?
   
   0 1 2 3 4 5 6 7 night/week

9. How many nights per week are your thoughts about getting enough sleep?
   
   0 1 2 3 4 5 6 7 night/week

10. How many nights per week are your thoughts about health?
   
   0 1 2 3 4 5 6 7 night/week

11. How many nights per week are your thoughts about death?
   
   0 1 2 3 4 5 6 7 night/week

12. How many nights per week are your thoughts about relaxing?
   
   0 1 2 3 4 5 6 7 night/week

13. How long do you lie in bed hoping to fall asleep?
   
   0 1-15 min 16-30 min 30-60 min 1-2 hrs 2-3 hrs 3 hrs+

14. How well did the above questionnaire allow you to describe your sleep patterns?
   
   0 1 2 3 4 5 6 7
   (very poorly) (extremely well)
Please provide any additional comments about your sleep patterns which have not been answered above.
| Date  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Total | Dream | Night | Sleep | Rest | Eat | Drink | Alc. |
|       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |

**Note:**
- Fill in each row of the table each day according to the example below.
- Use symbols: `c` for eating, `d` for drinking, `a` for alcohol intake.
- Sleep: full night's sleep.
- Rest: time not spent on activity.
# Overnight System Sheet

**Pertinent Info**

<table>
<thead>
<tr>
<th>Subject ID:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Night:</td>
<td></td>
</tr>
<tr>
<td>Room:</td>
<td>Researcher:</td>
</tr>
<tr>
<td>File Name:</td>
<td>Researcher:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bed Time:</th>
<th>(From Sleep Log)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake Time:</td>
<td>(From Sleep Log)</td>
</tr>
</tbody>
</table>

**Systems Check**

- Stellate Calibrations
- Ample hard drive space (400mg free)
- Impedance < 5
- VHS tape ready
- BAFQ (night 1)
- Pre-Sleep Q

**Recording Times**

<table>
<thead>
<tr>
<th>Video Start</th>
<th>Bio-Cals</th>
<th>Temp.</th>
<th>Lights off</th>
<th>Lights on</th>
</tr>
</thead>
</table>

**Morning**

<table>
<thead>
<tr>
<th>Temp.</th>
<th>Subject was awakened by experimenter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subject awakened on own</td>
</tr>
<tr>
<td></td>
<td>Post-Sleep Q</td>
</tr>
</tbody>
</table>

**Miscellaneous Events**

<table>
<thead>
<tr>
<th>Awakenings</th>
<th>Other</th>
</tr>
</thead>
</table>

**Notes/Comments/Doodles**
Sleep Questionnaire – Nighttime

Name: ___________________________ Date: ____________

1. Has today been an unusual day? ☐ Yes ☐ No
   If yes please explain ____________________________________________________________

2. How much sleep did you have last night? ______ Hrs ______ Mins.

3. Did you take a nap today? ☐ Yes ☐ No
   If yes how long? ______ Hrs ______ Mins

4. Did you have any of the following today?
   Coffee: ☐ Yes ☐ No, When? ______ How much? ______
   Tea: ☐ Yes ☐ No, When? ______ How much? ______
   Alcohol: ☐ Yes ☐ No, When? ______ How much? ______
   Chocolate: ☐ Yes ☐ No, When? ______ How much? ______

5. Did you do any physical exercise today? ☐ Yes ☐ No.
   What time? ______ How much? ______

6. List any medications you took today (Include vitamins and aspirin).

<table>
<thead>
<tr>
<th>Medication</th>
<th>Amount</th>
<th>Time Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Do you have any physical complaints right now? ☐ Yes ☐ No
   If so please explain ____________________________________________________________

8. Do you feel ready for bed now? ☐ Yes ☐ No.
   If no give reason ______________________________________________________________

9. Circle the number that best describes how you feel right now:
   1. Feeling active and vital; alert; wide awake.
   2. Functioning at a high level, but not at peak; able to concentrate.
   3. Relaxed, not at full alertness; responsive.
   4. A little foggy; let down.
   5. Fogginess; beginning to lose interest in remaining awake.
   6. Sleepiness; prefer to be lying down; fighting sleep; woozy.
   7. Almost in reverie; sleep onset soon; losing struggle to remain awake.

Please add any additional comments or information ________________________________
**Sleep Questionnaire -- Morning**

Name: ____________________________ Date: ____________

1. How long did it take you to fall asleep last night? _____ hrs _____ mins

2. How long do you think you were asleep? _____ hrs _____ mins

3. Was this the same, shorter, or longer than you usual sleep at home? (Circle one).

4. How many times do you remember waking up last night? _____ times.

5. Do you have any physical complaints right now? □ Yes □ No

6. Check the adjectives which best describes your sleep last night:
   □ light or □ deep
   □ interrupted or □ uninterrupted
   □ dreamless or □ many dreams
   □ restless or □ restful
   □ short or □ long

7. Do you remember any dreams from last night? □ Yes □ No
   If so please describe? ___________________________________________
   __________________________________________
   __________________________________________

8. In general, would you say that your sleep last night was worse, better, or the same as you usual sleep at home? (circle one).

9. Circle the number that best describes how you feel right now:
   1. Feeling active and vital; alert; wide awake.
   2. Functioning at a high level, but not at peak; able to concentrate.
   3. Relaxed, not al full alertness; responsive.
   4. A little foggy; let down.
   5. Fogginess; beginning to lose interest in remaining awake.
   6. Sleepiness; prefer to be lying down; fighting sleep; woozy.
   7. Almost in reverie; sleep onset soon; losing struggle to remain awake.

Please add any additional comments or information __________________________________________
____________________________________________________________________________________
____________________________________________________________________________________