# Effectiveness of Hand Self-Shiatsu for Post Sport-related Concussion Sleep Disturbance in Young Athletes

by

Pei Qin

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# Abstract

**Background:** Sport-related concussion (SRC) is a prevalent injury with significant health consequences. One important, but under-addressed area of health affected by SRC, is sleep. Not only can SRC cause sleep disturbance but, in turn, sleep disturbance affects recovery from SRC and increases the risk of symptom recurrence. Sleep deficiency also affects learning ability, memory and can lead to suboptimal academic performance, which is significant for youth. Hand self-Shiatsu (HSS) is a form of Complementary and Alternative Medicine (CAM). Promising outcomes of HSS to improve sleep were found with chronic pain patients in a pilot study and the literature suggests that HSS is an approach worth studying further in larger studies of various populations. **Objective:** The purpose of this study is to test the HSS as a self-management approach promoting sleep in young post-concussion athletes and non-concussion population with self-reported sleep problems. **Methods:** Using the consecutive case series design, the study recruited a group of participants with self-reported sleep disturbance after SRC. Another group of participants without SRC history was added four months later to expand the study. There were seven participants in each group, whose ages were between 18 to 25 years. After seven days of sleep diary and baseline actigraphy data collection, participants were taught to apply the standardized HSS technique and instructed to use it every night before bed and during awakenings. Follow-up data collection occurred at 4 and 8 weeks. Additional standardized sleep and CAMs questionnaires were included at baseline and follow-up to collect data about self-reported sleep quality, daytime fatigue and participant attitudes toward HSS. Statistical analysis was carried out to compare the results from baseline to follow-ups within groups. **Key Results:** There was no significant improvement in the results of actigraphy sleep measures from baseline to the 2$^{nd}$ follow-up in the post-SRC group. However, total sleep time significantly increased at the 2$^{nd}$ follow-up in the non-SRC group. Both groups had significant improvements in self-report sleep quality questionnaire and daytime fatigue. **Conclusion:** The results suggests that the HSS may be useful to improve the self-reported sleep quality in both groups. Further study with larger sample size and control groups need to be conducted to build more evidence for the HSS.

## Preface

This thesis is an original work by Pei Qin. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name “Effectiveness of Hand Self-Shiatsu for Post Sport-related Concussion Sleep Disturbance in Young Athletes”, No. Pro00061581, February 8 2016.

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# CHAPTER 1. INTRODUCTION

## 1.1 Problem Statement

Sport-related concussion (SRC) is a prevalent injury, especially in youth (Laker, 2015). In the US, it was reported that about 1.6-3.8 million SRCs occur every year (Voss, Connolly, Schwab, & Scher, 2015). Sport is the second leading cause of traumatic brain injury (TBI) among young athletes aged from 15 to 24, which account for 30% of all TBI in youth (Voss et al., 2015). One important, but under-addressed area related to SRC is sleep. Sleep disturbance is one of the common symptoms after concussion. It was reported that approximately 35 to 70% of concussed athletes in all age groups had self-reported sleep problems (Lovell et al., 2006).

Sleep occupies nearly one third of a person's life and plays an important role in multiple physiological processes such as brain function, neuronal detoxification and energy conservation. The risk of SRC and sleep problems appears to be bidirectional. Not only does SRC often make sleep worse, sleep disturbance also affects recovery from SRC and increases the risk of recurrence. Lack of sleep is also considered as a risk factor for many other health issues including obesity, diabetes, heart disease, mental health problems, contributes to risk taking behavior, and, thereby consequently contributes to the incidence of severe accidents (Hereford, 2014).

The epidemiology data along with the serious nature of sleep deficiency indicate the importance of SRC and sleep study in youth. However, studies related to post-SRC sleep problems are limited. While SRC shares physiological similarities with concussions acquired through events such as military service, workplace injury and leisure events, there are social and economic differences that make this an important population with which to carry out focused research. For example, athletes may refuse to use medication to avoid the risk of positive results in doping control, refuse medical attention out of fear of being sidelined and not allowed to maintain status in the team, and refuse medication courses of treatment in consideration of the high financial and time cost (Delaney, Lamfookon, Bloom, Al-Kashmiri, & Correa, 2015). Especially for young athletes, the cognitive effects on the developing brain from pharmacological therapy cannot be neglected.

Therefore, conducting studies on non-pharmacological therapy and Complementary and Alternative Medicine (CAM) are necessary. A pilot study applying Hand Self-Shiatsu (HSS) as a sleep intervention for persons with chronic pain, showed a positive trend towards decreased sleep onset latency (SOL) and longer overall duration of sleep (Brown, Bostick, Bellmore, & Kumanayaka, 2014). The study results suggest that HSS warrants further testing in larger studies and has potential application with other populations. Thus, this study will test the patient self-management non-pharmacological intervention HSS as a CAM approach to improve sleep in young athletes with SRC.

## 1.2 Study Objectives

The primary objective of this study is to test HSS as a self-management approach promoting sleep onset and maintenance in young post-concussion athletes and non-concussion population with self-reported sleep problems.

The secondary objectives are: 1) to evaluate young persons' attitudes toward CAM; 2) to evaluate young persons' adherence to the HSS protocol; and 3) to evaluate the correlation between objective measures of sleep quality and self-reported sleep quality in young persons' with self-reported sleep problems during a trial of HSS.

## 1.3 Hypothesis

We hypothesize that HSS will promote sleep onset and maintenance in young post-concussion athletes and non-concussion population with self-reported sleep problems. Sleep efficiency and total time asleep will improve compared with baseline. Furthermore, because HSS is a form of CAM and involves concentrating on a motor activity, it will be acceptable and appealing to young people who have self-reported sleep problems.

# CHAPTER 2. LITERATURE REVIEW

This chapter gives an introduction to sleep disturbance after SRC, including the definition of concussion, concussion epidemiology, why post-SRC sleep disturbance is important, and current studies of interventions to improve sleep. In particular, hand self-Shiatsu, as a Complementary and Alternative Medicine (CAM) intervention, is examined in greater depth.

## 2.1 Definition of Concussion and Epidemiology

According to the 4th International Conference on Concussion in Sport, concussion is defined as "a brain injury and a complex pathophysiological process affecting the brain, induced by biomechanical forces" (McCrory et al., 2013, p. e56). Although acknowledgement has been made by the Concussion in Sport Group (CISG) that concussion and mild traumatic brain injury (mTBI) are different injury constructs, the term "mild traumatic brain injury" (mTBI) is used in many SRC research studies and corresponds to mTBI with the score 13-15 on the Glasgow Coma Scale (Sherer & Sander, 2014). In this paper, the term "concussion" will be used to discuss the sports-related mTBI literature as well as the SRC literature to avoid misunderstandings.

According to the CISG, SRC can result in clinic symptoms that may not be related to a pathological injury. These common features include:

"1) Concussion may be caused by direct force to head, face and neck as well as indirect force transmitted to the head.

2) Concussion typically results in a short-lived impairment of neurologic function, but sometimes last for a number of minutes to hours.

3) The acute clinical symptoms largely reflect functional disturbances rather than a structural injury.

4) Symptoms are graded by severity according to the grading system. Loss of consciousness may or may not be involved. Resolution follows a sequential course and it is important to note that some symptoms may last for a long time." (McCrory et al., 2013, p. e56)

Sport-related concussion is a prevalent injury, especially in youth (Laker, 2015). Although it has received more attention in recent years in Canada, a review of the literature was unable to retrieve reliable and up-dated epidemiologic data. In Gordon et al.'s study, data from Canadian National Population Health Survey (1996-1997) were analyzed. It was reported about

110 per 100,000 in the general population had concussion at that time and 54% were SRC (Gordon, Dooley, & Wood, 2006). In a nationwide study, 692 acute care institutions received 22,651 TBI patients across Canada in 2006 and 24,706 in 2011 (Fu, Jing, Mcfaull, & Cusimano, 2015). However, Fu et al.'s study did not provide information specifically identifying which of these were SRC. This paper will draw on studies from the US, where more data has been collected, and because the US athletes share similar sports and lifestyles with Canadian athletes. In the US, it was reported that about 1.6-3.8 million SRCs occur every year (Voss et al., 2015). Sport is the second leading cause of traumatic brain injury (TBI) among young people aged from 15 to 24, accounting for 30% of all TBI in youth (Gessel et al., 2007; Voss et al., 2015). Football, girls' soccer, girls' basketball, rugby, ice hockey and lacrosse have a higher possibility of contact with others, contact with the equipment, and falls, and so are considered to have a higher risk for concussion. Interestingly, some researchers have found that women athletes have a higher rate of concussion (Halstead & Walter, 2010). Weaker neck muscles and a smaller head mass are considered to be the possible reasons (Mansell, Tierney, Sitler, Swenil, & Stearne, 2005).

Concussion is not as mild as this word seems to imply. Some researchers suggest that, due to the use of the term 'concussion' instead of 'brain injury', coaches, trainers, team physicians, parents and athletes themselves may take concussion so lightly that it often go undiagnosed and undocumented (DeMatteo et al., 2010). More than 4.4 million youth play sports in organized community leagues and school athletic programs in the US, and it seems likely that the number of young people who actually sustain concussions may be larger than reported (Carroll & Rosner, 2011).

One important, but under-addressed area related to SRC is sleep. Sleep occupies nearly one-third of a person's life and plays an important role in multiple physiological processes such as brain function, neuronal detoxification and energy conservation. Lack of sleep is also considered a risk factor for many other health issues include obesity, diabetes, heart disease, mental health problems and contributes to severe accidents (Hereford, 2014). Sleep deficiency will also affect learning ability and memory, which is significant for youth (Goodlin-Jones, Tang, Liu, & Anders, 2009). For example, a study conducted in Sweden showed that adolescents with self-reported sleep disturbance had a higher risk for academic failure in at least one subject during the school year (Titova et al., 2015). Sleep disturbance is one of the common post-concussion symptoms. In one study, conducted with 452 patients with minor to severe TBI in the

province of Quebec, Canada, the rate of insomnia was higher in minor TBI (38.5%) and mild TBI (38.2%) than in moderate TBI (35.1%) or severe TBI (24.6%) (Ouellet, Beaulieu- Bonneau, & Morin, 2006). Within SRC, it was reported that about 35 to 70% of athletes in all age groups had self-reported sleep problems (Guskiewicz, Weaver, Padua, & Garrett, 2000; Gosselin, Thériault, Leclerc, Montplaisir, & Lassonde, 2006; Lovell et al., 2006). These statistical data along with the dangerousness of sleep deficiency indicate the significance of SRC and sleep study in youth.

2.2 The Relationship between Sleep and Sport-related Concussion

Studies demonstrate that concussion can affect sleep quantity and quality. Self -reported sleep disturbance after concussion is reported in several studies (Orff, Ayalon, & Drummond, 2009). For example, a study of 102 patients in Sweden found that 21 among them still complained of sleep problems 3 months after injury (Lundin, Boussard, Edman, Borg, 2006). However, studies using both subjective and objective measures of sleep in youth with SRC are few. Thus, studies of athletes with SRC in all age groups are drawn on in this paper. In one study, 10 concussed athletes and 11 non-concussed athletes completed questionnaires related to sleep quality, polysomnographic (PSG) recording and the CogSport computer battery (evaluating reaction time, divided attention, working memory, and associate learning). The results showed concussed athletes had more subjective reports of poor sleep quality than controls but no significant difference was found in objective sleep characteristics (Gosselin et al., 2009). Other studies with TBI patients showed similar findings that despite the significant differences between patients and controls in sleep problems from subjective reports, objective measures did not find differences (Arbour et al., 2015; Chung, Sadeghniiat, Hwang, & Shapiro, 2014; Ouellet & Morin, 2006). However, another study found significant differences between 26 mTBI patients and 26 controls with PSG (Schreiber et al., 2008). These different results may be due to the small sample size in the studies and heterogeneity of samples with respect to age and the severity of injury (Orff et al., 2009). Although PSG is considered to be a ‘gold standard’ for measuring sleep, most studies only tested one or two nights of sleep, which may lead to unreliable results if sleep problem symptoms are highly variable (Gilbert, Kark, Gehrman, & Bogdanova, 2015).

In the past two decades, it has been possible to study the pathophysiology of concussion in greater detail due to the advances in assessment technology (Apps & Walter, 2012). We now

know the pathophysiology of concussion is neurological dysfunction, which is described as a "neurometabolic cascade" and not primarily destruction of cerebral structures (Giza & Hovda, 2001; Iverson, 2005). The clinical post-concussion symptoms result from sequential neuronal dysfunction such as ionic flux, energy crisis, axonal injury, changes in neurotransmission and cell death. The acute concussion occurrence leads to potassium efflux, and sodium and calcium influx. This ionic shift can trigger voltage- or ligand-gated ion channels, resulting symptoms such as migraine and mental status change. This process can then lead to a cellular energy crisis, which means a mismatch between energy supply and demand at cellular level. Vulnerability to secondary injury is considered to be associated with this energy crisis. Biomechanical forces can damage the cytoskeleton including dendritic arbors, axons and astrocytic which are all important for cognitive function. The impaired post-concussion cognition have been measured by functional MRI (fMRI), using the signal of blood oxygen level-dependent (BOLD). Studies show that BOLD changes are related to excitatory glutamatergic neurotransmission. Other neurotransmission changes including γ-amiobutyric acid (GABA) and its receptors. The axonal injury and impaired neurotransmission can be correlated to symptoms such as impaired cognition, slowed processing, and slowed reaction time. And cell death may happen after repeated concussions, leading to chronic impairments (Giza & Hovda, 2014).

The exact mechanism of sleep disturbance after SRC remains unclear. Recent study indicated that it might relate to neurophysiologic changes, which affect the regulation of sleep and wakefulness. For example, the level of hypocretin-1, a neuropeptide promoting wakefulness, showed a significantly decrease after concussion, which may lead to the sleep disturbance (Orff et al., 2009). GABA is another neurotransmitter that may affect the transition between the wake and sleeping state (Hofman & Talamini, 2014). Regardless of which mechanism, it appears that sleep-related co-morbid symptoms, such as headache, light sensitivity, sound sensitivity, anxiety and depression, are common complaints after concussion (Laker, 2015), and the effects of SRC to sleep cannot be ignored. One study pointed out that ruminative thoughts, one of the characteristics of depression, are also associated with sleep disturbance, and especially the difficulty in falling asleep in concussed athletes (Towns, Silva, & Belanger, 2015). These studies suggested that the relationship between sleep disturbance, neurologic function, and other post-concussion symptoms are complex and inter-related.

SRC and sleep appears to be bidirectional. Sleep deficiency also affects athletes' performance and recovery from SRC (Covassin, Elbin, Larson, & Kontos, 2012; Kostyun, Milewski, & Hafeez, 2014). Sleep deficiency leads to negative impacts on nearly all aspects of neurocognitive function (for example reaction time), which may increase the risk of accidents, such that sleep deficiency becomes a risk factor for SRC (Wesensten, Hughes, & Balikin, 2011). One study of 265 concussed athletes aged between 14 and 23 years of age from schools in Michigan, Pennsylvania and California showed that 34 athletes with preinjury sleep difficulties performed worse than 231 athletes without preinjury sleep difficulties on reaction time at 5-7 days and 10-14 days after injury. Moreover, athletes with preinjury sleep difficulties reported more post-concussion symptoms such as headache, nausea, vomiting, balance problems, dizziness, and fatigue (Sufrinko et al., 2015). Similar results were showed in a study when the researchers retrospectively reviewed the baseline neurocognitive testing results of 231 concussed athletes. In this study, Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) was used to evaluate all athletes' pregame performance to establish a baseline. The ImPACT is a computer-based test that measures athletes' neurocognitive performance such as verbal memory, visual memory, visual- motor processing, and reaction as well as information about self-reported concussion symptoms. The athletes were divided into 3 groups according to their self-reported total sleep time pre-concussion (<7 h, 7-9 h, and ≥9 h). The results showed athletes sleeping fewer than 7 hours performed worse and reported more pregame baseline symptoms than those who sleeping more than 7 hours (McClure, Zuckerman, Kutscher, Gregory, & Solomon, 2014). These findings suggest that negative consequences of SRC are made worse if athletes return to play without addressing their sleep problems. This is not only because there may be an increasing risk of a recurrent concussion but also poor sleep may decrease the accuracy of baseline test results such as memory, reaction time, and self-reported symptoms, which are used for comparison before and after SRC to assess recovery and safety for return to play.

Furthermore, sleep plays an important role in disease and injury rehabilitation (Hereford, 2014), including SRC. One study showed that, during the post SRC recovery period, participants with sleep disturbance either as a result of SRC or before injury, had worse scores than those who did not have sleep disturbance in neurocognitive function tests, which meant a worse recovery (Kostyun et al., 2014). Indeed, sleep problems and related symptoms like headache

were considered as risk factors for delayed recovery and a longer time to return to play (Bock et al., 2015).

### 2.3 Interventions for Post-concussion Sleep Disturbance

In some cases, sleep problems can not be resolved automatically with time or recovery from other consequences of SRC. For example, in a one-year follow-up study of 346 patients in New Zealand with mTBI, sleep difficulties became chronic in over half of the participants and 38.9% of them needed intervention (Theadom et al., 2015). Looking for interventions in the research literature revealed limited evidence and it appears that studies are few in number (Jaffee, Winter, Jones, & Ling, 2015).

#### 2.3.1 Pharmacological Therapy

Pharmacotherapy is the most common and accessible sleep intervention. Melatonin is a hormone that assists in controlling the night-day cycle that is related to sleep (Hereford, 2014). The efficacy of using melatonin has been shown in Kemp and colleagues' study to improve the sleep quality, sleep duration, and sleep latency in patients with insomnia after TBI (Kemp, Biswas, Neumann, & Coughlan, 2004). However, although melatonin is considered to be a dietary supplement in the USA, the safety of extended use of melatonin has not been evaluated, especially for children or adolescents. The potential long-term effects may include problems with cardiovascular, immune and metabolic systems (Kennaway, 2015). Other medications such as Zopiclone and Eszopiclone are also recommended in an updated clinical practice guideline (Marshall et al., 2015). However, as studies showed, medications have numerous side effects and are not routinely suggested for chronic insomnia (Flanagan, Greenwald, & Wieber, 2007). For example, Orff et al. pointed out that hypnotic medications might lead to daytime sleepiness, dizziness, and cognitive and psychomotor impairments, which are adverse effects to a concussion population (Orff et al., 2009). In the Ontario Neurotrauma Foundation Guidelines about management of concussion/mTBI, pharmacotherapy is only recommended in the acute stage with limitation (Ontario Neurotrauma Foundation [ONF], 2013, p.31).

### 2.3.2 Non-pharmacological Therapy, Complementary and Alternative Medicine and self-management approaches

Non-pharmacological therapy and Complementary and alternative Medicine (CAM) are widely used in treating sleep problems like insomnia in recent years because of the side effects of medications (Ebben & Spielman, 2009). The CAM approaches, especially, are receiving increasing notice. Studies in the US and Europe showed that people who were younger and with higher education may more likely to use the CAM methods (Wang, Peloquin, & Kain, 2002; Buda, Lampek, & Tahin, 2002). A survey was conducted with intercollegiate athletes at US universities and the results showed that 56% of 309 athletes used CAM within the past one year. Massage was the most common CAM type be used, accounting for 38%. It was also interesting that athletes with different ethnicity tended to choose a CAM type from their own culture background. The researchers concluded that the prevalence of using CAM in intercollegiate athletes was higher than in adults in the United States because these competitive athletes had higher motivated to try every possible approach to recover from sports injuries (Nichols & Harrigan, 2006).

Increasingly intervention studies for chronic conditions such as pain and insomnia are turning to the self-management model. The number of publications about chronic disease self-management has increased fourfold during 2004 to 2014 (Lu, Li, & Arthur, 2014). Such an increase suggests growing use and possibly acceptance of self-manage strategies, a need to increase the range of strategies, and that more studies are needed to build the evidence-base for self-managed interventions. Self-management is defined as "the individual's ability to manage the symptoms and the consequences of living with a chronic condition, including treatment, physical, social, and lifestyle changes" (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002). In Lorig et al.'s paper, three tasks- medical management, role management and emotional management were emphasized in the definition. They concluded that self-efficacy was one of the keys to the changes in health status (Lorig, &Holman, 2003). Through a self-management approach, patients may manage the symptoms, treatment and changes in their lifestyle, rebuild and increase their self-confidence about the future, as well as their feelings of control of own life (Reid et al., 2008; Moseley, 2004). Particularly for young population, this is the period of time that they expand personal decision-making including personal decision-making in the area of their own health (Patterson & Arthur, 2009). This is also an important period for them to transit

from childhood to adulthood, and supporting young people to develop self-management skills for health care is a key task (Sattoe et al., 2015).

While SRCs share physiological similarities with concussions acquired through events such as military service, workplace injury and leisure events, there are social and economic differences that make this an important population with which to carry out focused research. For example, athletes may refuse to use medication to avoid the risk of positive results in doping control, refuse medical attention out of fear of being sidelined and not allowed to maintain status in the team, and refuse medication courses of treatment in consideration of the high money and time cost. Especially for young athletes, the cognitive effects on the developing brain from pharmacological therapy cannot be neglected.

Thus, conducting studies on non-pharmacological therapy, CAM and self-management approaches are necessary. In the following section, current studies about CBT-i and CAM interventions are discussed. Finally, the cases for research into hand self-Shiatsu as an intervention to promote sleep are presented.

### 2.3.3 Cognitive Behavioural Therapy for Insomnia

Cognitive Behavioural Therapy for insomnia (CBT-i) is one of the non-pharmacological sleep interventions for concussion patients that has been studied widely in recent years. The aim of this intervention is to act on cognitive and behavioural factors that may affect sleep, for example, sleep habits, sleep hygiene, and psychological states or attitudes towards sleep. Researchers propose that an integrated CBT-i intervention includes 5 components: cognitive therapy, stimulus control (avoiding non-sleep activities in the bedroom, going to sleep only when sleepy, and leaving the bedroom when unable to sleep and returning only when sleepy), sleep restriction, sleep hygiene and relaxation (Trauer, Qian, Doyle, Rajaratnam, & Cunnington, 2015).

Ouellet and colleagues reported successful use of CBT-i in TBI patients. In the study, 11 patients (6 men and 5 women, mean age 27.3 years) in Quebec received 8 weekly sessions of CBT-i. The results showed a significant reduction in total wake time over the sleep period and improvement in sleep efficiency. Furthermore, the effect was well maintained after 1 month and 3 months follow-up (Oluellet & Morin, 2007). However, this was a small sample study and mixed the severity of injury. Although CBT-i is suggested in some guidelines (Marshall et al., 2015; Sherer & Sander, 2014), a recommended standardized treatment process that indicates key

components such as treatment duration and the frequency remains unclear (Potter & Brown, 2012). Lastly, considering the social and economic differences in young athletes mentioned above, CBT-i may not be universally accepted nor appropriate for concussed athletes because of the long process, the cost, and the requirement of a certain level of cognitive function and motivation to participate.

### 2.3.4 Acupuncture

Acupuncture is one of the Complementary and Alternative Medicine (CAM) intervention based on Traditional Chinese Medicine (TCM). This technique uses thin, solid, metallic needles manipulated by hand or by electrical stimulation to penetrate the skin. From a western medical perspective, acupuncture is believed to release hormones and neuropeptides, which influence the body's internal regulating system, to treat diseases (Zoilman, Larson, Wasek-Throm, Cyborski, & Bode, 2012). A study, piloting the intervention of acupuncture for sleep treatment in 24 mTBI patients randomized to treatment and control groups, showed an improvement in the Insomnia Severity Index (ISI), which reflected the degree of insomnia, as well as in the Repeatable Battery for the Assessment of Neuropsychological Status and Paced Auditory Serial Addition Test, which reflected cognitive function. However, actigraphy, which is an objective measurement for sleep time, showed no difference between groups (Zoilman et al., 2012). This result may relate to the limited one-night only measurement of actigraphy and the small sample size. An additional consideration is that acupuncture may not be accepted by everyone, which is costly, not self-administered, and not accessible in many places.

### 2.3.5 Shiatsu

Shiatsu is another form of CAM based on the theory of TCM, which includes the philosophy of Yin and Yang and the concept of Ki, or energy intended to balance, restore and maintain the body energy and to prevent stress (Makoto, 2013). The word "Shiatsu" means "finger pressure", and it shares many similarities with acupressure. Shiatsu practitioners, either professionals or patients themselves, apply thumb and finger pressure to specific points on the body, which are based on meridian theory and anatomy. This concept is similar to acupuncture in that the mechanism may relate to biomedical effects on the body system, such as improved blood circulation, reduced muscle tension, and increased production of serotonin from the perspective

of western medicine (Robinson, Lorenc, & Liao, 2011; Yuan, Berssaneti, & Marques, 2013). Literature reviewing current evidence states that certain pain (like headache, low-back pain, stiff necks) and mental problems (like tension or anxiety) can be treated by Shiatsu (Beresford-Cooke, 2011).

Several studies have been done to explore the efficiency of using Shiatsu or acupressure to improve sleep (Chen, Lin, Wu, & Lin, 1999; Hsu, & Sun, 2006; Reza et al., 2010; Sun, Sung, Huang, Cheng, & Lin, 2010). However, although the results were promising, the participants of most of studies were elderly people and not athletes with SRC. For example, in one randomized control trail (RCT) study, 50 residents with insomnia in long-term care facilities in Taiwan were divided into two groups. In a 5-week acupressure treatment, one group received acupressure on several points on the wrist while the control group only received light touch on the same places. The results showed a significant improvement in sleep quality in the treatment group not only during the intervention period but also 2 weeks after the intervention (Sun et al., 2010). This study showed successful sleep outcomes during the use of Shiatsu, however, Shiatsu treatments given by professionals are not always accessible for patients due to the cost and the long course of treatment. Also, the patient has no or very limited control over the dose and timing of the intervention which precludes practical use at bedtime or during night wakenings.

A systematic review identified and assessed 10 studies of self-acupressure for symptom management, including allergic disease, cancer, respiratory disease, dysmenorrhea, perceived stress, insomnia, and sleep disturbances. All the 10 studies showed positive effects on the main outcomes and safety associated with using self-acupressure in different population. Quality assessment revealed moderate quality for these 10 studies, with more than 50% noted to be at low risk of bias (Song et al., 2015). One of the few examples of the application of self-management principles to CAM interventions to promote sleep is Brown et al.'s study of hand self-Shiatsu. In Brown and colleagues' study, 14 participants with sleep problems caused by chronic pain were taught a standardized Hand Self- Shiatsu (HSS) intervention with baseline and outcomes tested by subjective and objective (actigraph) measurements. They found a promising, but non-statistically significant, trend towards change through objective measurement, and self-reported sleep latency and sleep duration were improved. Also, HSS was acceptable to all the 14 patients (Brown et al., 2014) and researchers concluded that HSS warranted larger studies and had potential application with other populations.

The mechanism of Shiatsu for treating sleep problems is unknown but may relate to biomedical effects such as improved blood circulation, reduced muscle tension, and increased production of serotonin (Yuan et al., 2013). Another possible mechanism is that self-Shiatsu, because it requires focused attention, may reduce rumination and worry before sleep. Rumination is known to be a risk factor for sleeplessness, pain, and negative emotions (Edwards, Tang, Wright, Salkovskis, & Timberlake, 2011). As has been discussed in the previous section on the relationship between sleep disturbance and SRC, one study showed that ruminative thoughts are associated with sleep disturbance and contribute to the difficulty concussed athletes have in falling asleep (Towns et al., 2015). Studies of brain functioning demonstrated that concentration on one thing could release the individual from other thoughts (Styles, 2006). One study pointed out that the prefrontal cortex, which is an area toward the front of the brain, spans both the left and right sides of the brain. The left and right parts of the prefrontal cortex work together when focused on a single task. However, when there are two tasks, the two sides of the prefrontal cortex work separately, which slows down the brain and increases mistakes. When there are three or more tasks, only two will be remembered because there are only two parts of the prefrontal cortex (Charron &Koechlin, 2010). As a specific self-management intervention, applying self-Shiatsu require a sustained concentration on one target. For example, in the Brown et al. study (2014), participants needed to focus on the sequence of applying their own Shiatsu, which may have precluded their ability to focus on negative rumination and emotions at bedtime. Through blocking rumination and the stress-related neurochemicals released because of negative thoughts, participants may fall asleep and stay asleep more easily.

Unlike an interpersonal cognitive therapy, self-Shiatsu is a motor activity that may be acceptable by individuals who do not tolerate or respond to the cognitive therapies. Furthermore, the HSS therapy has no cost and requires no equipment, which makes it accessible to every athlete. After a 30-45 minute session to learn HSS, participants can apply it anywhere and at anytime. This may be more appealing to athletes than other therapies in situations such as travelling away from home to other sports events or at night during wakening. It may also be more acceptable to young athletes because, as a pre-sleep therapy, HSS is quiet and inconspicuous so that coaches or team members do not know the athlete is carrying out HSS. Studies showed that young athletes have great anxiety about missing future games after concussion and that this anxiety was one of the reasons that they refused to seek medical

attention (Delaney et al., 2015). Lastly, as a form of CAM, hand self-Shiatsu had none of hypnotic medicine's negative side effects on athletes' physical and cognitive health such as muscle strength, problem solving, new learning and attention. Importantly, it will also not lead to any risk of possible positive results in doping control, which is important to all athletes.

## 2.4 Summary of Literature Review

The above review briefly introduced the definition of concussion and the epidemiology, especially in the SRC area. The high occurrence rate of SRC and the consequences identifies that post-SRC sleep disturbance is a significant health problem to young people. Although this problem is getting increased attention in recent years, intervention studies are still limited. Most of the current studies were about the relationship between SRC and sleep. Post-concussion symptoms and sleep problems appear to be bidirectional. Sleep disturbance is not only a common symptom after SRC, but may also increase the risk of further SRCs and affect the rate and success of recovery. One of the biggest gaps in this area is the lack of evidence-based interventions for sleep disturbance in young athletes with SRC. Although there are several approaches such as CBT-i and acupuncture as well as medication for sleep disturbance treatment, few have been studied in young concussed athletes. The social, health and economic considerations make this an important population for more focused studies.

With the increasing use of CAM, we are focusing our research on this area and the intervention of HSS. This self-management approach is a form of CAM based on the theory of TCM. The mechanism of HSS is not clear but may related to physiological effects and/or have a psychological basis in the reduction of negative rumination and worries before sleep. A pilot study involving people with chronic pain showed a positive trend in improving sleep. The literature suggests that HSS is an approach worth studying further to help reduce sleep problems in larger studies of various patient populations.

# CHAPTER 3. METHODS

This chapter discusses the research methods in this study, including study design, sampling, recruitment method, inclusion and exclusion criteria, data collection, procedures of the study and data analysis. Details about how the study was carried out and the justification for this research are provided in the following sections.

## 3.1 Study Design

A prospective case series study design, in which participants act as their own controls, was employed. Participants were tested at baseline and received the same HSS teaching session. Follow-up data collection was at the 4$^{th}$ and 8$^{th}$ week. To reduce bias, both standardized self-report and objective assessment tools were used to evaluate HSS protocol.

A case series study is designed to follow a group of patients who are undergoing similar procedures or with similar issues during a certain period of time (Kooistra, Dijkman, Einhorn, & Bhandaari, 2009). A prospective case series study is similar to a before-after study or a time series study, and is defined as a study that administers an intervention and compares data between pre-intervention and post-intervention across a cohort of participants (Hartling, 2010). This study design is suitable for hypothesis generation, determining treatment safety and preliminary testing of novel interventions because of the design's low cost and simplicity.

Because of the low recruitment rate in the initial process, another group of non-SRC participants were added into the study. This group of non-SRC participants was not a control group and comparisons were conducted within groups. Deviating from the original study, the non-SRC group was warranted and may help us to better illustrate the effectiveness of the HSS on young population with self-reported sleep problems.

## 3.2 Sampling

The sampling method used in this study was convenience sampling. Convenience sampling is accessible, fast and suitable for pilot studies (Emerson, 2015). Sample size was calculated with statistical significance set at 0.05, power at 0.80 and effect size at 0.40. The calculation suggested 21 participants would be required to achieve sufficient power for the proposed analyses.

3.3 Recruitment

Participants between the ages of 18-25 from the Edmonton, Canada area were recruited. The study used electronic and printed posters (Appendix A) to invite participants through sports medicine clinics, sports organizations, universities and social media. Posters for recruitment process is one of the most common and effective recruitment approaches (Feman et al., 2007) and the study information can potentially reach a large number of participants (Fleming et al., 2015). The poster of the study contained a brief introduction of the study, what the participant was required to do and contact information of the researcher. There was a QR code on the poster which linked to Fluidsurveys (http://fluidsurveys.com/) for contact information collection (Appendix B). This site collected only contact names and email address so the researcher could contact potential participants. As each person was contacted, their data were deleted from the FluidSurvey site by the researcher manually so that no lasting record was retained.

The posters were distributed in the following ways:

1) Using the Mailman Service, which serves the campus mailing list at the University of Alberta (U of A), to send a mass email to all the students at the U of A. Emails were sent on Mar. 9, Mar. 30, Apr. 13, Aug. 31, Sep. 21, and Oct. 26 in 2016 to both undergraduate and graduate students. The posters were also sent to the administrative assistants in Faculty of Rehabilitation Medicine and Faculty of Physical Education and Recreation at the U of A. They were asked to help distribute the posters inside the faculties through emails, as well as in the high traffic areas in the buildings.

2) In order to reach more targeted participants, we contacted the U of A Glen Sather Sports Medicine Clinic. Study information and the electronic poster was posted on the clinic website to attract potential participants (https://www.ualberta.ca/glen-sather-clinic/research/current-studies) from May 2016. Printed posters were also posted on the information board in the clinic waiting room.

3) We contacted the local sports organizations and asked them if they would be willing to distribute print and/or electronic poster to the members of their organization. The organizations acted as gatekeepers and we did not ask for access to email list. Four sports organizations in Edmonton area with teams which may have potential participants had been contacted since Sep 2016. They were Football Alberta, Edmonton District Soccer Association, Leprechaun Tiger

Rugby Club, and Golden Bears and Pandas Athletics. Football Alberta and and Golden Bears and Pandas Athletics agreed to forward the electronic and/or print poster to their members.

4) We advertised through Gateway, which is a student newspaper at the U of A, inviting athletes between the ages of 18-25 who have sleep problems and have experienced a SRC to contact the researcher.

Once the potential participant has contacted the researcher, a PDF of the consent form and study information (Appendix C) would be sent to them by return email.

### 3.4 Inclusion and exclusion Criteria

The inclusion criteria for the post-SRC group in this study were: 1) Aged between 18-25 at the time of study. 2) Diagnosed with SRC in the last 6 months. 3) With self-reported sleep disturbance after concussion.

The inclusion criteria for the non-SRC group in this study were: 1) Aged between 18-25 at the time of study. 2) Without any SRC or mTBI history. 3) Have had self-reported sleep disturbance, but without any specific physical discomfort (e.g. pain), in the last 6 months.

The exclusion criteria for the SRC group were: 1) With pre-existing self-reported sleep disturbance before developing a SRC. The common exclusion criteria for both groups were: 1) Inability to communicate in English. 2) With an active arthritic condition involving the hand or with unhealed hand injuries. 3) With noctambulism (sleepwalking), sleep apnea, or parasomnia (abnormal movements during sleep).

As participants acted as their own controls, those using sleep medication were not be excluded unless there was a change to their prescription and dose during the study period.

### 3.5 Data Collection

#### 3.5.1 Actigraph wGT3X-BT Sleep Monitor

The Actigraph wGT3X-BT device (ActiGraph, Pensacola, FL, USA) is a small, wristwatch sized portable device using acceleration sensors to translate physical motion into a numeric representation. The representations can be then analyzed by software (ActiLife 6) to determine sleep onset latency (SOL), sleep efficiency (SE%), time in bed (TIB), total sleep time (TST), wake after sleep onset (WASO), times of awakenings, and average awakening minutes. These are all components that relate to the perceived and realized quality of sleep. Studies (Sadeh,

2011; Marino et al., 2013; Kosmadopoulos, Sargent, Darwent, Zhou, & Roach, 2014) showed a significant correlation between actigraphy and the results measured by PSG, which is considered to be the 'gold standard' method to assessing sleep. One study concluded that the sensitivity, specificity and accuracy of the Actigraph wGT3X-BT worn on the wrist are 90, 46 and 84%, respectively (Slater, Botsis, Walsh, King, Straker, & Eastwood, 2015). Although PSG is considered to be the most accurate measure for sleep studies, it is expensive, not an accurate reflection of the 'real world' context of the individual's sleep, and not acceptable to many participants because it requires sleeping in a lab setting. With good validity and reliability (Weiss, Johnson, Berger & Redline, 2010), using an actigraph is a convenient, low cost and simple way to monitor sleep. Zollman et al. (2010) concluded that actigraphy is a convenient and appropriate tool in sleep evaluation for TBI patients.

In this study, the Actigraph wGT3X-BT device were used to measure the sleep patterns as the primary outcomes. Seven days of baseline data were collected. After HSS intervention was taught and applied, follow-up one-week data collection was conducted at the 4$^{th}$ and 8$^{th}$ week. The device was placed on the non-dominant wrist during sleep (Zinkhan et al., 2014; Sadeh, 2011) and not change during the data collection period. The Actilife 6 software (http://www.actigraphcorp.com/product-category/software/), which is provided by the manufacturer of Actigraph wGT3X-BT, was used to analyze the raw data.

3.5.2 Sleep log (Appendix D)

A sleep log is a common and useful tool for individuals recording sleep and related information including the use of substances (such as caffeine, alcohol and nicotine) and behaviors (such as the location of sleeping and activities before bed) that can interfere with sleep. One study shows that the sleep log used with young participants had sensitivity of 87.93% and specificity of 96.51% in relation to actigraph data (Usui, 1999). However, no study was found reporting the psychometric properties with concussed population.

In this study, a sleep log was also used to gather time and date information required when analyzing the Actigraph wGT3X-BT data (Augger, Varghese, Silber & Slocumb, 2013) and to record nightly use of HSS to help determine adherence to the HSS protocol. Participants were required to keep the log for 7 days at baseline and two follow-ups, together with actigraph data collection.

### 3.5.3 The Pittsburgh Sleep Quality Index (Appendix E)

The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) is a widely used, psychometrically strong self-report measure to evaluate sleep quality during the preceding month. It contains 19 self-rated questions (scored) and 5 partner/roommate-rated questions (non-scored), with the final score "0" means no difficulty and "21" means severe difficulties in sleep. A score of 5 is used to distinguish "good sleep" and "poor sleep". The PSQI was first developed in 1988 and is currently considered as the only standardized tool that covers a wide range of indicators relevant to sleep quality (Mollayeva et al., 2016). It shows strong reliability and moderate validity in clinical and non-clinical samples. Although the results of the PSQI are presented as ordinal scores, the questionnaire collect both quantitative and qualitative information. It can reflect participants' subjective sleep quality and other self-rated habitual sleep patterns.

In this study, the PSQI was used as a self-report assessment tool to monitor the sleep quality of participants. Furthermore, the potential relationship between objective outcome and self-reported sleep quality in post-SRC and non-SRC participants was evaluated. The questionnaire was collected at baseline and two follow-ups.

### 3.5.4 Flinders Fatigue Scale (Appendix F)

The Flinders Fatigue Scale (FFS) is a self-reported questionnaire with 7 items to measure the level of a person's daytime fatigue in a variety of situations. The score for FFS is from 0 to 31. Psychometric study shows that the FFS is a brief and clinically sensitive measurement in discriminating between good and poor sleeper (Gradisar et al. 2007).

In this study, the FFS was used to measure participants' self-reported fatigue because sleep quality is strongly associated with daytime functioning. Subjective feelings of daytime sleepiness are considered as one of the important components for evaluating pre-night sleep quality (Harvey, Stinson, Whitaker, Moskovitz, & Virk, 2008). The FFS was completed at baseline and two follow-ups.

3.5.5 Holistic Complementary and Alternative Medicine Questionnaire (Appendix G)

The Holistic Complementary and Alternative Medicine Questionnaire (HCAMQ) is a 12-item questionnaire exploring beliefs about scientific validity of CAM and holistic health. It contains seven items about attitudes towards CAM and five items about holistic health beliefs. Study shows that the HCAMQ had good test-retest reliability (r=0.86) and internal validity (Hyland, Lewith, & Westoby, 2003).

In this study, the HCAMQ was included to explore if there was a relationship between HCAMQ scores and adherence and perceived benefit of the intervention. The HCAMQ was completed by participants at baseline and the 2nd follow-up.

3.5.6 Sleep Beliefs Scale (Appendix H)

The Sleep Beliefs Scale (SBS) is a 20-item revised version of the Sleep Hygiene Awareness tool developed to assess sleep attitudes and beliefs (Adan, Fabbri, Natale, & Prat, 2006). It is a brief scale with good psychometric properties (internal consistency Cronbach's $\alpha = 0.714$).

The SBS was included in this study to see if sleep beliefs shifted over the course of the study. The HSS intervention was not intended to alter sleep beliefs and as such we would expect to see no change in SBS scores between baseline and follow-up. A shift in beliefs may be indicative of a cofounding influence which would need to consider in data analysis. The SBS was completed by participants at baseline and the 2nd follow-up.

3.5.7 Visual Analogue Scale (Appendix I)

The Visual Analogue Scale (VAS) is a widely used outcome measurement in health studies (Kersten, Küçükdeveci, & Tennant, 2012). It is usually presented as a single line with words (e.g. not at all-very much) at either end, or 0-10 from the beginning to the end of the line. The VAS is considered a simple and fast tool to reduce the bias of confounding effects, such as the age and the variation between individual's understanding of the graduations on the rating scale, (Kersten et al. 2012; Voutilainen, Pitkäaho, Kvist & Vehviläinen-Julkunen, 2016). However, Kersten et al. pointed out that the VAS data should be treated as an ordinal scale and analyzed by non-parametric statistics.

In this study, four questions (specified in Appendix I) related to participants' expectation and satisfaction of the HSS protocol were designed in a VAS format with 0-10 scale. Participants anonymously answered the questionnaire at the end of the study.

3.6 Procedures

1) Participants were recruited through the approaches which were mentioned above. The principal investigator (PI) arranged an in-person meeting through email with each person who was willing to participate in this study. The meeting room was in Corbett Hall, University of Alberta. During the meeting, the PI introduced the study in detail. Signing the consent form was considered as consent to participate. Each participant also received a copy of the consent form. After that, they completed the PSQI, the HCAMQ, the SBS and the FFS as the baseline data. The procedure for using an actigraph device was taught after completing the questionnaires and an actigraph care and use instruction handout was provided. The date of the next meeting for HSS teaching was arranged.

2) From the day of meeting, seven days of baseline actigraph data together with the sleep log was collected. The actigraph device was only required to be worn when the participant went to sleep. Text messages (See Appendix J for text message samples) were sent to participants twice a week (on the 3$^{rd}$ and the 5$^{th}$ day) to remind them to wear the actigraph, record the sleep log and when the next meeting was scheduled. Studies have shown that simple text message reminders can increase adherence to treatment (Raifman, Lanthorn, Rokicki, & Fink, 2014; Nglazi, Bekker, Wood, Hussey, & Wiysonge, 2013) and may avoid data missing because participants forget to wear the actigraph device or record their sleep diary. All the participants received the same text message to avoid any bias. The actigraph devices were returned after the seven-day data collection.

3) After baseline data collection, participants received a one-to-one training session in HSS. The training typically took 30-45 minutes but as much time as required was provided. Instructional brochures were also provided as memory aids. The HSS protocol is standardized and the research team has received training from Leisa Bellmore (Shiatsu therapist) prior to carrying out teaching sessions for participants.

4) From the day of HSS teaching, participants were instructed to apply HSS once in bed to go to sleep every night for the following three weeks. There were no text message reminders during this period of time.

5) The first follow-up data collection was the 4th week after the baseline data collection week. E-mails were sent one week and 2 days ahead to make an appropriate arrangement. First, questionnaires including the PSQI and the FFS were completed by participants when they met the researcher to receive the actigraph. The actigraph devices and sleep logs were provided to participants at the same meeting. A seven-day data collection period, including the actigraphy and sleep log, was then conducted. During that time, participants were encouraged to continue the HSS protocol. Text messages were sent to participants twice a week (on the 3rd and the 5th day) to remind them to apply HSS, wear the actigraph device and record the sleep log. All the participants received the same text message to avoid any bias. After the one-week data collection period, the actigraph was returned in-person or through the mail in a pre-paid envelop provided by the researcher.

6) After that, participants continued to do the HSS protocol for another three weeks. During this period of time, there were no text message reminders.

7) The second follow-up data collection was at the 8th week after the baseline data collection week. Questionnaires including the PSQI, the SBS, the FFS and the HCAMQ were completed by participants when they meet the researcher to receive the actigraph. The actigraph devices, the sleep logs, and the VAS questionnaire were provided to participants at the same meeting. A seven-day data collection including the actigraphy and sleep log was then conducted. During that time, participants were encouraged to continue the HSS protocol. Text messages were sent to participants twice a week (on the 3rd and the 5th day) to remind them to apply HSS, wear the actigraph device and record the sleep log. All participants received the same text message to avoid any bias. The device returning was done in-person or through the mail in a pre-paid envelop provided by the researcher.

### 3.7 Data analysis

The study used IBM SPSS Statistics (version 21; IBM) software for the data analysis, included descriptive statistics (means, errors, standard deviation), one-way repeated ANOVA for comparing within groups, and independent-sample t test for comparing between groups. If non-

parametric testing was required, Mann-Whitney test for compared between groups and Friedman test for comparing within groups were used respectively. The statistical significance was set at 0.05.

### 3.8 Summary of Methods

A prospective case series study design, with participants acting as their own controls, was employed in this study. A group of post-concussion young athletes and a group of non-concussion people who were in the same age, were recruited. Recruitment sources included universities, local sports medicine clinics, sports organizations, and through social media. After a 7-day baseline actigraphy (Actigraph wGT3X-BT) data collection with sleep log, the HSS protocol was taught and was required to be applied by participants before bedtime. Follow-up data collection periods were at the $4^{th}$ and $8^{th}$ week after the baseline data collection. Additional standardized sleep and CAMs questionnaires were also be included at baseline and follow-ups to evaluate self-reported sleep quality and the attitudes toward HSS.

# CHAPTER 4 RESULTS

This chapter presents the results of this study, including the participants' demographics, findings from both objective sleep monitors and self-reported measurement tools. Descriptive data are presented in the format of mean ± standard deviation in the tables. All tables are provided in Appendix L.

## 4.1 Participants' Involvement

The recruitment of the post-SRC group and the non-SRC group occurred at March 2016 and October 2016, respectively. At the end of December 2016, a total of 78 people who were interested in the study had contacted the PI. Seven individuals who had post-SRC sleep disturbance and twelve people without SRC history met the inclusion criteria and participated the study. In the non-SRC group, one participant was not able to finish the 1st follow-up because of personal reasons. Two participants dropped out from the study by the second follow-up. There were also two participants who did not have completed data from the Actigraph sleep monitor because of technical problems with the devices. Their data were excluded from the analysis. Accordingly, there were seven participants in both the post-SRC group and the non-SRC group.

## 4.2 Participants' Demographics

As Table 1 shows, of the seven participants in the post-SRC group, there were five females and two males. The mean age of the post-SRC group was 21.43 years old. These young athletes had SRC from soccer, judo, baseball, and basketball. Two participants had a SRC within one month when participated in the study, while two participants had a SRC 1-3 months before the study. Three participants' SRC history was 4 to 6 months.

Of the seven participants who had self-reported sleep problems in the non-SRC group, four participants identified as female and three participants were males. The statistical analysis indicated no significant age differences between the two groups.

## 4.3 Results from the Actigraph wGT3X-BT

Table 2 lists the results from the sleep monitor for the post-SRC group and the non-SRC group, at the baseline, the 1st follow-up, and the 2nd follow-up. Seven variables are presented in the table, including the sleep onset latency (SOL), sleep efficiency (SE%), time in bed (TIB), total

sleep time (TST), wake after sleep onset (WASO), times of awakenings, and average awakening minutes. Although there were only seven participants in each group, the results of the normality test showed that the data is normally distributed. Thus, the study used one-way repeated ANOVA to analyse the data within each group. However, it is notable that the small sample size is one of the limitations in this study.

The statistical analysis results showed that there was a significant difference in the TIB ($F$ (2, 12) = 5.061, $p$= .025) and TST ($F$ (2, 12) = 5.093, $p$= .025) in the non-SRC group. To be more specific, participants in the non-SRC group had longer TIB at the 2nd follow-up (479.45± 60.92 minutes) compared with the baseline (454.18± 63.84 minutes) and the 1st follow-up (428.72± 55.79 minutes). However, participants' TST only increased from the 1st follow-up (390.32± 48.74 minutes) to the 2nd follow-up (428.70± 40.71 minutes). There was no significant difference in other variables.

4.4. Global Score of the Pittsburgh Sleep Quality Index

As explained in the previous section (see Section 3.5.2.2), the PSQI (Buysse et al., 1989) is a reliable self-reported sleep quality questionnaire with a total score from 0 to 21, which is also known as the "global score". A global score that is equal to, or less than five is considered to be a sign of good sleep quality. In contrast, a score of more than five is associated with poor sleep quality. Table 3 shows the results of the global score of PSQI for each group at baseline, the 1st and the 2nd follow-up.

The mean global score at the baseline for the post-SRC and the non-SRC group was 10.57 and 8.57 respectively. The results indicated that the average sleep quality for both groups was poor at baseline. However, there was no significant difference between two groups. At the 1st follow-up, the mean global score for the post-SRC and the non-SRC group changed to 7.14 and 8.43 respectively. At the 2nd follow-up, the mean global score was 5.29 for the post-SRC group and 5.86 for the non-SRC group. Although the final results still showed poor sleep quality in both groups, there was a significant improvement from the baseline to the follow-ups by the Friedman test (post-SRC group: $X^2(2)= 8.22$, $p$= .016; non-SRC group: $X^2(2)= 7.92$, $p$= .019).

By categorizing the times of when the participants developed SRC, they were divided into three categories: "within 1 month"; "1-3 months"; and "4-6 months". Figure 1 shows the mean change in the PSQI Global Score in the three categories. It is interesting that participants

who had SRC within 1 month and in 4-6 months demonstrated a greater decrease in the PSQI Global Score than the participants who had SRC in the 1-3 months period. Further discussion on this will be provided in the following chapter.

### 4.5 Results of Flinders Fatigue Scale

The FFS is a self-reported questionnaire that measures daytime fatigue. The questionnaire contains seven items, including six items with a scoring range from 0 to 4, and one multiple choice question. The potential score of FFS is 0 to 31. Lower score indicates better daytime functioning. Participants took the questionnaire at baseline, the 1st follow-up and the 2nd follow-up.

As the results show in Table 4, the mean of the FFS total score for the post-SRC group dropped from 19.00 at baseline to 14.00 at the 1st follow-up, and 13.29 at the 2nd follow-up. The score also decreased in the non-SRC group, from 15.14 at baseline to 14 at the 1st follow-up, and 11.29 at the 2nd follow-up. Statistical analysis, using the Friedman test, showed significant improvement from baseline to the follow-ups in both groups (post-SRC group: $X^2(2)=6.46$, $p= .04$; non-SRC group: $X^2(2)=8.273$, $p= .02$).

### 4.6 Attitudes towards Holistic Complementary and Alternative Medicine Questionnaire

The 11-item HCAMQ questionnaire consists of two parts. One part is related to holistic health (HH) with a score range from 5 to 30, and the other part is in relation to the attitudes towards CAM with a potential score ranging from 6 to 36. The sum score of HH and CAM is the total score of HCAMQ. A lower score indicates a more positive attitude toward HH and CAM. Participants in both groups finished the HCAMQ questionnaire at baseline and the final follow-up.

Table 5 shows the results of HCAMQ. Both the post-SRC and non-SRC groups had positive attitudes toward HH (mean of 8.86 and 7.57, respectively) at baseline, but less positivity in CAM (22.57 and 19.43, respectively). Participants' attitudes did not deviate much from the baseline to the final follow-up. There was no significant difference in either group.

## 4.7 Results of Sleep Beliefs Scale

The participants responded to each item in the SBS with either "positive effect", "neither effect", or "negative effect" at baseline and the final follow-up. The right answers to item in the SBS are based on what were provided in the scale. Every correct answer to a question earns one point and an incorrect answer earns zero points. The total score of SBS is from 0 to 20. The results of the SBS total score show in Table 6.

As the study did not provide any information related to sleep beliefs, by using the Wilcoxon Signed Rank test, the results showed that there was no difference between the baseline SBS total score and the follow-up score.

Table 7 shows the items that more than half of the participants got the incorrect answer in either post-SRC group or non-SRC group. Items with a high incorrect rate in both groups, such as "drinking alcohol in the evening", "doing intense physical exercise before going to bed, and "recovering lost sleeping for a long time", are further discussed in the next chapter.

## 4.8 Findings from the sleep log

The sleep log used in this study detailed the time when participants went to bed and got up. It also included information such as the HSS protocol adherence, caffeine and alcohol use, and the activities that participants did one hour before bed. The following paragraphs exhibit some noticeable findings from the sleep log.

### 4.8.1 The HSS Protocol Adherence

Table 8 presents the information regarding participants' adherence to the HSS protocol. Participants recorded information on whether they applied HSS before bed, whether they had completed the whole protocol, and the reasons for incompletion, for each night of the data collection weeks.

As the table shows, the overall adherence to the HSS protocol was good for both groups. The majority of people did the HSS before they went to bed. At the 1$^{st}$ follow-up, four out of seven participants in the post-SRC group (57.1%) applied the HSS every night, while three participants did the HSS for four to six nights of one week. In the non-SRC group, three participants (42.9%) did the HSS every night and another three participants did the HSS for four to six nights of one week. Only one participant tried the protocol for less than two nights of the

week. The results improved slightly at the 2nd follow-up in the non-SRC group. Four participants (57.1%) did the HSS every night and three participants (42.9%) applied the HSS for four to six nights. However, the rate of adherence dropped down in the post-SRC group at the 2nd follow-up. One participant did the HSS every night and the other six participants did the HSS for four to six nights.

The rate of completion was not as high as the frequency that participants carried out the HSS protocol. They majority of participants could not finish the whole cycle of the protocol before they fell asleep (or felt ready to fall asleep). It is noticeable that in the post-SRC group, five participants (71.4%) at the 1st follow-up and four participants (57.1%) at the 2nd follow-up could finish the whole protocol for two to three nights of one week. While in the non-SRC group, the majority (57.1%) could only finish the whole cycle for less than two nights. The reasons for incompletion provided by participants were insufficient. However, some of the reasons given by the participants were: "fell asleep" and "too tired to finish the whole cycle".

Another question the sleep log asked was whether the participants applied HSS during awakenings in the nights. However, none of the participants reported carrying out the HSS protocol when they woke up during the night.

### 4.8.2 One Hour before Bed Activities

As participants were in the same age group and were university/college students, their activities before bed were similar. Thus, we combined the two groups when examining the activities.

Table 9 lists the activities that participants engaged in one hour before bed. The numbers in the table indicate how many participants carried out each activity with the frequency of "always (more than 15 nights of three weeks data collection nights)", "often (8 to15 nights)", "sometimes (3-7 nights)", and "occasionally (less than 3 nights)". For example, four participants were doing academic work/ reading/ writing one hour before bed for more than 15 nights during the data collection weeks (total 21 nights). The popular activities, which more than half of the participants engaged in, include "academic work/ reading/ writing", "using electronic devices", and "watching TV/ videos/ movies". These may be uncontrolled confounding factors that negatively affect individuals' sleep in this study.

4.8.3 Irregular sleep schedule

The sleep log indicated an irregular and late sleep schedule for the participants. Figure 2 and Figure 3 show the earliest and latest bedtime for the participants in each data collection week, the average bedtime, and the self-reported "usual bedtime" from the PSQI in post-SRC group and non-SRC group, respectively. The earliest and latest bedtime was retrieved from the sleep log and reflected the actual time that participants went to bed and attempted to sleep. The average bedtime calculation was based on the seven nights of every data collection week.

In both groups the difference between the earliest and the latest bedtime of every participant was more than 1.5 hours. All of the participants in the post-SRC group had a bedtime variation which was greater than three hours at least once across the three data collection weeks. Furthermore, two of the participants' latest bedtime differed by more than 5 hours from their earliest bedtime (see participant No.5 and No.6 in Figure 2). In the non-SRC group, only five participants' bedtime variations were ever greater than three hours in the three data collection weeks (see participant No.2, No.3, No.4, No.5, and No.6 in Figure 3). Among these five participants, one participant's bedtime variation was greater than five hours (No.2 in Figure 3). However, one participant's bedtime variation was more than eight hours at both the 1st and 2nd follow-up (No.4 in Figure 3).

The average bedtime for most participants was found to be later than their self-reported "usual bedtime", which may have led to inaccuracies in the self-reported sleep quality. There was no obvious trend of improvement in either the average bedtime or the regularity of bedtime from the baseline to the follow-ups.

4.9 Results of Visual Analogue Scale

This study used the VAS to gather the participants' overall attitudes and satisfaction levels with the HSS protocol. Three questions with 0-10 scale and one "yes/ no" question were designed and responded to by participants at the end of the study. Five participants in each group sent back this VAS at the end of the study. The results are presented in Table 10.

The results indicated that the participants in the post-SRC group were more satisfied with the HSS protocol. They considered that the effectiveness of the HSS had met their expectations prior to the study. However, participants in the non-SRC group did not think that the HSS improved their sleep to the extent that they expected. The Mann-Whitney U test showed that the

non-SRC participants' score on the second question was significantly lower than the score of the post-SRC group ($U$=3.00, $p$= .04).

## 4.10 Summary of Results

Seven people in each of the post-SRC group and the non-SRC group participated in the study. The mean age was 21.43 and 22.57, respectively. There was no significant difference in the results of actigraphy sleep monitors from the baseline to the 2nd follow-up in the post-SRC group. However, the TIB and TST significantly increased at the 2nd follow-up in the non-SRC group. Both groups had significant improvements in the PSQI and the FFS from the baseline to the 2nd follow-up. Participants' responses to the HCAMQ and SBS did not change before and after the study. The overall adherence to the HSS protocol was good among groups. But few participants could complete the whole HSS cycle before they fell asleep. From the sleep logs recorded by participants, we found the most frequently activities that participants did before bed was related to electronic devices, which may increase the exposure to blue light. Moreover, participants did not have regularity in their sleep schedules. All the findings are presented in Appendix L in tables and figures. Further discussion will be provided in the following chapter.

# CHAPTER 5 DISCUSSION

The following chapter discusses the key findings generated from the results of the study, including implications of the objective sleep measurements, the self-reported information, and potential biases of this study. As a pilot HSS study on post-SRC and non-SRC young persons, this chapter also addresses the limitations of the study and makes recommendations for further research.

## 5.1 Challenges of Recruitment

Base on the original plan, the study required 21 post-SRC participants to achieve power (See Section 3.2). However, we were not able to recruit enough participants by the end of the study because of time limitations. Two key reasons were concluded in this regard. Firstly, the electronic posters, emails, and posters on the notice boards around the campus may not have been sufficiently attractive for young adults, thus causing them to neglect such information. Moreover, although these posters and emails were send out to large population, many of the students who responded were not eligible for the post-SRC group in this study. Thus, the study added the second arm, which was the non-SRC group. A second email about the recruitment of non-SRC group was send to those participants who gave response at the first recruitment process but did not have SRC history. However, few of them took the chance to participated in the study. Secondly, the contact with local sports organizations was not as efficient as what we had intended. For example, few organizations responded to the emails we sent requesting cooperation.

Although the sample size of this study was insufficient to draw strong conclusions, the findings are promising. The challenges during the study process also provided useful information and recommendations for future studies.

## 5.2 Interpretation of the Objective and the Self-Reported Sleep Quality

The results from the Actigraph wGT3X-BT sleep monitor did not reveal apparent changes in sleep variables, except the TIB and TST in the non-SRC group. The increases of TIB and TST in the non-SRC group at the 2$^{nd}$ follow-up may relate to the time of year when classes are over and participants may have more time to sleep during holidays. However, the increase of TIB and TST in the non-SRC group did not have an impact on the results of other sleep characteristics

such as SOL, SE%, and WASO. The lack of statistically significant results from the objective measurements aligned with a previous HSS study on individuals with chronic pain (Brown et al., 2014).

Sleep quality is "a complex phenomenon that is difficult to define and measure objectively" (Buysse et al., 1989). Research has shown weak correlations between self-reported sleep quality and the PSG results (Harvey et al., 2008). As previously mentioned, studies using objective sleep measurements on the SRC or mTBI population also failed to find significant abnormal sleep traits (Gosselin et al., 2009; Arbour et al., 2015; Chung et al., 2004; Ouellet & Morin, 2006). Although the actigraph sleep monitor is considered as a useful tool to assess people's sleep patterns, there are some limitations that may diminish its usefulness in evaluating sleep quality. For example, actigraphy has not been validated for measuring sleep stages (Martin & Hakim, 2011). It can be challenging to measure poor sleep in people who have self-reported sleep disturbance. Perception of changes in sleep may have been strong although there were no changes in the actigraphy results between baseline and follow-up periods. It should also be noted that the study was not powered enough to detect a statistical significance due to the small sample size. However, what is clinically significant is not identical to statistically significant and the importance of the self-reported changes should not be minimized.

The biopsychosocial model, originally proposed by Engel (1977), may better illustrate the interactive factors of sleep. The model highlights that biological, emotional, and environmental factors may influence the health-related symptoms simultaneously and bidirectionally. In the domain of sleep, family, peers, academic demand, mental health, electronic media use, extracurricular activities, and culture have been considered as the psychosocial factors that may affect sleep among adolescence (Becker, Langberg, & Byars, 2015). Furthermore, the biopsychosocial model indicates individuals' perception of symptoms and experience are also important in understanding a problem (Higgins, Scioli-Salter, Martin, & Kerns, 2015). Accordingly, it is notable that there were improvements with both statistical and clinical significance in the self-reported sleep quality (PSQI) and the level of daytime fatigue (FFS) in both groups. These improvements may be possibly attributed to the following factors.

Firstly, for the participants in the non-SRC group, the improvements may have arisen from the longer sleep duration, which happened at the 2$^{nd}$ follow-up. With the increasing TST in the non-SRC group, the mean PSQI score dropped, together with the FFS score. The decrease in

daytime fatigue was important because tiredness throughout the day is considered as a critical self-reported part to define sleep quality subjectively by both those who report insomnia and normal sleepers (Harvey et al., 2008). In other words, improving daytime functioning was interpreted by participants as a sign that they achieved better sleep than before. However, we cannot determine whether the improvements were causally related to the HSS.

Secondly, the significant improvements in PSQI may have been caused by participants' reporting bias on components of sleep onset latency, duration, efficiency, and sleep disturbances. However, as mentioned above, perceived sleep quality is often psychological in nature rather than a construct that can be measured objectively. According to the biopsychosocial theory, participants' optimistic anticipation of sleep may support the positive effects of HSS as a self-management CAM method on sleep disturbance. It is noteworthy that participants in the post-SRC group gave higher scores in the VAS than the non-SRC group. The differences between the two groups on "how much do you think the HSS improve your sleep after participating" illustrated that the post-SRC group may be more satisfied with the effectiveness of the HSS protocol on their sleep. This also explains the results which indicated that there were larger improvements on the global PSQI score in the post-SRC group than the non-SRC group. Further discussion on the possible mechanisms of HSS will be provided in the following paragraphs. Another factor that may contribute to the results is the obsequiousness bias, which is defined as "subjects may alter their response towards the direction they perceive desired by investigator" (Hartman, Forsen, Wallace, & Neely, 2002). However, several control techniques, such as blinding the participants to the hypothesis and the scoring system, and using neutral language when meeting, were made to reduce obsequiousness bias.

Thirdly, as can be seen in Figure 1, participants in the post-SRC group who developed the SRC within one month had the biggest reduction in the PSQI global score, which fell from a mean score of 13 at baseline to 5 at the 2$^{nd}$ follow-up. This improvement may come from natural recovery of post-concussion syndrome. The literature showed that most concussion or mTBI patients experienced recovery of acute symptoms within one to three months, while some milder symptoms can last for more than one year (McAllister & Arciniegas, 2002). Although the small sample size in our study did not allow us to conclude the exact reasons behind the changes of PSQI score in the participants with the SRC history of one to three months, we speculated that

both the nature of overall recovery and the effectiveness of the HSS may contribute to the results.

## 5.3 Interpretation of the Holistic Complementary and Alternative Medicine Questionnaire Results

The results of the HCAMQ indicated participants' positive attitudes toward the HH and neutral attitudes toward the CAM. The background literature failed to provide sufficient data to compare participants' HCAMQ results with the overall young population in North America. However, as mentioned in the preceding section (see Section 2.3.2), post-secondary population, particularly the college athletes, may be more willing to use CAM methods. This could explain the non-negative results of the HCAMQ and indicated that CAM approaches would be acceptable to the young population.

The score of the HCAMQ did not change significantly before and after the intervention in both groups. This reduced the bias of attitudes change, which may alter participants' responses to other questionnaires in the study. Furthermore, there was no obvious correlation between the attitudes toward HCAMQ and the adherence to the HSS protocol. In other words, an individual's more positive attitude did not forecast a higher rate of HSS completion.

## 5.4 Interpretation of the Sleep Beliefs Scale Results

The purpose of using the SBS was to control for bias of sleep beliefs change. A significant change in SBS may indicate that there were confounding factors related to participants' sleep habits. Because the process did not include any information related to sleep beliefs, no significant difference of the SBS score was found in either group. This result showed that the study did not change participants' knowledge and understanding of sleep. However, the results of the SBS showed participants' high rate of incorrect beliefs about sleep, which was a worrying situation among the young population, especially those who experienced sleep disturbance. Four SBS items with high incorrect rate (>50% in both groups) will be discussed in the following paragraphs. These items are "drinking alcohol in the evening", "doing intense physical exercise before going to bed", "getting up when it is difficult to fall asleep", and "recovering lost sleep by sleeping for a long time".

There is extensive evidence shows the impact of alcohol using on sleep quantity and quality. While a few studies found that alcohol consumption before bedtime reduces sleep onset latency, the advantageous effects are short-term and individuals quickly develop tolerance. Studies suggested that alcohol can increase the number of awakenings during the night, reduce the length of deep sleep, interrupt the hormone secretions, and aggravate daytime sleepiness (Roehrs & Roth, 2001).

The belief that it is possible to recover sleep by sleeping more during weekends or holidays seems prevalent among post-secondary students (Digdon, 2010). However, there is clear evidence demonstrating the association between irregular sleep schedules and sleep problems (Irish, Kline, Gunn, Buysse, & Hall, 2015). While common sleep hygiene supports consistent bed- and wake-time, current clinical sleep therapies more strongly stress regular wake-time than the bedtime (Morin, 2011). Therefore, making up the lost sleep by sleeping for a longer time may not be of benefit to sleep episodes in the following days.

While the effects of alcohol use and irregular sleep schedules were clear, there was insufficient evidence to support the claim that exercising at late night would disrupt sleep (Irish et al., 2015). Another item that researchers have shifted mind on is "getting up when it is difficult to fall asleep" (Brown et al., 2014). However, there is not enough evidence to support the usefulness of this traditional sleep hygiene strategy.

Scrutinizing the records on sleep logs of this study revealed that none of the participants regularly used alcohol to facilitate sleep. Few participants did intense exercise before bedtime. However, irregular sleep schedules were common in both groups. The irregularity of sleep may weaken the effects of the HSS on sleep.

### 5.5 Interpretation of the Records from the Sleep Log

The key results derived from the sleep log included participants' adherence to the HSS protocol, activities that participants did one hour before going to bed, and sleep schedule. The following paragraphs discuss the implication of these findings.

One of the aims of this study was to identify young persons' adherence to the HSS protocol. The results indicated that the HSS protocol was feasible and acceptable to young people with self-reported sleep problems, either athletes or the general population. However, the high protocol adherence during the data collection weeks may be related to the text reminders

sent during the weeks and participants' interest in the study. One problem that emerged from the results of protocol adherence was that, although participants did HSS before bed, most of them were not able to complete the entire cycle. The standard time of finishing the current protocol is 12 to 15 minutes. According to the results from the actigraphy sleep monitor, the average SOL was less than 9 minutes in the post-SRC group and 6 minutes in the non-SRC group. Therefore, one possible reason for the incompletion was that the participants fell asleep and the information on the sleep log supported this conjecture. Although the reasons offered by participants were not sufficient, a few people mentioned that falling asleep was the reason that they did not complete the whole cycle. Despite the fact that participants had many times of awakenings during the night, none of the participants reported applying HSS when they woke up in the night. This was possibly because the length of awakenings was short, which supported by the results from actigraphy. Thus, participants were not conscientious in applying HHS. This finding suggests that the HSS protocol may not be useful to maintain sleep if the person does not report significant difficulty with falling sleep again after awakenings.

The results of the activities that participants did one hour before bed suggested that there was a high rate of electronic devices using. Laptops, smartphones, and televisions increase exposure to blue spectrum light, which is a shortwave light delivered by the screens. Evidence has been established that blue light suppresses melatonin production, delayed the decline of core body temperature, and thus, altered circadian rhythm (Chellappa et al. 2013; Kubota et al., 2002). In our study, the use of electronic devices may reduce the effects of HSS. It may also be a confounding factor as the study did not control the time of electronic device use and the degree of the blue light exposure to individuals. However, the academic and social demands of the young population made it challenging to forbid electronic devices before bed. Therefore, future studies should take the blue light factor into consideration and control for it.

The long spread between end points in Figure 2 and Figure 3 indicated that participants in both the post-SRC and the non-SRC group lacked consistency in sleep schedule. Moreover, it appeared that the participants estimated their bedtime optimistically as the average bedtime calculated from the sleep log were later than individual's records on the PSQI questionnaire, which may be a recall bias. One possible reason for the differences between the PSQI recorded bedtime and the actual average bedtime was that the one-week data collection period did not reflect sleep time over the past month. The PSQI asks participants to respond on the basis of the

previous month, while the sleep log collected data for only one week. Especially for those participants who do not have the regular bedtime, a single time measure on the PSQI may not reveal the whole situation. In addition, research shows that the correlation between the PSQI and sleep diary in younger adults was not as strong as the older adults (Grandner, Kripke, Yoon, & Youngstedt, 2012). With the exception of two participants in the non-SRC group who had extreme variations in bedtime, it appeared that the non-SRC group was more consistent in sleep schedule than the post-SRC group. Studies have indicated that irregular sleep schedules were associated with increased daytime sleepiness and worse self-reported sleep quality (Irish et al., 2015). This can be one of the contributors that participants in the post-SRC reported worse results in the PSQI and the FFS at baseline. Another reason may be the nature of SRC. However, the post-SRC group improved more in results of the PSQI and the FFS than the non-SRC group. The various magnitudes of improvements may come from the different mechanisms of sleep disturbance in the two groups. This will be discussed in the following section.

### 5.6 The mechanisms of HSS

As explained in the preceding sections, this study contained two groups- the post-SRC group and the non-SRC group. These two groups were not used as a control trial. However, they may help us see some differences between the population and better illustrate the mechanism of the HSS.

The review of literature suggested three major reasons for post-SRC sleep disturbance. Firstly, dysfunction of the brain may cause neurophysiologic changes, for example, the secretion of GABA (Hofman & Talamini, 2014). Secondly, the sleep disturbance may be an offshoot of other post-SRC symptoms such as headache, light and sound sensitivity. Thirdly, the sleep disturbance may arise due to the mental issues, including anxiety, depression, and rumination before bedtime (Towns, Silva, & Belanger, 2015). However, the participants in the non-SRC included people who had self-reported sleep disturbance and excluded individuals with any lesion that can cause the sleep problems. Therefore, participants in the two groups may share some common reasons for the sleep disturbance such as anxiety and ruminative thoughts. Furthermore, incorrect sleep habits and irregular sleep schedule may be another common reason for sleep disturbance among groups.

From the descriptive data of our study, it appeared that participants in the post-SRC group improved more than the non-SRC group. Evidence supports the treatment effects of

acupressure or shiatsu on varieties of conditions, including pain, nausea, vomiting, insomnia, and stress (Robinson, Lorenc, & Liao, 2011; Song et al., 2015). According to the meridian theory, acupressure helps balance energy, or Ki (Qi) in the body. In the view of western medicine, the relief effects may be due to the release of endorphins and other hormones through neural reflex, the increase of blood circulation, and inflammatory substance metabolism (Jiang, Robidoux, & Yang, 2008). In addition, gentle and slow massage can also diminish the excitability of the sympathetic nervous system and inhibit the cerebral cortex activities, which has sedative impacts on individuals. The extra improvement in the post-SRC group may support the existence of biological effects resulting from HSS in participants with brain dysfunctions.

Another mechanism behind HSS may relate to the improvement of self-efficacy and sense of control over the symptoms. As a CAM intervention and a self-management approach, HSS has advantages such as safe, cost-free, and easy to perform. The practice of the HSS may also bring participants increased hope, relaxation, positive moods, body awareness and feelings of well-being, which are considered as the unanticipated benefits of CAM (Hsu, Bluespruce, Sherman, & Cherkin, 2010). This is significant because, as explained in the previous section, self-reported sleep disturbance is a biopsychosocial problem and is likely more than what can be objectively measured. The subjective variables that distinguish between self-reported normal sleepers and worse sleepers may include depressed mood, anxiety, and dysfunctional beliefs regarding sleep (Harvey et al., 2008). Therefore, the changes of subjective attitudes may be another factor affecting the effectiveness of HSS, particularly in participants with less self-efficacy. This does not suggest that a single mechanism is dominant to a specific population. We speculated that several mechanisms work together in participants. However, it may be worthwhile to evaluate participants' self-efficacy using standardized questionnaires pre- and post- intervention in future studies to better illustrate the contribution of these "unanticipated benefits".

Lastly, according to the theory of combined task and divided attention (Style, 2006), the high cognitive demands of performing HSS, which requires memory and focus, may compete with the capacity for ruminative thoughts before bed. The HSS may serve as a transition activity that blocks ruminations and anxiety in order to assist sleep onset (Brown et al., 2014). However, the efficiency of this rumination-blocking mechanism after a long-term practicing remains unknown. With the expertise in the protocol, the cognitive demands of performing the HSS may

decrease. One relaxation technique, which shares similarities with the HSS in the mechanism of attention control, is mindfulness meditation (Sedlmeier et al., 2012). Sedlmeier et al.'s meta-analysis shows that the initial improvement of meditation happens in one month and longer training does not lead to more improvement. Furthermore, they found that the effects of meditation are smaller on people with longer meditation experience. These results indicate that there may be timeliness of applying HHS. However, further studies need to be carried out to help build evidence.

### 5.7 Limitations and Suggestions for Future Studies

This study faced several limitations. Firstly, the sample size of this study was small, which decreased the statistical power of the study. Therefore, this pilot study was not sufficient to draw generalizable conclusions and the results should be interpreted with caution. However, the study shows statistically and clinically significant differences in self-reported measures of sleep quality. These results indicated the potential application of the HSS in young people and large studies need to be carried out.

A second limitation is that the study did not have a blank control group, which is a group of matched participants without any intervention. While a placebo control group may not be suitable in relation to the study design and the ethics consideration, a blank control group with matched participants may be helpful to appraise the effect of the nature recovering process of the SRC. However, because of the limited time, we were unable to recruit enough post-SRC young athletes and match them according to age, gender and SRC history.

Thirdly, there were some uncontrolled confounding factors that may have affected the results positively or negatively, such as caffeine taking, blue light exposure before bed, irregular sleep schedule, school term, and holidays. Although we gathered the information on caffeine intake in the sleep log, the information was too general to analyse the amount and the effect on sleep. As mentioned in the previous section, blue light exposure may also impact on sleep onset latency and quality. However, we had no control over blue light exposure. These confounding factors may decrease the effects of the HSS protocol, and thus, may negatively impact the results. The mid-term and final exam time of a semester also affected the participants' sleep schedule, especially for the non-SRC group. For example, individuals participated in the 1$^{st}$ follow-up data collection around their final exam time and the 2$^{nd}$ follow-up data collection at

the first week of the new semester. The decrease of academic pressure during the 2nd follow-up may exaggerate the effects from the HSS itself.

Additionally, participants answered the VAS at the end of the study. However, the question "How much did you expect that HSS could improve your sleep before participating?" was supposed to be answered by the participants prior to the study in order to avoid the reporting bias and obsequiousness bias. The reason that participants answered the whole VAS questions after the study was that we added the VAS in the middle of the study at which time some participants have had finished the study protocol. However, the VAS was anonymous and the researcher was blind to the answering process to reduce bias.

Future studies of the post-SRC population should attempt to recruit from more targeted organizations such as sports clinics and sports teams to achieve a larger sample size. In-person meetings and more contact with these organizations should be carried out. Using the participants on the waiting-list as a blank control group may be an option if a placebo intervention is not appropriate. However, researchers should carefully match participants with their age, gender and the SRC history.

The researchers will revise the sleep log for future work to gather more accurate information related to caffeine and alcohol taking. Both the amount and the time need to be recorded to determine the effects on sleep. Multiple choice questions on the sleep log may also be more efficient for participants to finish and for researchers to interpret the findings. Moreover, to control the confounding factor of blue light exposure, researchers can provide participants with pairs of blue light blocking glasses and instruct participants on the proper way to use the glasses. We will also try to reduce the time demand of completing the HSS protocol from its current 12-15 minutes to 7-10 minutes as the results indicated most participants could not complete the whole protocol before falling asleep.

Sleep disturbance is a complex problem with biopsychosocial factors. Although this study included both objective and self-reported sleep measurements, they yielded quantitative data. As the biopsychosocial model points out, individuals' experience of illness is also an important component in understanding the problem. To help build more evidence for the shiatsu practitioners and other health providers, future research may add qualitative methodology to evaluate participants' experience of their sleep disturbance and the experience of applying the HSS. Studies using EEG to test the changes of electrical activities of the brain when applying

HHS and bio-markers such as melatonin can also be carried out to better elucidate the mechanism of HHS.

# CHAPTER 6 CONCLUSION

The main purpose of this study was to test HSS as a self-management and CAM approach to promoting sleep in young post-SRC athletes and non-SRC individuals with self-reported sleep problems. The results indicated that the technique potentially improved both post-SRC and non-SRC participants' self-reported sleep quality and daytime fatigue. However, there was no apparent change in sleep onset and maintenance when measured by actigraphy monitors. Research suggested that self-reported sleep disturbance was complex and difficult to measured objectively. Thus, the significant improvements in subjective questionnaires were notable as well.

The study also evaluated young peoples' attitudes towards CAM and their adherence to the HSS protocol. The results showed that these young athletes and post-secondary students held neutral attitudes toward the CAM and positive attitudes toward the holistic health. The non-negative attitudes and the good adherence to the HSS protocol indicated that the HSS technique can be an acceptable non-pharmacological approach to improve sleep. However, the low completion rate before bed suggested that we may need to shorten the time requirement of the current HSS protocol. Furthermore, we found that young people appeared to not have regular sleep schedules and to have much blue light exposure before bedtime. Both of the two sleep habits may weaken the effectiveness of the HSS, as well as other sleep interventions. The irregularity may also bring problems to the accuracy of the self-reported sleep questionnaires.

Although the small sample-size pilot study did not allow us to determine the mechanism of the HSS. The possible reasons may relate to bio-physiological effects, increasing self-efficacy, and/or have a psychological basis in the reduction of negative rumination triggering a stress response before sleep. To help build stronger evidence for the HSS, future studies need to achieve larger sample-size with control groups. Standardized psychological, cognitive questionnaires, and qualitative interviews may also helpful to better illustrate the mechanism of the HSS.

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# Appendixes

Appendix A Recruitment Poster

FACULTY OF REHABILITATION MEDICINE
UNIVERSITY OF ALBERTA

Pursuing **your best**

# VOLUNTEERS NEEDED FOR SLEEP RESEARCH STUDY

**If you are 18-25 years' old**
**If you are concerning about your sleep because…**
**You had sport-related concussion in the last 6 months**
**OR**
**Stress from daily life**

If so, we invite you to take part in a study to determine if hand self-Shiatsu can help improve your sleep.

**What would you have to do?**

- massage your hands for about 7-10 minutes once you are in bed
- wear a sleep monitor (looks like a wrist watch) for 1 week at the start, then at week 4 and week 8.
- keep a sleep log.
- complete sleep questionnaires at the start of the study and then again at 4 and 8 weeks.

**You will-**

- Receive free training in hand self-Shiatsu.
- Receive a copy of your sleep monitor results.

**We would like to give you more information-**

Please email Pei Qin (pqin1@ualberta.ca), MSc Student, Faculty of Rehabilitation Medicine or click the QR code.


Pei Qin Pqin1@ualberta.ca


Pei Qin Pqin1@ualberta.ca
Pei Qin Pqin1@ualberta.ca
Pei Qin Pqin1@ualberta.ca
Pei Qin Pqin1@ualberta.ca
Pei Qin Pqin1@ualberta.ca
Pei Qin Pqin1@ualberta.ca
Pei Qin Pqin1@ualberta.ca

Appendix B Fluidsurveys for Contact Information- Website Overview

# Hand self-Shiatsu Study- Faculty of Rehabilitation Medicine, U of Alberta

Thank you for your interest in this hand self-Shiatsu study. This is a contact information collection. We will keep the information confidential and only use for contacting you. Please fill form below and we will send you the study information to your e-mail account. --Pei Qin

Name

Type here

Gender

- Male
- Female

E-mail address

Type here

Submit

Appendix C Information Letter and Consent Form

FACULTY OF REHABILITATION MEDICINE
UNIVERSITY OF ALBERTA

Pursuing your best

**Effectiveness of Hand Self-Shiatsu for Post Sport-related Concussion Sleep Disturbance in Young Athletes**

March- December 2016

**Why are we studying self-applied hand Shiatsu?**
There is some evidence that hand self-Shiatsu is an effective sleep intervention. However, the technique of hand self-Shiatsu for people who have sport-related concussion and sleep problems has not yet been well studied.

We specifically selected hand self-Shiatsu (HSS) because, with a short training of about 20-30 minutes, people can do HSS for themselves. Also, HSS, unlike many other forms of body massage, is accessible, practical and low-cost. It can be done by someone with sleep problems with little notice by those around them.

**What is hand self-Shiatsu?** Shiatsu is based on the principles of Traditional Chinese Medicine related to pressure points and has similarities to acupressure. It involves applying firm, but not painful, thumb and finger pressure to specific points on each hand for a set number of repetitions.

**What would you have to do?**

- We would first gather a baseline about your sleep. This will involve about 20 minutes to complete several forms and questionnaires.
- Next we will give you a wristwatch sized sleep monitor to wear while you are in bed for the next 7 nights. At the same time, filling in a short sleep log every morning. It will take you about 5 minutes.
- After 7 days you give the monitor back and we will teach you to do hand self-Shiatsu. This will take about 20-30 minutes.
- For three weeks we ask that you do hand self-Shiatsu before bed.
- After three weeks, we will arrange with you to wear the wristwatch sleep monitor again for 7 nights and to keep the sleep log. You will also complete some questionnaires.
- After another three weeks, we will contact you for the last time to again wear the sleep monitor for 7 nights, keep a sleep log and complete the questionnaires. At the end of the study you will receive a copy of your sleep report for all three periods.

**What will be the benefit of participating in the study?**
You will receive free training in hand self-Shiatsu and a copy of your sleep monitor results. You will also receive a copy of the final report about the study.

**Are there any risks to participation?** There is no foreseen risk to your participation and since you control the HSS process, you can monitor for discomfort and stop at any time. You can also withdraw from the study by notifying the researcher at anytime until seven days after the end of your last follow-up is finished.

**To become involved in the study and/or find out more:** E-mail Pei Qin at pqin1@ualberta.ca. We can arrange an in-person meeting to give you more information, sign the consent form and start the study.

**Confidentiality:** Participation in the study will only be known to you and the researchers. If you are receiving rehabilitation or medical treatment you are free to mention the study to your care provider and you should not alter any treatment you are currently receiving. Any information collected will be reported in a way that does not identify you personally. All data collected will be stored a minimum of five years in a locked filing cabinet in the offices of Dr. Cary Brown, Faculty of Rehabilitation Medicine, University of Alberta, and then destroyed.

**Can you quit?** You don't have to take part in the study at all and you can let us know you wish to drop-out at any point up to seven days after your last follow-up data collection.

**Would you like more information?**
Please call Pei Qin (780-492-9545) or email (pqin1@ualberta.ca) if you have any questions or would like more information.

The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

Pei Qin, MSc student
Faculty of Rehabilitation Medicine
University of Alberta
2-64 Corbett Hall
Edmonton, Alberta
Canada T6G 2G4

**Thank you for your time and interest**

**Study Consent Form**

**Hand self-shiatsu as an Intervention to Promote Sleep Efficiency**

Principal Investigator: Pei Qin MSc student Faculty of Rehabilitation Medicine University of Alberta

Phone Number(s): (780) 492-5945 E-mail: pqin1@ualebrta.ca

**Please tick each box to indicate you understand about the study and agree to participate.**

| | Yes | No |
|---|---|---|
| Do you understand that you have been asked to be in a research study? | ☐ | ☐ |
| Have you read and received a copy of the attached Information Sheet? | ☐ | ☐ |
| Do you understand the benefits and risks involved in taking part in this research study? | ☐ | ☐ |
| Do you know who to contact to ask questions and discuss this study? | ☐ | ☐ |
| Do you understand that you are free to withdraw from the study at any time up to seven days after your last follow-up data collection, without having to give a reason? | ☐ | ☐ |
| Do you understand how your information will be kept confidential as explained in the information letter? | ☐ | ☐ |
| Do you understand that only the researchers will have access to the information collected for the study? | ☐ | ☐ |

"My signature indicates I agree to take part in this study"

Your signature: _____

Printed Name: _____

Date: _____

Phone number we should use to contact you: _____

E-mail we should use to contact you: _____

Address we should use to mail items to you: _____

Appendix D Sleep Log (Baseline & Follow-up)

Baseline Sleep Log-


**Hand Self-Shiatsu Study – Baseline Sleep log (participant # ____)**

Please complete the sleep log for everyday that you are wearing the actigraph. This information is important to help us determine the effectiveness of the hand self-Shiatsu, so please fill out the log as accurately as possible.

Background information: Please describe where you usually sleep: _____

| Day 1 Date: | | | | | Day 2 Date: | | | |
|---|---|---|---|---|---|---|---|---|
| Last night I went to bed at | This morning I got up at | | I woke up # of times during the night | | Last night I went to bed at | This morning I got up at | | I woke up # of times during the night |
| AM PM | AM PM | | | | AM PM | AM PM | | |
| List amount of: Caffeine | | | | | List amount of: Caffeine | | | |
| Alcohol | | | | | Alcohol | | | |
| Nicotine | | | | | Nicotine | | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | | One hour before going to bed I was ….(what activity were you doing?) | | | |
| I slept .... (at home, hotel, dormitory, friend's home) | | | | | I slept .... (at home, hotel, dormitory, friend's home) | | | |
| My sleep last night was disturbed by… | | | | | My sleep last night was disturbed by… | | | |
| This morning I woke up feeling … | | | | | This morning I woke up feeling … | | | |

| Day 3 Date: | | | | | Day 4 Date: | | | |
|---|---|---|---|---|---|---|---|---|
| Last night I went to bed at | This morning I got up at | | I woke up # of times during the night | | Last night I went to bed at | This morning I got up at | | I woke up # of times during the night |
| AM PM | AM PM | | | | AM PM | AM PM | | |
| List amount of: Caffeine | | | | | List amount of: Caffeine | | | |
| Alcohol | | | | | Alcohol | | | |
| Nicotine | | | | | Nicotine | | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | | One hour before going to bed I was ….(what activity were you doing?) | | | |
| I slept .... (at home, hotel, dormitory, friend's home) | | | | | I slept .... (at home, hotel, dormitory, friend's home) | | | |
| My sleep last night was disturbed by… | | | | | My sleep last night was disturbed by… | | | |
| This morning I woke up feeling … | | | | | This morning I woke up feeling … | | | |

| Day 5 Date: | | | | | Day 6 Date: | | | |
|---|---|---|---|---|---|---|---|---|
| Last night I went to bed at | This morning I got up at | | I woke up # of times during the night | | Last night I went to bed at | This morning I got up at | | I woke up # of times during the night |
| AM PM | AM PM | | | | AM PM | AM PM | | |
| List amount of: Caffeine | | | | | List amount of: Caffeine | | | |
| Alcohol | | | | | Alcohol | | | |
| Nicotine | | | | | Nicotine | | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | | One hour before going to bed I was ….(what activity were you doing?) | | | |
| I slept .... (at home, hotel, dormitory, friend's home) | | | | | I slept .... (at home, hotel, dormitory, friend's home) | | | |
| My sleep last night was disturbed by… | | | | | My sleep last night was disturbed by… | | | |
| This morning I woke up feeling … | | | | | This morning I woke up feeling … | | | |

| Day 7 Date: | | | | | Day 8 Date: | | | |
|---|---|---|---|---|---|---|---|---|
| Last night I went to bed at | This morning I got up at | | I woke up # of times during the night | | Last night I went to bed at | This morning I got up at | | I woke up # of times during the night |
| AM PM | AM PM | | | | AM PM | AM PM | | |
| List amount of: caffeine | | | | | List amount of: Caffeine | | | |
| Alcohol | | | | | Alcohol | | | |
| Nicotine | | | | | Nicotine | | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | | One hour before going to bed I was ….(what activity were you doing?) | | | |
| I slept .... (at home, hotel, dormitory, friend's home) | | | | | I slept .... (at home, hotel, dormitory, friend's home) | | | |
| My sleep last night was disturbed by… | | | | | My sleep last night was disturbed by… | | | |
| This morning I woke up feeling … | | | | | This morning I woke up feeling … | | | |

Follow-up Sleep Log-


**Hand Self-Shiatsu Study – Follow-up Sleep log (participant # ____)**

Please complete the sleep log for everyday that you are wearing the actigraph. This information is important to help us determine the effectiveness of the hand self-Shiatsu, so please fill out the log as accurately as possible.

Background information: Please describe where you usually sleep: _____

| Day 1 | | | | Day 2 | | |
|---|---|---|---|---|---|---|
| Last night I went to bed at… Date: | This morning I got up at… Date: | I woke up # of times during the night | | Last night I went to bed at Date: | This morning I got up at Date: | I woke up # of times during the night |
| AM PM | AM PM | | | AM PM | AM PM | |
| List amount of: | | | | List amount of: | | |
| Caffeine | | | | caffeine | | |
| Alcohol | | | | Alcohol | | |
| Nicotine | | | | Nicotine | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | One hour before going to bed I was ….(what activity were you doing?) | | |
| I slept in .... (at home, hotel, dormitory, friend's home) | | | | I slept in .... (at home, hotel, dormitory, friend's home) | | |
| This morning I woke up feeling …<br>a. Not refreshed<br>b. Somewhat refreshed<br>c. Rested and refreshed | | | | This morning I woke up feeling …<br>a. Not refreshed<br>b. Somewhat refreshed<br>c. Rested and refreshed | | |
| Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | | | Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | |

| Day 3 | | | | Day 4 | | |
|---|---|---|---|---|---|---|
| Last night I went to bed at… | This morning I got up at… | I woke up # of times during the night | | Last night I went to bed at | This morning I got up at | I woke up # of times during the night |
| Date: | Date: | | | Date: | Date: | |
| AM<br>PM | AM<br>PM | | | AM<br>PM | AM<br>PM | |
| List amount of: | | | | List amount of: | | |
| Caffeine | | | | caffeine | | |
| Alcohol | | | | Alcohol | | |
| Nicotine | | | | Nicotine | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | One hour before going to bed I was ….(what activity were you doing?) | | |
| I slept in .... (at home, hotel, dormitory, friend's home) | | | | I slept in .... (at home, hotel, dormitory, friend's home) | | |
| This morning I woke up feeling …<br>a. Not refreshed<br><br>b. Somewhat refreshed<br><br>c. Rested and refreshed | | | | This morning I woke up feeling …<br>a. Not refreshed<br><br>b. Somewhat refreshed<br><br>c. Rested and refreshed | | |
| Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | | | Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | |

| Day 5 | | | | Day 6 | | |
|---|---|---|---|---|---|---|
| Last night I went to bed at… | This morning I got up at… | I woke up # of times during the night | | Last night I went to bed at | This morning I got up at | I woke up # of times during the night |
| Date: | Date: | | | Date: | Date: | |
| AM<br>PM | AM<br>PM | | | AM<br>PM | AM<br>PM | |
| List amount of: | | | | List amount of: | | |
| Caffeine | | | | caffeine | | |
| Alcohol | | | | Alcohol | | |
| Nicotine | | | | Nicotine | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | One hour before going to bed I was ….(what activity were you doing?) | | |
| I slept in .... (at home, hotel, dormitory, friend's home) | | | | I slept in .... (at home, hotel, dormitory, friend's home) | | |
| This morning I woke up feeling …<br>a. Not refreshed<br><br>b. Somewhat refreshed<br><br>c. Rested and refreshed | | | | This morning I woke up feeling …<br>a. Not refreshed<br><br>b. Somewhat refreshed<br><br>c. Rested and refreshed | | |
| Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | | | Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | |

| Day 7 | | | | Day 8 | | |
|---|---|---|---|---|---|---|
| Last night I went to bed at… | This morning I got up at… | I woke up # of times during the night | | Last night I went to bed at | This morning I got up at | I woke up # of times during the night |
| Date: | Date: | | | Date: | Date: | |
| AM<br>PM | AM<br>PM | | | AM<br>PM | AM<br>PM | |
| List amount of: | | | | List amount of: | | |
| Caffeine | | | | caffeine | | |
| Alcohol | | | | Alcohol | | |
| Nicotine | | | | Nicotine | | |
| One hour before going to bed I was ….(what activity were you doing?) | | | | One hour before going to bed I was ….(what activity were you doing?) | | |
| I slept in .... (at home, hotel, dormitory, friend's home) | | | | I slept in .... (at home, hotel, dormitory, friend's home) | | |
| This morning I woke up feeling …<br>a. Not refreshed<br><br>b. Somewhat refreshed<br><br>c. Rested and refreshed | | | | This morning I woke up feeling …<br>a. Not refreshed<br><br>b. Somewhat refreshed<br><br>c. Rested and refreshed | | |
| Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | | | Did you do self-Shiatsu before bed<br>**YES NO**<br>Did you do self-Shiatsu after awaking at night<br>**YES NO**<br>If YES, did you finish all three cycles before falling asleep?<br>**YES NO**<br>If No-why? | | |

Appendix E The Pittsburgh Sleep Quality Index

## PITTSBURGH SLEEP QUALITY INDEX (PSQI)

**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 take 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 spend in bed.)

   HOURS OF SLEEP PER NIGHT _____

**INSTRUCTIONS:** 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 morning | ☐ | ☐ | ☐ | ☐ |
| (c) ...have to get up to use the bathroom | ☐ | ☐ | ☐ | ☐ |
| (d ...cannot breathe comfortably | ☐ | ☐ | ☐ | ☐ |
| (e) ...cough or snore loudly | ☐ | ☐ | ☐ | ☐ |
| (f) ...feel too cold | ☐ | ☐ | ☐ | ☐ |
| (g) ...feel too hot | ☐ | ☐ | ☐ | ☐ |
| (h) ...had bad dreams | ☐ | ☐ | ☐ | ☐ |
| (i) ...have pain | ☐ | ☐ | ☐ | ☐ |
| (j) Other reason(s), please describe _____ _____ | | | | |
| How often during the past month have you had trouble sleeping because of this? | ☐ | ☐ | ☐ | ☐ |

***PSQI Page 1***

| | Very good | Fairly good | Fairly bad | very bad |
|---|---|---|---|---|
| 6. During the past month, how would you rate your sleep quality overall? | ☐ | ☐ | ☐ | ☐ |

| | Not during the past month | Less than once a week | Once or twice a week | Three or more times a week |
|---|---|---|---|---|
| 7. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep? | ☐ | ☐ | ☐ | ☐ |
| 8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity? | ☐ | ☐ | ☐ | ☐ |

| | No problem at all | Only a very slight problem | Somewhat of a problem | A very big problem |
|---|---|---|---|---|
| 9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done? | ☐ | ☐ | ☐ | ☐ |

| | No bed partner or roommate | Partner/ roommate in other room | Partner in same room, but not same bed | Partner in same bed |
|---|---|---|---|---|
| 10. **Do you have a bed partner or roommate?** | ☐ | ☐ | ☐ | ☐ |

If you have a roommate or bed partner, ask him/her how often in the past month you have had...

| | Not during the past month | Less than once a week | Once or twice a week | Three or more times a week |
|---|---|---|---|---|
| (a) ...loud snoring | ☐ | ☐ | ☐ | ☐ |
| (b) ...long pauses between breaths while asleep | ☐ | ☐ | ☐ | ☐ |
| (c) ...legs twitching or jerking while you sleep | ☐ | ☐ | ☐ | ☐ |
| (d) ...episodes of disorientation or confusion during sleep | ☐ | ☐ | ☐ | ☐ |
| (e) Other restlessness while you sleep; please describe | ☐ | ☐ | ☐ | ☐ |

_____

_____



☐ Baseline

☐ 1st Follow-up

☐ 2nd Follow-up

PSQI Scoring Scale

| | | |
|---|---|---|
| Component 1 | #9 Score | C1_____ |
| Component 2 | #2 Score (≤15min=0; 16-30 min=1; 31-60 min=2, >60 min=3) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3) | C2_____ |
| Component 3 | #4 Score (>7=0; 6-7=1; 5-6=2; <5=3) | C3_____ |
| Component 4 | (total # of hours asleep)/(total # of hours in bed) x 100 >85%=0, 75%-84%=1, 65%-74%=2, <65%=3 | C4_____ |
| Component 5 | Sum of Scores #5b to #5j (0=0; 1-9=1; 10-18=2; 19-27=3) | C5_____ |
| Component 6 | #6 Score | C6_____ |
| Component 7 | #7 Score + #8 Score (0=0; 1-2=1; 3-4=2; 5-6=3) | C7_____ |

Add the seven component scores together _____ **Global PSQI Score** _____

Buysse, D.J., Reynolds III, C.F., Monk, T.H., Berman, S.R., & Kupfer, D.J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Journal of Psychiatric Research, 28*(2), 193-213.

Appendix F Flinders Fatigue Scale

☐ Baseline
☐ Follow-up 1
☐ Follow-up 2

## FATIGUE SCALE

**Name**_____ **Date**_____

We are interested in the extent that you have felt **fatigued** (tired, weary, exhausted) over the last **two weeks**. We **do not** mean feelings of **sleepiness** (the likelihood of falling asleep). Please circle the appropriate response in accordance with your average feelings over this two-week period.

Was fatigue a problem for you?

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | | Moderately | | Extremely |

Did fatigue cause problems with your everyday functioning (e.g., work, social, family)?

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | | Moderately | | Extremely |

Did fatigue cause you distress?

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | | Moderately | | Extremely |

How often did you suffer from fatigue?

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 0 days/ week | 1-2 days/ week | 3-4 days/ week | 5-6 days/ week | 7 days/ week |

At what time(s) of the day did you typically experience fatigue? (Please tick box(es))

| | | | |
|---|---|---|---|
| Early morning | ☐ | Late afternoon | ☐ |
| Mid morning | ☐ | Early evening | ☐ |
| Midday | ☐ | Late evening | ☐ |
| Mid afternoon | ☐ | | |

How severe was the fatigue you experienced?

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | | Moderate | | Extreme |

How much was your fatigue caused by poor sleep?

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | | Moderately | | Entirely |

Gradisar, M., Lack, L., Richards, H., Harris, J., Gallasch, J., Boundy, M., & Johnston, A. (2007). The flinders fatigue scale: Preliminary psychometric properties and clinical sensitivity of a new scale for measuring daytime fatigue associated with insomnia. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine, 3*(7), 722-728.

Appendix G Holistic Complementary and Alternative Health Questionnaire

Name _____ Date _____ ☐ Baseline ☐ Follow-up

**Holistic Complementary and Alternative Health Questionnaire**

Listed below are a number of statements concerning your health and complementary medicine. Please decide to what extent you agree or disagree with each statement. For each statement you should circle the number that corresponds most closely to your own view. There are no right or wrong answers. **Please do not leave out any statements**.

| | *Strongly Agree* | *Agree* | *Mildly agree* | *Mildly disagree* | *Disagree* | *Strongly disagree* |
|---|---|---|---|---|---|---|
| 1 Positive thinking can help you fight off a minor illness | 1 | 2 | 3 | 4 | 5 | 6 |
| 2 Complementary medicine should be subject to more scientific testing before it can be accepted by conventional doctors | 1 | 2 | 3 | 4 | 5 | 6 |
| 3 When people are stressed it is important that they are careful about other aspects of their lifestyle (e.g. healthy eating) as their body already has enough to cope with | 1 | 2 | 3 | 4 | 5 | 6 |
| 4 Complementary medicine can be dangerous in that it may prevent people getting proper treatment | 1 | 2 | 3 | 4 | 5 | 6 |
| 5 The symptoms of an illness can be made worse by depression | 1 | 2 | 3 | 4 | 5 | 6 |
| 6 Complementary medicine should only be used as a last resort when conventional medicine has nothing to offer | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 If a person experiences a series of stressful life events they are likely to become ill | 1 | 2 | 3 | 4 | 5 | 6 |
| 8 It is worthwhile trying complementary medicine before going to the doctor | 1 | 2 | 3 | 4 | 5 | 6 |
| 9 Complementary medicine should only be used for minor ailments and not for the treatment of more serious illness | 1 | 2 | 3 | 4 | 5 | 6 |
| 10 It is important to find a balance between work and relaxation in order to stay healthy | 1 | 2 | 3 | 4 | 5 | 6 |
| 11 Complementary medicine builds up the body's own defences, so leading to a permanent cure | 1 | 2 | 3 | 4 | 5 | 6 |

Hyland, M. E., Lewith, G. T., & Westoby, C. (2003). Developing a measure of attitudes: The holistic complementary and alternative medicine questionnaire. Complementary Therapies in Medicine, 11, 33-38. doi:10.1016/S0965-2299(02)00113-9

## *Scoring of the Holistic Complementary and Alternative Health Questionnaire (HCAMQ)*

The total score is obtained by adding up over all 11 questions the numbers shown in the following table. The CAM subscale is obtained by adding up over the six CAM items (labelled in the table) and the HH subscale by adding up over the five HH items (labelled in the table. A lower score indicates a more positive attitude towards CAM and HH.

| *Item number 4 type* | *Strongly agree* | *Agree* | *Mildly agree* | *Mildly disagree* | *Disagree* | *Strongly disagree* |
|---|---|---|---|---|---|---|
| 1 HH | 1 | 2 | 3 | 4 | 5 | 6 |
| 2 CAM | 6 | 5 | 4 | 3 | 2 | 1 |
| 3 HH | 1 | 2 | 3 | 4 | 5 | 6 |
| 4 CAM | 6 | 5 | 4 | 3 | 2 | 1 |
| 5 HH | 1 | 2 | 3 | 4 | 5 | 6 |
| 6 CAM | 6 | 5 | 4 | 3 | 2 | 1 |
| 7 HH | 1 | 2 | 3 | 4 | 5 | 6 |
| 8 CAM | 1 | 2 | 3 | 4 | 5 | 6 |
| 9 CAM | 6 | 5 | 4 | 3 | 2 | 1 |
| 10 HH | 1 | 2 | 3 | 4 | 5 | 6 |
| 11 CAM | 1 | 2 | 3 | 4 | 5 | 6 |

# Appendix H Sleep Beliefs Scale

Sleep Beliefs Scale

☐ Baseline

Name: _____ Date: _____

☐ Follow-up

This is a survey of the effects of selected behaviours upon sleep. We are interested in knowing your opinion about whether any of these behaviours may influence the quality and/or quantity of sleep. For the following list of behaviours, please indicate whether you believe they produce a "positive" effect, a "negative" effect, or "neither" effect in sleep (this is the central list below). Please do male reference to how they influence your sleep in particular, but to the effects you think these behaviours have on people in general. Please answer ALL the statements by checking the appropriate box., even if you are not completely sure of the answer.

1. Drinking alcohol in the evening
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
2. Drinking coffee or other substances with caffeine after dinner
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
3. Doing intense physical exercise before going to bed
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
4. Taking a long nap during the day
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
5. Going to bed and waking up always at the same hour
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
6. Thinking about one's engagements for the next day before falling sleep
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
7. Using sleep medication regularly
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
8. Smoking before falling asleep
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect
9. Diverting one's attention and relaxing before bedtime
   - ☐ Positive effect
   - ☐ Neither effect
   - ☐ Negative effect

10. Going to bed 2 h later than the habitual hour
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
11. Going to bed with an empty stomach
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
12. Using the bed for eating, calling on the phone, studying, or other non-sleeping activities
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
13. Trying to fall asleep without having a sleep sensation
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
14. Studying or working intensely until late night
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
15. Getting up when it is difficult to fall asleep
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
16. Going to bed 2 h earlier than the habitual hour
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
17. Going to bed immediately after eating
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
18. Being worried about the impossibility of getting enough sleep
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
19. Sleeping in a quiet and dark room
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect
20. Recovering lost sleep by sleeping for a long time
    - ☐ Positive effect
    - ☐ Neither effect
    - ☐ Negative effect

Adan, A., Fabbri, M., Natale, V., & Prat, G. (2006). None. Sleep beliefs scale (SBS) and circadian typology. *Journal of Sleep Research, 15*(2), 125-132.

Appendix I Visual Analogue Scale

**Please circle on the line:**

1. How much did you expect that HSS could improve your sleep before participating:

0 1 2 3 4 5 6 7 8 9 10
Non Large

2. How much do you think HSS improve your sleep after participating:

0 1 2 3 4 5 6 7 8 9 10
Non Large

3. How much do you like HSS and be willing to keep doing it:

0 1 2 3 4 5 6 7 8 9 10
Not very

4. Will you recommend to others if they complain to you about their sleep:

Yes No

***Thank you sincerely for participating! Please do not hesitate to contact if there is any further question or need for proving of volunteer.***

Appendix J Text Message Reminder

| Samples of Text Message Reminder | |
|---|---|
| Baseline | Thank you for participating in this study. Please remember to wear your actigraph monitor to bed and keep the sleep log. |
| Follow-up | 4th week: Thank you for volunteering. Please remember to wear your actigraph monitor to bed and keep the sleep log. We also recommend you do the HSS every night before bed. |
| | 8th week: This is the last step of the sleep study. Please remember to wear your actigraph monitor to bed and keep the sleep log. We also recommend you do the HSS every night before bed. Thank you so much for your participation. |

Appendix L Summary Tables and Figures

Table 1 Demographics Information

| | Gender | Age | Time of SRC |
|---|---|---|---|
| Post-SRC Group (n=7) | Female: 5<br>Male: 2 | 21.43±2.15 | <1 month:2<br>1-3 months:2<br>4-6months: 3 |
| Non-SRC Group (n=7) | Female:4<br>Male:3 | 22.57±2.30 | NA |

Table 2 Actigraph wGT3X-BT Sleep Monitor Results (n=7)

| | Post-SRC Group | Non-SRC Group |
|---|---|---|
| Sleep Onset Latency-B (min) | 8.52±3.23 | 4.48±1.96 (n=6) |
| Sleep Onset Latency -F1 (min) | 7.17±4.90 | 5.76±2.15 |
| Sleep Onset Latency -F2 (min) | 6.18±3.24 | 5.53±3.32 |
| Time in Bed -B (min) | 472.22±66.71 | 454.18±63.84 |
| Time in Bed -F1 (min) | 477.94±78.58 | 428.72±55.79 |
| Time in Bed -F2 (min) | 473.23±115.32 | 479.45±60.92* |
| Total Sleep Time-B (min) | 410.00±61.33 | 414.82±43.61 |
| Total Sleep Time -F1 (min) | 421.63±73.23 | 390.32±48.74 |
| Total Sleep Time -F2 (min) | 409.48±102.16 | 428.70±40.71** |
| Sleep Efficiency-B | 87.27%±4.57% | 91.73%±4.39% |
| Sleep Efficiency-F1 | 88.35%±4.09% | 90.83%±3.36% |
| Sleep Efficiency-F2 | 86.62%±5.27% | 89.92%±5.31% |
| Wake after Sleep Onset-B (min) | 54.77±20.57 | 36.82±23.97 |
| Wake after Sleep Onset-F1 (min) | 47.54±25.25 | 33.76±15.46 |
| Wake after Sleep Onset-F2 (min) | 51.90±34.75 | 46.02±30.60 |
| # of Awakenings-B | 20.25±5.15 | 16.08±8.48 |
| # of Awakenings-F1 | 20.08±6.18 | 14.36±5.53 |
| # of Awakenings-F2 | 19.80±7.49 | 17.21±8.32 |
| Avg. Awakenings-B (min) | 2.75± .74 | 2.17± .41 |
| Avg. Awakenings-F1 (min) | 2.63± .82 | 2.38± .62 |
| Avg. Awakenings-F2 (min) | 2.87± .79 | 2.48± .52 |

B: baseline; F1:1st follow-up; F2: 2nd follow-up
*: One-way repeated ANVOA; compared with the baseline, the 1st follow-up and the 2nd follow-up in non-SRC group; $p$= .025.
**: One-way repeated ANVOA; compared with the baseline, the 1st follow-up and the 2nd follow-up in non-SRC group; $p$= .025.

Table 3 Global Score of the Pittsburgh Sleep Quality Index (PSQI)

| | Post-SRC Group* | Non-SRC Group** |
|---|---|---|
| Baseline | 10.57±4.86 | 8.57±4.28 |
| 1st Follow-up | 7.14±2.85 | 8.43±3.26 |
| 2nd Follow-up | 5.29±1.89 | 5.86±2.27 |

*: Friedman test; compared with the baseline, the 1st follow-up and the 2nd follow-up in post-SRC group; $p$= .016
**: Friedman test; compared with the baseline, the 1st follow-up and the 2nd follow-up in non-SRC group; $p$= .019

Table 4 Results of Flinders Fatigue Scale (FFS)

| | Post-SRC Group* | Non-SRC Group** |
|---|---|---|
| Baseline | 19.00 ± 4.24 | 15.14 ± 6.12 |
| 1st Follow-up | 14.00 ± 3.87 | 14.00 ± 4.87 |
| 2nd Follow-up | 13.29 ± 4.79 | 11.29 ± 4.19 |

*: Friedman test; compared with the baseline, the 1st follow-up and the 2nd follow-up in post-SRC group; $p$= .04
**: Friedman test; compared with the baseline, the 1st follow-up and the 2nd follow-up in non-SRC group $p$= .02

Table 5 Results of Holistic Complementary and Alternative Medicine Questionnaire (HCAMQ)

| | Post-SRC Group | | Non-SRC Group | |
|---|---|---|---|---|
| | Baseline | Follow-up | Baseline | Follow-up |
| HH | 8.86 ± 1.86 | 9.57 ± .98 | 7.57 ± 2.64 | 7.86 ± 2.48 |
| CAM | 22.57 ± 3.74 | 22.71 ± 3.45 | 19.43 ±5.03 | 19.57 ± 5.94 |
| HCAMQ | 31.43 ± 4.61 | 32.29 ± 3.77 | 27.00 ± 6.00 | 27.43 ± 6.43 |

HH: holistic health; CAM: complementary and alternative medicine

Table 6 Results of Sleep Beliefs Scale (SBS)

| | Post-SRC Group | Non-SRC Group |
|---|---|---|
| Baseline | 12.71 ± 3.50 | 12.71 ± 3.30 |
| Follow-up | 11.71 ± 4.11 | 14.00 ± 3.87 |

Table 7 SBS Items with >50% Incorrect Rate in Either Groups (# of participants (%))

| | Post-SRC Group | | Non-SRC Group | |
|---|---|---|---|---|
| | Baseline | Follow-up | Baseline | Follow-up |
| Drinking alcohol in the evening$^{\Delta}$ | 4 (57.1%) | 4 (57.1%) | 4 (57.1%) | 5 (71.4%) |
| Doing intense physical exercise before going to bed$^{\Delta}$ | 4 (57.1%) | 4 (57.1%) | 5 (71.4%) | 5 (71.4%) |
| Using sleep medication regularly | 4 (57.1%) | 5 (71.4%) | 2 (28.6%) | 3 (42.9%) |
| Smoking before falling asleep | 2 (28.6%) | 4 (57.1%) | 3 (42.9%) | 1 (14.3%) |
| Using the bed for non-sleeping activities | 3 (42.9%) | 4 (57.1%) | 0 | 0 |
| Trying to fall asleep without having a sleep sensation | 4 (57.1%) | 3 (42.9%) | 2 (28.6%) | 0 |
| Studying or working intensely until late night | 1 (14.3%) | 4 (57.1%) | 2 (28.6%) | 4 (57.1%) |
| Getting up when it is difficult to fall asleep$^{\Delta}$ | 5 (57.1%) | 6 (85.7%) | 5 (71.4%) | 5 (71.4%) |
| Going to bed 2h earlier than the habitual hour | 3 (42.9%) | 2 (28.6%) | 4 (57.1%) | 2 (28.6%) |
| Going to bed immediately after eating | 3 (42.9%) | 2 (28.6%) | 4 (57.1%) | 2 (28.6%) |
| Recovering lost sleep by sleeping for a long time$^{\Delta}$ | 5 (71.4%) | 5 (71.4%) | 4 (57.1%) | 5 (71.4%) |

$\Delta$ Items with >50% incorrect rate in both groups

Table 8 The HSS Protocol Adherence in Data Collection Weeks (# of participants (%))

| | Post-SRC Group | | Non-SRC Group | |
|---|---|---|---|---|
| | 1st Follow-up | 2nd Follow-up | 1st Follow-up | 2nd Follow-up |
| HHS before bed: | | | | |
| 7 nights | 4 (57.1%) | 1 (14.3%) | 3 (42.9%) | 4 (57.1%) |
| 4-6 nights | 3 (42.9%) | 6 (85.7%) | 3 (42.9%) | 3 (42.9%) |
| 2-3 nights | 0 | 0 | 0 | 0 |
| <2 nights | 0 | 0 | 1 (14.3%) | 0 |
| HHS completed | | | | |
| 7 nights | 1 (14.3%) | 2 (28.6%) | 2 (28.6%) | 2 (28.6%) |
| 4-6 nights | 1 (14.3%) | 1 (14.3%) | 1 (14.3%) | 1 (14.3%) |
| 2-3 nights | 5 (71.4%) | 4 (57.1%) | 0 | 0 |
| <2 nights | 0 | 0 | 4 (57.1%) | 4 (57.1%) |
| Reason for not complete: | | | | |
| Fall asleep | 3 (42.9%) | 2 (28.6%) | 3 (42.9%) | 3 (42.9%) |
| Too tired | 2 (28.6%) | 2 (28.6%) | 1 (14.3%) | 0 |
| No Reason offered | 2 (28.6%) | 3 (42.9%) | 3 (42.9%) | 4 (57.1%) |

Table 9 One Hour before Bed Activities (# of participants (%))

| | Always (>15 nights) | Often (8-15 nights) | Sometimes (3-7 nights) | Occasionally (<3 nights) | Total |
|---|---|---|---|---|---|
| Academic work/ reading/ writing | 4 (28.6%) | 1 (7.1%) | 5 (35.7%) | 2 (14.3%) | 12 (85.7%) |
| Using electronic devices | 3 (21.4%) | 1 (7.1%) | 5 (35.7%) | 2 (14.3%) | 11 (78.5%) |
| Watching TV/ videos/ movies | 0 | 3 (21.4%) | 4 (28.6%) | 1 (7.1%) | 8 (57.1%) |
| Housework/ bedtime preparing | 0 | 1 (7.1%) | 4 (28.6%) | 2 (28.6%) | 7 (7.1%) |
| Social activities | 0 | 0 | 1 (7.1%) | 6 (42.9%) | 7 (7.1%) |
| Chatting | 0 | 1 (7.1%) | 1 (7.1%) | 2 (14.3%) | 4 (28.6%) |
| Driving | 0 | 0 | 1 (7.1%) | 3 (21.4%) | 4 (28.6%) |
| Relaxing/ Praying | 0 | 0 | 1 (7.1%) | 2 (14.3%) | 3 (21.4%) |
| Exercise | 0 | 0 | 0 | 2 (14.3%) | 2 (14.3%) |
| Listening to music/ audiobook | 0 | 0 | 0 | 2 (14.3%) | 2 (14.3%) |
| Feel stress | 0 | 0 | 0 | 1 (7.1%) | 1 (7.1%) |
| Night shift work | 0 | 0 | 0 | 1 (7.1%) | 1 (7.1%) |

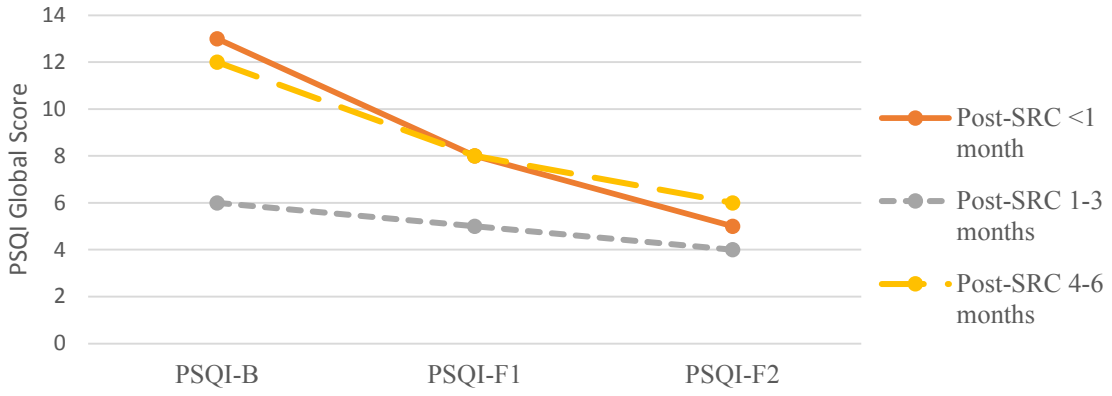
The results combined the three data-collection weeks and mixed the group.

Table 10 Results of Visual Analogue Scale

| | Post- SRC Group (n=5) | Non-SRC Group (n=5) |
|---|---|---|
| How much did you expect that HSS could improve your sleep before participating? | 6.00± 1.26 | 6.80 ± 2.04 |
| How much do you think HSS improve your sleep after participating? | 6.00 ± 1.26 | 4.20 ± 1.6* |
| How much do you like HSS and keep doing it? | 7.20 ± 2.04 | 6.40 ± 1.98 |
| Will you recommend to others? (n) | 5 Yes/ 0 No | 4 Yes/ 1 No |

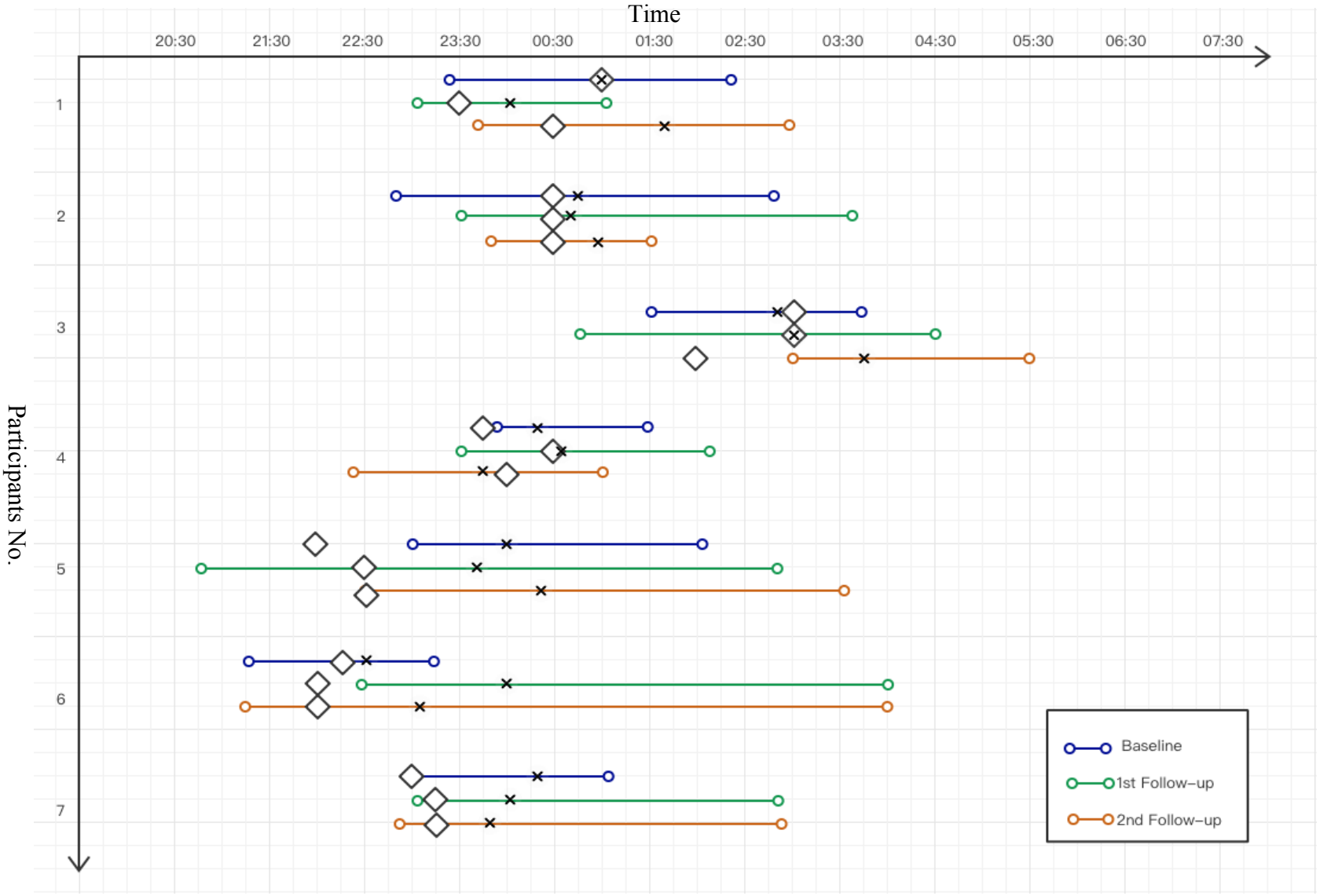
* Mann-Whitney U test; compared non-SRC group with Post-SRC group; $p = .04$.

Figure 1 Changing of the PSQI Global Score in the Post-SRC group




B: Baseline; F1: 1st follow-up; F2: 2nd follow-up

Figure 2 Sleep schedule- Post-SRC Group

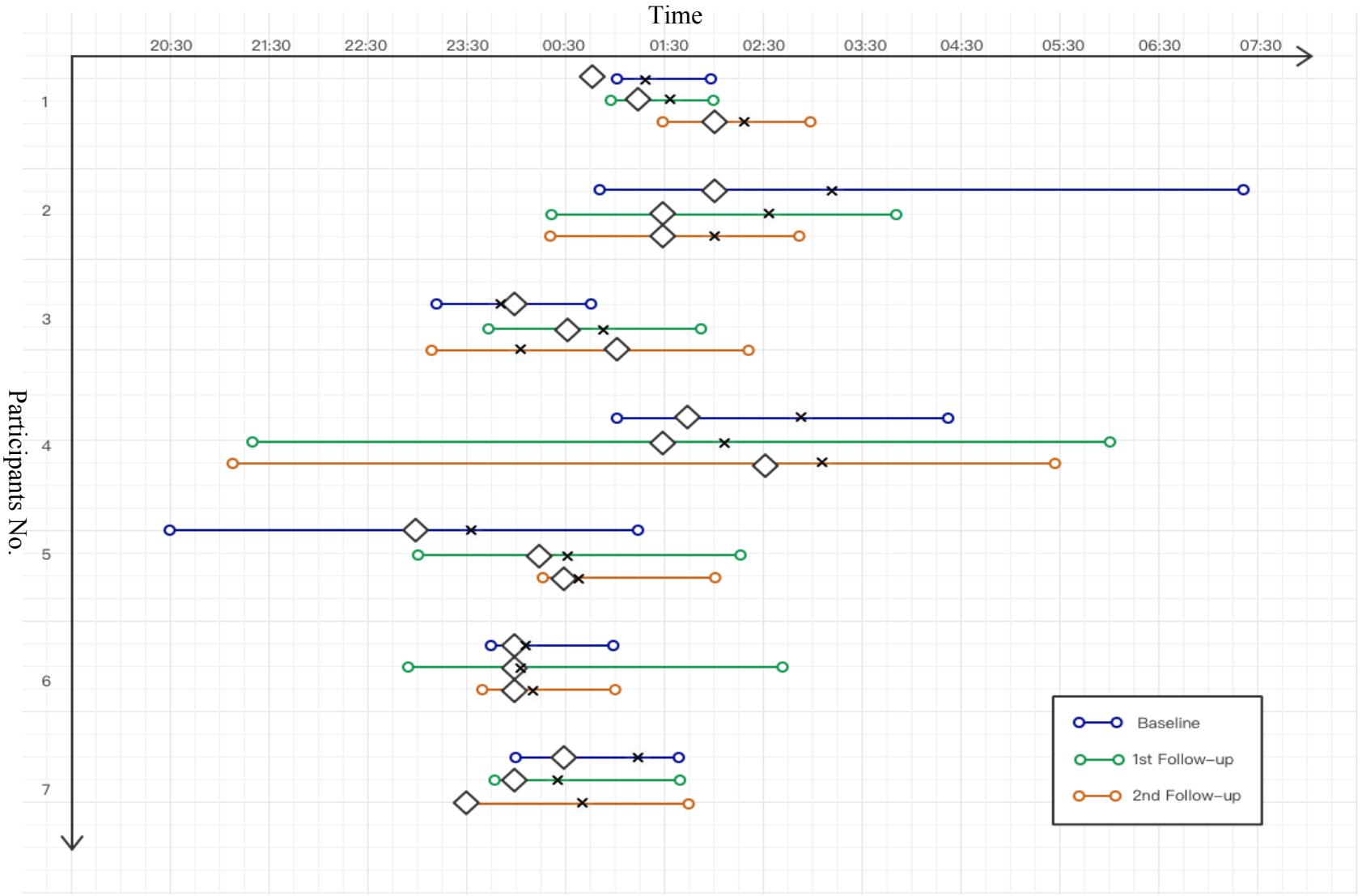



The start of the line: participant's earliest bed time (retrieved from the sleep log)

The end of the line: participant's latest bed time (retrieved from the sleep log)

◇ The usual bedtime that participant recorded on the PSQI

Figure 3 Sleep Schedule- Non-SRC Group




The start of the line: participant's earliest bed time (retrieved from the sleep log)

The end of the line: participant's latest bed time (retrieved from the sleep log)

◇ The usual bed time that participant recorded on the PSQI

× The average bed time (calculated from the sleep log)