RELATIONSHIP BETWEEN POST CONCUSSION SYMPTOMS AND FUNCTIONAL PERFORMANCE AMONG PERSONS WITH MILD TRAUMATIC BRAIN INJURY IN WENZHOU, CHINA

YUHANG HUANG

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR MASTER DEGREE OF NURSING SCIENCE
(INTERNATIONAL PROGRAM)
IN ADULT NURSING PATHWAY
FACULTY OF NURSING
BURAPHA UNIVERSITY
2024

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The Thesis of Yuhang Huang has been approved by the examining committee to be partial fulfillment of the requirements for the Master Degree of Nursing Science (International Program) in Adult Nursing Pathway of Burapha University

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Mild traumatic brain injury (mTBI) persons generally have post-concussion syndrome (PCS) and impaired functional performance after the trauma. The aims of this research were to describe PCS, functional performance (FP) and examine the relationship between PCS (physical symptoms, cognitive symptoms, and behavior symptoms) with FP among persons with mTBI 2 weeks after the trauma in Wenzhou, China. Sampling technic by determining the period of time during August to December 2021, and recruited the samples followed inclusion criteria, 108 mTBI persons who visited to the neurosurgery outpatient department of the First Affiliated Hospital of Wenzhou Medical University, were recruited. Research instruments included Demographic Data Questionnaire, The Rivermead Post-Concussion Symptoms Questionnaire [RPQ], The Rivermead Head Injury Follow up Questionnaire [RHFQO]. The reliability of RPQ and RHFQO were .87 and .89, respectively. Data was analyzed by descriptive statistics and Pearson correlation.

The results showed that the mean score of the physical symptoms dimension was .47 (SD = .51), the cognitive symptoms dimension was .55 (SD = .84), the behavior symptoms dimension was .55 (SD = .90). The mean score of FP was .55 out of 4 (SD = .70). The Pearson correlation analysis revealed the physical symptoms, cognitive symptoms, behavior symptoms were positive correration with FP ($r = .68$, $r = .58$, $r = .76$, $P < .001$ respectively).

The findings suggested that three dimensions of PCS all had significant impact on FP, these can fulfill the gap and provide scientific evidence to management PCS and promote FP in mTBI persons 2 weeks after trauma.

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Yuhang Huang

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CHAPTER 1
INTRODUCTION

Background and significance of the problem

Traumatic brain injury (TBI) is an important global public health problem as a major cause of traumatic death and disability, is one of the most common neurological diseases, which can affect all aspects of life, including work and leisure activities (Haarbauer-Krupa et al., 2021). Brain injury does not heal like other injuries, which not only limits the use of specific parts of the body, but also changes the patient's interpersonal relationships and mental abilities (Bannon et al., 2020; Elder et al., 2019).

The incidence of TBI in the world is more than 50 million (Mikolić, Polinder, et al., 2021), the global incidence is estimated at 200-300/100,000 persons per year for hospitalized patients and probably twice as high if non-hospitalized patients are included, a population-based study in New Zealand, including all cases of TBI (hospitalized or not), reported total incidence was 790/100,000 persons per year (Lefevre-Dognin et al., 2021). According to the clinical and surveillance definitions, 70–90% of TBIs is classified as mild traumatic brain injury (mTBI) (Haarbauer-Krupa et al., 2021), for patients with mild TBI, the incidence of hospitalization mTBI is about 100 to 300 per 100,000, as many individuals do not seek professional medical treatment following a brain concussion, so the actual annual incidence of mTBI may be over 600/100,000 (Barker-Collo et al., 2019).

TBI is also a serious health problem in China (Jiang et al., 2019). Population-based mortality of TBI in China is estimated to be approximately 13 cases per 100,000 people, which is like the rates reported in other countries (Tiantong, 2020). For the past 30 years, nationwide data for the incidence of TBI in China have not been available (Zhao-fan & Guo-sheng, 2021). Population based studies did in the 1980s showed an incidence of TBI of 55.4–64.1 cases per 100,000 people per year (Jiang et al., 2019). With the rapid economic development, the prevalence of TBI continues to increase, more car crashes and industrial injuries, and sports-related injuries (Jiang et al., 2019). China had a population of more than 1.41 billion at the

end of 2021, representing approximately 18% of the world population, the absolute numbers of patients with TBI in China exceed those of most other countries (Jiang et al., 2019). In China, 80-90% of TBI patients are mild, which consists with the worldwide condition (Bo et al., 2019). According to statistical data, Wenzhou, a city with a permanent population of more than 9 million in China, there were 13,271 TBI patients admitted to hospital in Wenzhou between 2014 and 2016, and 73.56% were mild traumatic brain injury (Wen et al., 2018). The incidence of mTBI in hospitalized patients is 1-3% of all hospitalized patients (Wen et al., 2018).

Mild traumatic brain injury (mTBI) is considered to be an important public-health concern (Liu, 2015). mTBI is typically defined as a closed head injury, with brief loss or disturbance of consciousness, the Glasgow Coma Scale score is 13–15 (Roy et al., 2019), a concussion is a common form of mTBI. Mortality in mTBI patients is very low, neurosurgical interventions are barely needed (Marshall et al., 2015). Nevertheless, in the first week after mTBI, 80%-100% of the patients suffer from post-concussion symptoms, 15–25% of cases still experience symptoms three months post-injury (Asselstine et al., 2020). When post-concussion symptoms persist for over three months, it is referred to post-concussion syndrome (PCS), which lead to inability to reintegrate activities including those at work place and at home (Yousefzadeh-Chabok et al., 2019).

Post-concussion syndrome are divided into three clinical domains: physical symptoms (headache, dizziness, fatigue, blurred vision, auditory disturbance, tinnitus, noise or light sensitivity), cognitive symptoms (memory, attention and concentration) and behavioral symptoms (depression, irritability and anxiety), different patients may have symptoms in one or more domains (Balakrishnan et al., 2019). Poor memory, headache, fatigue, concentration difficulties and sleep disturbances were the most common (Oldenburg et al., 2016). Based on the Theory of Unpleasant Symptoms [TOUS] (Lenz et al., 1997), PCS are symptoms the individual is experiencing, and the functional performance is the consequences of this experience. Given that patients with mTBI often have multiple post-concussion syndrome that co-occur, interact with each other, and/or exacerbate symptoms (Herrold et al., 2019). Moreover, symptoms themselves may affect performance outcomes, such as the ability of daily living decreased and the poor quality of life (Silva-Rodrigues et al., 2019).

Such persisting symptoms can affect patient outcomes in all aspects of life, headaches and fatigue as the most frequent post-concussion syndrome often led to limited daily activities (Cheng et al., 2017; Li et al., 2019). Sleep disorders after injury in mTBI can lead to failure of judgment, decision-making (Killgore et al., 2020). Difficulties of memory, attention, and inhibitory control, often coincide with difficulties to maintenance tasks (Xu et al., 2017). A review concluded that damage to parts of the frontal lobe often results in behavioral symptoms such as depression, anxiety, or fear, and that these can cause additional distress and make it difficult for the patient to return to normal life (Broshek et al., 2015).

Many studies have found that functional performance in the physical, social and psychological domains is compromised in patients with mTBI, 33% of the mTBI subjects were functional impaired at 3 months after injury, and 22.4% of the mTBI subjects who could be followed were still below full functional status at 1 year after injury (McMahon et al., 2014). Another study assessed outcomes occurred at 2 weeks and 3, 6, and 12 months postinjury, found that functional limitation rates were highest at 2 weeks post injury and lowest at 12 months (Nelson et al., 2019). Since they have problems with functional outcomes, they experience difficulties returning to work or return to work at reduced level, their ability to interact socially decreases (Yue et al., 2019). Among adolescents, engagement in school activity often decreases, they fail to return to school for higher education due to cognitive and executive function deficits (Yue et al., 2019). These functioning problems and decreased ability to perform previous activities will make it difficult for them to reintegrate into society and even affects their daily activities, then lead to decreased life satisfaction and increased medical burden (Nelson et al., 2019).

These functional limitations may be related to post-concussion syndrome (PCS), since continued post-concussion syndrome seriously affect functional performance (Fineblit et al., 2016). The relationship between PCS and functional performance has been extensively studied. One study showed that PCS including headache, dizziness, fatigue, and sensitivity to light and noise often lead to decreased physical function (Pundlik et al., 2020; Schiehser et al., 2017). A study in Thailand found that there were statistically negative relationships between headache, fatigue, sleep disturbance, and performance at the 2nd week after the injury (Wannasrithong et

al., 2016). Another study found that cognitive symptoms of PCS including difficulties of memory, attention, and inhibitory control, often executive functions decrease (Killgore et al., 2020; Xu et al., 2017). Behavioral symptoms of PCS such as depression and anxiety may interfere with a person's ability to functional performance in all areas of their life (Bay & de-Leon, 2011).

Referring to the above literature, mTBI persons generally have post-concussion syndrome and impaired functional performance after the trauma and these are most frequent in the early stage (2 weeks) (Nelson et al., 2019). Persons with mTBI who have more severe PCS within 2 weeks are more likely to suffer from symptoms in the long term, which affects recovery from functional impairment (Silva-Rodrigues et al., 2019). Moreover, ones have more severe PCS tend to have worse functional performance (Pundlik et al., 2020). Many previous studies from other countries have shown correlations between post-concussion syndrome and functional performance in the early stage, but few have been found to explore the relationships between physical symptoms, cognitive symptoms, and behavioral symptoms with functional performance.

There were only a few studies about post-concussion syndrome and functional performance in persons with mTBI early post-trauma in China, and few studies have been done to investigate relationships between variables with functional performance so far. Considering that mTBI accounts for the vast majority of TBI patients in China, the economic burden of prolonged treatment and decreased productivity, so it is important to promptly identify mTBI persons who are at high risk of symptoms, assessment and intervention in the early stage, can be prevent persistent symptoms if reduce the symptoms in the early stage (Petchprapai, 2017). Therefore, the researcher found the necessary to conduct a study about the relationship between physical symptom, cognitive symptoms, and behavioral symptoms with functional performance in persons with mTBI at 2 weeks after trauma in Wenzhou, China. This study will fulfill the gap and provide scientific evidence for effective nursing practice and nursing research development aiming to management and reduce post-concussion syndrome and promote functional performance in patients with mTBI in China. Moreover, these can help mTBI persons to return to normal life and improve their quality of life.

Research objectives

1. To describe post-concussion syndrome among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China.

2. To describe functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China.

3. To determine the relationship between physical symptoms, cognitive symptoms, and behavioral symptoms with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China.

Research Hypotheses

1. There is positive relationship between physical symptoms with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China.

2. There is positive relationship between cognitive symptoms with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China.

3.There is positive relationship between behavioral symptoms with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China.

Scope of study

This study was the descriptive correlational research design, aimed to describe post-concussion symptoms and functional performance among persons with mild traumatic brain injury 2 weeks after the trauma, moreover, and the relationship between physical symptoms, cognitive symptoms, and behavioral symptoms with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China. Data were collected in neurosurgery Outpatient Department of the First Affiliated Hospital of Wenzhou Medical University during August to December 2021.

Research framework

The study was guided by the Theory of Unpleasant Symptoms [TOUS] along with the information from literature reviews. TOUS is a middle-range theory that was developed and intended for use and application by nurses, the first concept paper of the TOUS appeared during 1995 and was later revised during 1997 (Lenz et al., 1997; Lenz et al., 1995).The three main components of this theory are the symptoms the individual is experiencing, the factors that influence or affect symptoms and that give rise to the nature of the symptoms, and the consequences of this experience. Symptoms include four dimensions: timing, intensity, quality, and distress. The factors affecting symptoms include: 1) physiological factors; 2) psychological factors; and 3) situational factors, which may affect the symptom experience. Moreover, symptoms themselves may affect performance outcomes, such as the ability of daily living decreased and the poor quality of life (Silva-Rodrigues et al., 2019). Notably, as the theory has been revised, attention has been paid to the fact that symptoms may interact with one another, perhaps catalyzing each other. Through feedback, symptoms may also affect influencing factors, and changes in performance may also have a reciprocal influence on symptoms and/or influencing factors. This theory illustrates the complex nature of the symptom experience, which involves innumerable potential variables (Gholami et al., 2020).

In this study, post-concussion syndrome (PCS) are symptoms the individual is experiencing, and the functional performance is the consequences of this experience. Given that patients with mTBI often have multiple PCS that co-occur, interact with each other, and/or exacerbate symptoms, understanding the relationship between symptom presentation and function may be more important than simply identifying the etiology of individual symptoms (Herrold et al., 2019). PCS including headaches, poor memory and depression often brings unpleasant, complex, and perceptible experiences, which can lead to poor functional performance to some extent, such as failing to resume work or study (Mollayeva et al., 2017). However, functional limitations will not only affect the symptoms themselves in turn, but also lead to the influencing factors of the symptoms, such as anxiety (psychological factors) caused by poor ability, weakness (physiological factors) caused by reduced daily activities, reduced perceived social support (situational factors) caused by poor

relationships with family and friends, which can all exacerbate symptoms, then lead to worse outcomes. What's more, symptoms themselves can also exacerbate the factors, cognitive symptoms always make people anxious and depressed, these are psychological factors.

Post-concussion syndrome including 16 symptoms are divided into three clinical domains: physical symptoms, cognitive symptoms, and behavioral symptoms, these symptoms interact with each other and exacerbate symptoms. Influencing factors can directly affect symptoms, while functional impairment can affect influencing factors, thus, for better control of symptoms and functional outcomes, the relationship between physical symptoms, cognitive symptoms, and behavioral symptoms) with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma need to be understand. The research framework between all variables in this study is shown in Figure 1.

Post-Concussion syndrome

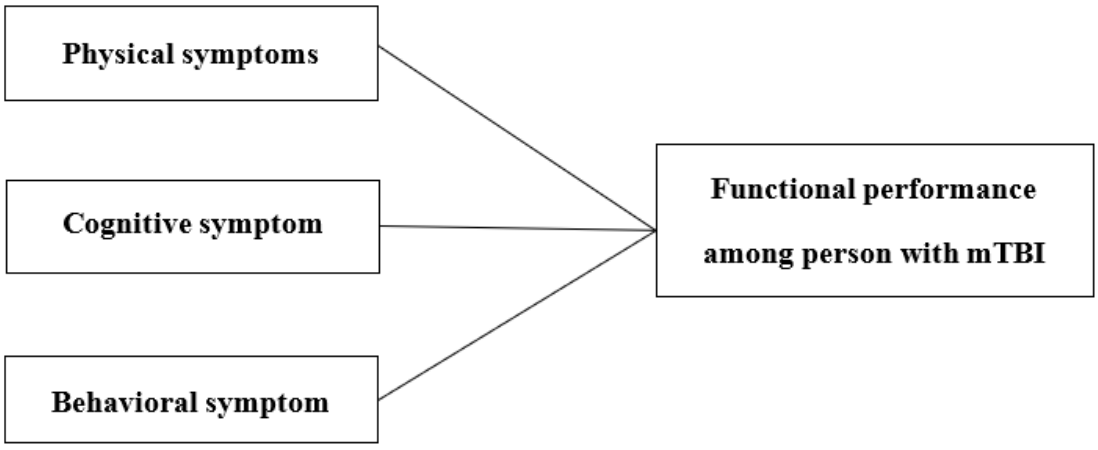

Figure 1 Research Framework

Operational definition

Persons with mild traumatic brain injury refers to those who have been diagnosed with mild traumatic brain injury, were treated in neurological ward, and come to neurosurgery outpatient department of the First Affiliated Hospital of Wenzhou Medical University for follow-up their condition at 2 weeks after trauma.

Moreover, they are conscious, having a good orientation to place and time and having Glasgow Coma Scale (GCS) =15.

Post-concussion syndrome was a set of perceive concussion symptoms after the initial injury to brain that affect cognitive, physical, and behavior of persons with mild traumatic brain injury 2 weeks after trauma.

Physical symptoms were the perceive post-concussion symptoms that affect physical of persons with mild traumatic brain injury 2 weeks after trauma, including headache, dizziness, fatigue, blurred vision, double vision, sleep disturbance, tinnitus, noise, or light sensitivity. In this study, The Chinese version of Rivermead Post-Concussion Symptoms Questionnaire (RPQ) physical domain (Zong, 2009) was used to assesses physical symptoms of persons with mild traumatic brain injury.

Cognitive symptoms were the perceive post-concussion symptoms that affect cognitive of persons with mild traumatic brain injury 2 weeks after trauma, including memory, attention, and concentration. In this study, The Chinese version of Rivermead Post-Concussion Symptoms Questionnaire (RPQ) cognitive domain (Zong, 2009) was used to assesses cognitive symptoms of persons with mild traumatic brain injury.

Behavioral symptoms were the perceive post-concussion symptoms that affect behavior of persons with mild traumatic brain injury 2 weeks after trauma, including depression, irritability, and anxiety. In this study, The Chinese version of Rivermead Post-Concussion Symptoms Questionnaire (RPQ) behavior domain (Zong, 2009) was used to assesses behavior symptoms of persons with mild traumatic brain injury.

Functional performance referred to the perception of persons with mild traumatic brain injury 2 weeks after trauma related to the difficulties and/or changes in the ability to perform activities in daily life since prior to their head injury, including the ability of engaged in home and social activities, which were communication, mobility, behavior skills, social skills, and daily living skills (Chen et al., 2016). The Chinese version of Rivermead Head Injury Follow Up Questionnaire (RHFUQ) (Zong, 2009) was used to measure functional performance of persons with mild traumatic brain injury.

CHAPTER 2
LITERATURE REVIEW

This chapter presented an overview about traumatic brain injury and mild traumatic brain injury, post-concussion syndrome among persons with mild TBI, The Theory of Unpleasant Symptoms, functional performance in persons with mild traumatic brain injury, and relationship between physical symptoms, cognitive symptoms, and behavior symptoms with functional performance in persons with mild TBI at 2 weeks after trauma, the review is presented as follows:

1. Overview of traumatic brain injury
    1.1 Definition of traumatic brain injury
    1.2 Classification and criteria for diagnosis traumatic brain injury
2. Mild traumatic brain injury
    2.1 Definition of mild traumatic brain injury
    2.2 Criteria for clinical identification of mild traumatic brain injury
3. Post-concussion syndrome in persons with mild traumatic brain injury
    3.1 Definition of post-concussion syndrome
    3.2 Diagnosis of post-concussion syndrome
    3.3 Physical symptoms
    3.4 Cognitive symptoms
    3.5 Behavior symptoms
4. Functional performance in persons with mild traumatic brain injury
    4.1 Definition of functional performance
    4.2 Functional performance in persons with mild traumatic brain injury
5. The Theory of Unpleasant Symptoms
6. Relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavior symptoms) with functional performance among persons with mild traumatic brain injury
7. Summary

Overview of traumatic brain injury

Definition of traumatic brain injury

The Demographics and Clinical Assessment Working Group of the International and Interagency Initiative toward Common Data Elements for Research on Traumatic Brain Injury and Psychological Health concluded that traumatic brain injury (TBI), defined as changes in brain function or brain pathology caused by external forces, leading to injury to brain structures and disruption of chemical and physiologic brain functions (Menon et al., 2010). The WHO defines head trauma as "an acute brain injury resulting from mechanical energy to the head from external physical forces", excluding manifestations related to "drugs, alcohol, medications, caused by other injuries or treatment for other injuries (e.g., systemic injuries, facial injuries or intubation), caused by other problems (e.g., psychological trauma, language barrier or coexisting medical conditions) or caused by penetrating craniocerebral injury." (Lefevre-Dognin et al., 2021).

TBI usually has at least one of the following symptoms: loss of consciousness or impairment, loss of event memory after injury, neurological deficits (weakness, imbalance, visual changes, etc.) or confusion with mental disorders, disorientation, slow thinking, etc. (Pavlovic et al., 2019).

TBI is a serious public health problem worldwide, causing many deaths and temporary and permanent disabilities every year. TBI is not only a single pathophysiological phenomenon, but also a complex disease process that generates structural and functional damage from both primary and secondary injury mechanisms, secondary injury develops over hours, days, months or even lifetime (Pavlovic et al., 2019). The incidence of TBI worldwide exceeds 10 million and has been rising over the past decade. TBI was reported to have killed 82,000 people in Europe in 2012 (Cheng et al., 2017). It is also the fifth leading cause of death among people under 40 years of age in China, the overall mortality rate of TBI in China in 2013 was 12.99 per 100,000 (Cheng et al., 2017).

Classification and criteria for diagnosis of traumatic brain injury

The most basic means of classifying traumatic brain injury (TBI) is by physical mechanism of injury either as blunt or penetrating (Hawryluk & Manley, 2015), it is very useful to clinicians given the high probability that penetrating TBI

will require surgery as well as consideration of vascular injury early and late in the course of patient management (Hawryluk & Manley, 2015). Another dichotomous, mechanistic classification is into the primary (or initial) injury and secondary (or delayed) injury which is incited by the primary injury. Primary injury occurs as the result of a force applied directly or indirectly to the brain. Numerous primary injury mechanisms of brain injury are described, including compression, rotation, translation, shearing, laceration, and others. Secondary injury is believed to involve mitochondrial dysfunction, excitotoxicity, free radical production, activation of injurious intracellular enzymes, and other mechanisms (Hawryluk & Manley, 2015).

One of the most important recent advances in the TBI field has occurred in TBI prognostic classification. The International Mission for Prognosis and Clinical Trial (IMPACT) study pooled patients from many completed TBI studies and generated three prognostic models of increasing complexity (Hawryluk & Manley, 2015).

Patients classified with complicated MBI meet the criteria for MBI and have intracranial lesions on MRI or focal neurological deficits such as hemiparesis or aphasia. Patients classified as having uncomplicated MBI are without demonstrable structure change or deficits (Hawryluk & Manley, 2015).

Pathoanatomic classification of TBI may be simply dichotomized into focal and diffuse injuries, focal injuries are generally caused by contact while diffuse injuries are generally caused by acceleration- deceleration forces. These lesions can also be thought of systematically in terms of the various tissues and planes of the cranium, including skull fracture, epidural hemorrhage, subdural hemorrhage, subarachnoid hemorrhage (SAH), brain contusion and laceration, intraparenchymal hemorrhage, intraventricular hemorrhage, and traumatic axonal injury (Hawryluk & Manley, 2015). In the clinical realm, computed tomography (CT) findings are typically used for premorbid pathoanatomic classification. The Marshall Score for CT findings was published in 1992 and it demonstrated an ability to correlate patterns of CT anomalies with intracranial pressure and with outcome (Hawryluk & Manley, 2015).

The most widely accepted taxonomy classifies brain injuries by severity, which can be considered a classification system based on symptoms (Hawryluk &

Manley, 2015). Severity is classified based on whether structural abnormalities are visible on imaging, duration of loss of consciousness, duration of altered mental status, duration of post-traumatic amnesia, and Glasgow Coma Scale (GCS) score. According to GCS, TBI can be classified as mild, moderate, and severe. Generally, less than 8 points are defined as severe traumatic brain injury, 9-12 points are defined as moderate traumatic brain injury, and 13-15 points are defined as mild traumatic brain injury (mTBI) (Scholten et al., 2015). The GCS has demonstrated good inter-rater reliability but is susceptible to the confounding effects of sedation, paralysis, and pre-existing injuries (Hawryluk & Manley, 2015).

However, classifying the clinical severity of TBI based on the level of GCS awareness is a relatively rough tool that may not adequately capture the severity of TBI (Pavlovic et al., 2019). According to the clinical and surveillance definitions, 70–90% of TBIs is classified as mild traumatic brain injury (mTBI) (Haarbauer-Krupa et al., 2021). The term "mild" of mild traumatic brain injury tends to mislead patients and medical staff about the disease. Since a proportion of mTBI patients have high GCS scores, physicians may not diagnose them with mTBI or discharge them without full recovery and patients with high GCS scores prefer to return to their previous lives rather than seek medical attention (Pavlovic et al., 2019). Determining which factors increase the risk of mTBI is necessary to develop public health plans to prevent problems and reduce the likelihood of disability in patients with mTBI.

Mild traumatic brain injury

Definition of mild traumatic brain injury

Mild traumatic brain injury (mTBI), also commonly referred to as mild head injury or concussion, due to mechanical energy generated by an external physical force to the head, is one of the most common neurologic disorders occurring today (de Guise et al., 2016). An immediate and transient impairment of neural function, such as alteration of consciousness, disturbance of vision, equilibrium, and other similar symptoms. Features common to mTBI include limited or absent loss of consciousness, limited post-traumatic amnesia, and an initial Glasgow Coma Scale of ≥ 13 of 15 (Marshall et al., 2012).

Forces causing mTBI can result from several mechanisms. Direct blows occur when the head forcibly hits an object or when an object hits the head, Beyond the direct distortion of the brain through translational forces, this motion can cause a coup-contrecoup injury, in which the brain impacts one side of the skull (Eapen & Subbarao, 2019). Acceleration and deceleration forces, which can occur with or without actual contact between the head and an object, result when the head moves rapidly quickly in one or more directions. Lastly, blast-related injuries are caused by transmission of force, via pressure waves accompanying blasts, to and through the brain, which can create abnormally strong rotational forces to the brain (rotational brain injury), causing damage to brain nerve cells and their shear (Eapen & Subbarao, 2019).

Common causes of mTBI include head injuries from falls, motor vehicle accidents, sports-related injuries, violence, or explosive blasts (Marshall et al., 2018). Physically, the head is jolted and there is an acceleration and deceleration following the impact to the head that results in the brain hitting against the skull. A car accident may lead to mTBI when the head strikes the steering wheel or another part of the vehicle. The force of impact causes the brain to move inside the skull, which can damage blood vessels and nerves. mTBI can be caused by minor accidents such as rear end collisions, or they can result from major accidents like motorbike crashes (Marshall et al., 2018). Falling causes a concussion when the head hits another object, such as the ground. This usually happens when someone falls backward or sideways. A person who has fallen may be knocked unconscious for several minutes, and then wake up confused and disoriented. Sports such as football, hockey, soccer, and basketball can cause concussions. When being struck, the brain bounces against the inside of the skull, which causes bleeding around the brain (Marshall et al., 2018).

In Americans, an estimated 5% to 90%, or between 2.15 and 2.58 million, of those injuries could be classified as mTBI. The most common causes are falls (40%), crashes involving motor vehicles, bicycles, or other forms of transportation (14%), striking, or being struck by objects (15%), and assault (10%). There are nearly 300,000 sports-related mTBIs per year as well (Marshall et al., 2018). In China, the common causes of mTBI include traffic accidents, falls, violent blows, sports, etc.

Falls and traffic accidents are the most common causes of mTBI in infants/elderly and middle-aged and young people respectively (Wenzhi & Xiuyun, 2016).

Criteria for clinical identification of mild traumatic brain injury

According to the Mild TBI Committee of the American Congress of Rehabilitation Medicine, revised by the World Health Organization (WHO), mTBI is defined by a Glasgow Coma Scale score between 13 and 15 at 30minutes post-injury, and one or more of the following symptoms: <30min loss of consciousness; <24hours post-traumatic amnesia (PTA); impaired mental state at time of accident (confusion, disorientation, etc.); and/or transient neurological deficit (Lefevre-Dognin et al., 2021).

The lack of clarity in the clinical criteria for mTBI has led to inconsistent medical management protocols for the disease, creating an impact on the clinical management of patients with mTBI (Prince & Bruhns, 2017). In China, a large number of suspected mTBI cases are not seen in a timely manner due to problems with diagnostic criteria, and medical staff lack standardized guidelines for patients who are seen regarding when to be hospitalized, when to be discharged from the emergency department, and when to be referred for outpatient follow-up (Wenzhi & Xiuyun, 2016).

In its report to Congress, the United State Centers for Disease Control and Prevention (CDC) made the conceptual definition of mTBI as “any period of observed or self-reported: transient confusion, disorientation, or impaired consciousness, dysfunction of memory around the time of injury; Loss of consciousness lasting less than 30 min” as well as “observed signs of neurological or neuropsychological dysfunction”, including feeling dazed, confused, and disoriented, lasts for up to 24 hours. Post-traumatic amnesia, the inability to reliably form new memories, also lasts up to 24 hours. GCS scores range from 13 to 15 (Katz et al., 2015; Prevention & Control, 2003).

Patients classified with complicated mTBI meet the criteria for mTBI and have intracranial lesions on MRI or focal neurological deficits such as hemiparesis or aphasia (Sussman et al., 2018). Patients classified as having uncomplicated mTBI are without demonstrable structure change or deficits. Those with complicated mTBI

have greater cognitive dysfunction than those with uncomplicated mTBI, but do not differ on manifestations of mood disorder (Sussman et al., 2018).

Mortality in mTBI patients is very low, neurosurgical interventions are barely needed (Marshall et al., 2015). However, for some patients, mTBI is not a mild disease, and many experience significant and persistent symptoms, the persistence of various symptoms such as headache, dizziness, problems with concentration and memory weeks after a mild head injury were post-concussion syndrome (McMahon et al., 2014).

Post-concussion syndrome in persons with mild traumatic brain injury

Definition of post-concussion syndrome

Immediate symptoms of mild traumatic brain injury include disorientation, headache, blurred vision, dizziness, sleep disturbance, memory, attention, and other cognitive difficulties. Typically, symptoms peak immediately following the incident, begin to recede within hours, and are gone within days to weeks. However, in approximately 10% cases, symptoms persist past three months. Recovery can be complicated by vestibular abnormalities and oculomotor changes, which can each lead to worsening headaches and overall function but are largely treatable once they are diagnosed (Broshek et al., 2015). Without proper management, a concussion and the symptoms that accompany the injury can develop into post-concussion syndrome (PCS), precise definitions vary, but generally post-concussion syndrome can be considered when persistent symptoms are experienced for greater than 1–3 months after injury (Broshek et al., 2015).

Post-concussion syndrome (PCS) are the set of symptoms that affect cognitive, physical, and behavior, including physical symptoms (headaches, feelings of dizziness, nausea and/or vomiting, noise sensitivity, sleep disturbance, fatigue, blurred vision, light sensitivity, double vision), cognitive symptoms (forgetfulness, poor concentration, taking longer to think) and behavioral symptoms (being irritable, feeling depressed or tearful, feeling frustrated or impatient, restlessness), different patients may have symptoms in one or more domains (Broshek et al., 2015). PCS usually disappear completely within 3 months after injury, however, about 50% of mTBI still experience post-concussion symptoms at one-month post-injury, 10-25%

continue to experience PCS at 6 months post-injury and a small minority still have difficulties at 1 year and beyond. In the latter, PCS can be defined as being 'long-term' or 'permanent', early intervention of PCS is important (Polinder et al., 2018). PCS in adult men usually resolves within 14 days, while symptoms in adolescents and women tend to last longer (Leddy et al., 2017). The non-specific nature of PCS makes the management of the disease more challenging (Leddy et al., 2017).

Diagnosis of post-concussion syndrome

There are two established sets of criteria for diagnosis of post-concussion syndrome (PCS), one by the International Classification of Diseases (10th edition) (Fann et al., 2004) and the other referred to as post concussive disorder (PCD) in the Diagnostic and Statistical Manual of Mental Disease (DSM) published by the American Psychiatric Association (APA). The International Classification of Diseases (ICD-10) clinical diagnostic criteria for post-concussion syndrome proposed in 1992 require: 1. History of head trauma with loss of consciousness preceding symptom onset by a maximum of 4 week. 2. Symptoms in 3 or more of the following symptom categories: 1) headache, dizziness, malaise, fatigue, noise intolerance; 2)irritability, depression, anxiety, emotional lability; 3)subjective concentration, memory, or intellectual difficulties without neuropsychological evidence of marked impairment; 4)insomnia; 5)reduced alcohol tolerance; and 6)preoccupation with above symptoms and fear of brain damage with hypochondriacal concern and adoption of sick role (Katz et al., 2015).

Due to inconsistent diagnostic criteria for mTBI, a large number of patients with mTBI are underdiagnosed (Prince & Bruhns, 2017). In turn, patients who are seen are often discharged quickly and do not receive routine follow-up care, and many discharge instructions fail to address the possibility that patients may continue to have PCS (Prince & Bruhns, 2017). This often causes medical staff to miss the best time to diagnose and intervene in PCS. In addition, there is also no consensus on the diagnostic criteria for PCS, which makes it difficult to define PCS clinically (Maruta et al., 2018).

There are substantial changes in the pathological, physiological, and cognitive aspects of the brain after mTBI (McMahon et al., 2014). PCS are usually self-reported by patients based on the subjective nature of each patient's experience,

which may lead to increased unreliability of results (McMahon et al., 2014). The common symptoms of PCS are not necessarily specific to mTBI, making the diagnosis of PCS yet more difficult (McMahon et al., 2014). PCS has considerable functional limitations and reduces quality of life, but there appears to be little correlation between mTBI severity and PCS severity, and the disability experienced by some individuals appears to be disproportionate to the severity of mTBI (Skandsen et al., 2020). Because PCS may not only be the result of neurological damage but may also develop due to psychological distress.

PCS often continues for months after the injury, lasting more than 1 year, and some symptoms, such as cognitive symptoms, do not show any trend toward improvement (Polinder et al., 2018). Cognitive (memory, attention, and concentration impairment), physical (headache, fatigue, dizziness) and behavioral (depression, anxiety, irritability) signs and symptoms manifest (Polinder et al., 2018). Recovery from mTBI is a nonlinear process, and the time to full recovery may be long, and some patients may never fully recover (Polinder et al., 2018). Patients with mTBI often have mild cognitive dysfunction in the first 2 weeks after injury, which can persist up to 6 months (Polinder et al., 2018). Even at 1-year follow-up, 20% to more than 30% of patients continue to experience clinically significant sequelae, and more than 80% of patients remain symptomatic despite reduced symptoms (McMahon et al., 2014). Physical symptoms including fatigue and headache are most common symptoms in patients with mTBI, which affect many aspects of life (Polinder et al., 2018). Self-reported cognitive symptoms are more prevalent at 1-2 weeks post-injury, while cognitive and behavioral symptoms are more prevalent in the long-term post-injury period due to a slower rate of resolution (Polinder et al., 2018). Among the cognitive symptoms of mTBI patients, attention was the first cognitive function to be improved, followed by executive function and finally memory (Munivenkatappa et al., 2017).

Age has been cited in the literature as a risk factor for post-concussion syndrome, young mTBI patients were more easily to suffer from post-concussion syndrome, a study showed that participants age <65 years-old endorsed headaches, noise/light sensitivity, irritability, and frustration/impatience at a greater frequency than participants age ≥65 years-old (Karr, Luoto, et al., 2020). Another study showed

that post-concussion syndrome was worse in women aged 35 to 49 years than in younger and older women (Levin et al., 2021). Older age was associated with less PCS reporting than in the middle or younger age-groups (Ponsford et al., 2019). In this study, 38% of mTBI were age under 18-44 years old, 69.5% were under 60 years old, so the participants in this study had a problem about post-concussion syndrome.

Gender is also an important factor of post-concussion syndrome. Previous study reported that females experience slower resolution of post-concussion syndrome, more severe emotional symptoms than male patients (Levin et al., 2021). Perhaps owing to psychosocial factors or a combination of psychosocial factors and hormonal changes (Levin et al., 2021). Another study indicating more severe symptoms in female than male patients was significant in the early stage, particularly following mTBI (Mikolić, Polinder, et al., 2021). This is in line with other studies that also show that women tend to report more symptoms and seek healthcare services more often than men (Fure et al., 2021). In this study, 38.9% of the participants were female, and the female group indeed had severer symptoms than the male group according to the data, this may explain the high occurrence of post-concussion syndrome in this study.

Educational level has an impact on the post-concussion syndrome of the mTBI population, the previous study showed that low education would aggravate behavior symptoms, a study showed that education, and age are important predictors for symptoms following mTBI (van der Naalt et al., 2017). Another study showed that post-concussion syndrome was associated with older age, female gender, less education (Cnossen et al., 2017). In this study, almost half of the participants had low level of education with primary school or lower (46.3%), which may explain the high rate of post-concussion syndrome in this study.

PCS are widely divided into 3 dimensions: physical symptoms, cognitive symptoms, and behavior symptoms.

Physical symptoms

Physical symptoms include headache, dizziness, sleep disturbance, fatigue, blurred vision, double vision, tinnitus, noise, or light sensitivity (Polinder et al., 2018). This is more helpful to distinguish between the types of symptoms. Physical symptoms appear early after the injury, also most frequent and most severe, and

decreased as time goes on after the injury (King & Kirwilliam, 2011). There is the possibility of progressive development of neurodegenerative disease with mTBI. When retinal axons are significantly reduced over time, mTBI patients have progressive loss of visual function (contrast and visual field sensitivity) and central nervous system function (Gilmore et al., 2020).

At 2 weeks after injury, more than half of patients complained of headache and dizziness, about 40% complained of noise sensitivity, light sensitivity, and sleep disturbances, about 30% complained of blurred vision and more than 20% complained of nausea (Polinder et al., 2018). The number of patients complaining of double vision was around 15% from 2 weeks to 1 year after the injury (Polinder et al., 2018). One year after the injury, patients complaining of dizziness, sound sensitivity, light sensitivity, sleep disturbance, and blurred vision all dropped to about 30% (Polinder et al., 2018). Only 15% of the patients continued to complain of nausea one year after the injury (Polinder et al., 2018).

Headache and dizziness are the most reported somatic symptoms in all patients with mild TBI (Sussman et al., 2018). Headache is one of the most disabling symptoms after mTBI, most of them exhibit the clinical features of primary headaches (Polinder et al., 2018). In the first week post-trauma, headache frequency ranges up to 90% and diminishes over time (Pundlik et al., 2020). A study in Thailand reported that 85.5% of mTBI samples having headache at 2 weeks after the trauma (Wannasrithong et al., 2016). Another study has reported headache in 47–78% at 3 months postinjury and in a longitudinal study at 6 months postinjury, 36% continued to suffer from headache (Katz et al., 2015). Persistent post-traumatic headache, occur in 10-15% of patients with mTBI (Marshall et al., 2015). 40% of mTBI patients still complained of headache one year later (Johansson & Rönnbäck, 2017). Dizziness complaints range from a sense of disequilibrium, imbalance, vertigo, or lightheadedness (Katz et al., 2015). Causes of post-traumatic dizziness include a variety of possible injuries and combined effects on peripheral and central vestibular functioning. Diffuse axonal injury and associated secondary pathology may disrupt central vestibular pathways.(Katz et al., 2015).

Fatigue is another common somatic complaint. Fatigue is almost invariable in most frequent symptoms from different studies (Losoi et al., 2016; Pavlovic et al.,

2019). A multicenter study reported 22% complaining of reduced energy at 3 months post mild TBI (Katz et al., 2015). One-third of mTBI patients complained of severe fatigue, decreased physical and social activities 6 months after injury, 40% still complained severe fatigue 1 year later, and 73% reported fatigue problems affecting their daily life 5 years later (Johansson & Rönnbäck, 2017).

In these patients, the persisting complaints are perceived as severe and distressing. They affect many aspects of life, may result in substantial decline in social and occupational functioning (Katz et al., 2015).

The presence and severity of PCS is commonly assessed clinically based on the Rivermead Post-concussion Symptom Questionnaire (RPQ) (King et al., 1995). Physical symptoms dimension including 9 items: “headaches”, “feeling of dizziness”, “nausea and/or vomiting”, “noise sensitivity, easily upset by loud noise”, “sleep disturbance”, “fatigue, tiring more easily”, “blurred vision”, “light sensitivity, easily upset by bright light” and “double vision”.

Cognitive symptoms

Cognitive symptoms of PCS include poor memory, poor concentration and taking longer to think (Twamley et al., 2014). In the cognitive domain, complaints are common in the early postinjury period. Patients generally complain of feeling foggy, losing track of thoughts and conversation, difficulty concentrating, inability to multitask, forgetfulness, and increased distractibility (Twamley et al., 2014).

Neuroimaging studies have identified abnormalities in the frontal cortex as a possible cause of cognitive dysfunction after mTBI (Li et al., 2019). Left middle frontal gyrus is an important component of information processing that coordinates short-term memory, attention, and emotion (Li et al., 2019). In addition, bilateral middle temporal gyrus (MTG) may be important for all aspects of working memory, visual and emotional cognitive perception, and has an important role in auditory and motor functions (Li et al., 2019). Previous neuroimaging studies have found that abnormalities in the frontal cortex may be the cause of cognitive impairment after mTBI. A study showed that acute mTBI showed decreased inflows from the left middle frontal gyrus (MFG) to bilateral middle temporal gyrus (MTG), left medial superior frontal gyrus (mSFG), and left anterior cingulate cortex (ACC) (Li et al., 2019). Of note, the degree centrality (DC) abnormalities in the left MFG and the

disrupted causal connectivity between left ACC and left MFG were significantly correlated with cognitive function performance in mTBI patients at the acute stage (Li et al., 2019).

A study showed that cognitive dysfunction after mTBI is very common (Maruta et al., 2018). Typically, patients with mTBI have mild cognitive dysfunction in the first 2 weeks after injury (Polinder et al., 2018). At 2 weeks post-injury, more than 60% of patients had trouble with "taking longer to think" and more than 50% had trouble with "poor memory" and “poor concentration” (Polinder et al., 2018). Due to the slow rate of remission of cognitive symptoms, long-term may remain higher than baseline levels post-injury, which may persist for more than 6 months in some of them (Polinder et al., 2018). One year after the injury, about 40% of the patients continued to suffer from "taking longer to think" and "poor memory", and more than 30% of the patients continued to suffer from "poor memory" and "poor concentration" (Polinder et al., 2018).

Several reviews have demonstrated improvement of overall cognitive functioning most rapidly in the first few weeks, returning to baseline by 3 months postinjury (Devi et al., 2020). In a meta-analysis, the greatest impairments in the subacute period involved delayed memory and fluency, but these deficits resolved by 3 months postinjury (Varner et al., 2017). Even when cognitive functioning has returned to baseline under usual demands, it is possible that cognitive capacity may still be vulnerable to various types of stressors because of residual brain damage, other injuries, or concomitant problems (Katz et al., 2015).

Based on the Rivermead Post-concussion Symptom Questionnaire (RPQ) (King et al., 1995). Cognitive symptoms dimension has 3 items: “forgetfulness, poor memory”, “poor concentration” and “taking longer to think”.

Behavioral symptoms

Behavioral symptoms include depression, irritability and anxiety (Broshek et al., 2015). Symptoms in the psychological domain are more common later, after the acute period following mild TBI. Emotional factors frequently interact with other symptoms and affect symptom reporting. Behavioral symptoms are often caused by damage to the frontal lobes, and these symptoms can lead to additional distress and make it difficult for patients to return to normal life (Broshek et al., 2015). In

particular, the left middle frontal gyrus and middle temporal gyrus are important for the information processing of emotions and the cognitive perception of emotions (Li et al., 2019).

Depression is extremely common following all severities of traumatic brain injury (Polinder et al., 2018). After 2 weeks of injury, more than 50% of patients with mTBI complained of loss and irritability, and more than 30% complained of depression (Polinder et al., 2018). After 1 month of injury, about 40% of patients complained of loss and irritability, and more than 20% of patients complained of depression (Polinder et al., 2018). Rates of depression between 11% and 44% have been reported within the first 3 months after injury. After 6 months of injury, more than 30% of patients still complained of loss and irritability (Polinder et al., 2018). The proportion of patients complaining of behavioral symptoms one year after injury decrease significantly from that at 6 months after injury. The younger age at the time of injury, the fewer memories of an unaffected life before the injury, leading to less depression, irritability, and frustration (Polinder et al., 2018).

Demoralization and discouragement related to delayed return to work and other social roles may further contribute to emotional symptoms. A study of patients with mTBI and moderate TBI showed that depression, irritability, and frustration had a significant impact on quality of life in patients (Li et al., 2019). Thus, the earlier the intervention for these problems, the less severe the behavioral symptoms (Di Battista et al., 2014).

Based on the Rivermead Post-concussion Symptom Questionnaire (RPQ) (King et al., 1995). Behavior symptoms including 4 items: “being irritable, easily angered”, “feeling depressed or tearful”, “feeling frustrated or impatient”, “restlessness.

All above persisting post-concussion syndrome can affect patient functional outcomes in all aspects of life. These symptoms can interfere with daily life and social and work activities **(Mikolić, Polinder, et al., 2021)**. That can be reduce mTBI’s quality of life in the future, thus this issue is very important for healthcare provider to concern and develop effective management for the persons with mild traumatic brain injury.

Functional performance in persons with mild traumatic brain injury

Definition of functional performance

Functional performance is observed in how the individual engages in the routine activities of everyday life, the perception of persons related to the difficulties and/or changes in the ability to perform activities in daily life, including the ability of engaged in home and social activities, which were communication, mobility, behavior skills, social skills, and daily living skills (Chen et al., 2016).

Functional performance in persons with mild traumatic brain injury

Patients with mTBI receive some impact on their functional performance in the physical domains (personal care, mobility, ability to travel), social (work/school, family maintenance, leisure/recreation, social integration, standard of living, financial independence) and psychological domains (ability to make decisions and execute) (Chen et al., 2016).

Several studies have suggested that changes occurring in neural regions associated with the default mode network (DMN) and medial temporal lobe may be associated with impaired task-related deactivation function (Johnson et al., 2012; Mayer et al., 2012). mTBI has the potential to disrupt brain function and even alter structural and functional normality over time (Xu et al., 2017). A recent prospective study showed that some patients experience persistent cognitive problems following mTBI. Most participants (mTBI, 87%) reported functional limitations at 2 weeks postinjury. At least 50% of patients who were followed up for mTBI demonstrated functional deficits on the Glasgow Outcome Scale Extended (GOSE) at 12 months after injury (Nelson et al., 2019). Approximately 50% of patients with mTBI experience chronic sleep disruption and associated cognitive decline after injury (Killgore et al., 2020). Sleep disorders can lead to a rapid decline in basic cognitive abilities with unpredictable decreases in attention and impairment of higher cognitive abilities such as judgment, decision-making and executive functions (Killgore et al., 2020).

A study have found that obvious functional impairment in patients with mTBI, 33% of the mTBI subjects were functional impaired at 3 months after injury, and 22.4% of the mTBI subjects who could be followed were still below full functional status at 1 year after injury (McMahon et al., 2014). Another study assessed

outcomes occurred at 2 weeks and 3, 6, and 12 months postinjury, found that functional limitation rates were highest at 2 weeks post injury and lowest at 12 months (Nelson et al., 2019). In one study, 29.3% of children and adolescents missed an average of more than one week of school due to physical symptoms such as headaches (Babcock et al., 2013). 34% of adult mTBI patients returned to work after one year, and behavioral symptoms were the main reason why mTBI patients did not return to work within one year (Vikane et al., 2016). Even patients with mTBI may struggle to reach complete return to work if twelve months after injury. Problems with reattaining pre-injury occupational status may lead to reduced social integration and quality of life (Fure et al., 2021).

Since they have problems with attention, learning, and memory, their ability to solve problems and interact socially decreases and even affects their daily activities (Twamley et al., 2014). Among adolescents, engagement in school activity often decreases and absenteeism rates increase (Olsson et al., 2013). Sleep disorders after injury in mTBI can lead to rapid decline in basic cognitive abilities, unpredictable decreases in attention, lead to judgment, decision-making, and executive functions impaired, these patients often experience a decrease in their work and study efficiency (Killgore et al., 2020). Headaches and fatigue are symptoms that often lead to limited daily activities and decreased physical function, so the physical condition is getting worse (Li et al., 2019). What's more, due to the inability to live and work as normal as before, the incomprehension of family and friends leads to the deterioration of the relationship, and the criticism from boss and colleagues leads to bad social interaction (Twamley et al., 2014). These functioning problems and decreased ability to perform previous activities may affect the ability to resume work or study, which will make it difficult for them to reintegrate into society, then lead to decreased life satisfaction and increased medical burden (Styrke et al., 2014).

These functional limitations may be related to post-concussion syndrome (PCS), since continued post-concussion syndrome seriously affect functional performance (Fineblit et al., 2016). The relationship between post-concussion syndrome and functional performance in this study was guided by The Theory of Unpleasant Symptoms (Lenz et al., 1997).

The Theory of Unpleasant Symptoms

The Theory of Unpleasant Symptoms, developed by Lenz, Pugh, Milligan, Gift, and Suppe (1997), includes both single and multiple symptom experiences and explains the relationship between performance, which is the result of symptom experience, and the antecedent factors that influence symptom experience, as a dynamic relationship (Lenz et al., 1997). TOUS is a middle-range theory that was developed and intended for use and application by nurses, the first concept paper of the TOUS appeared during 1995 and was later revised during 1997 (Lenz et al., 1997; Lenz et al., 1995).The three main components of this theory are the symptoms the individual is experiencing, the factors that influence or affect symptoms and that give rise to the nature of the symptoms, and the consequences of this experience.

Symptoms include four dimensions: timing (duration and frequency of occurrence), intensity (strength or severity), quality, and distress (degree of discomfort or bother), these four symptom dimensions may interact with one another (Blakeman, 2019). Intensity refers to the severity, strength, or amount of the symptom being experienced, is the dimension of symptoms most often addressed in clinical assessment and research. The time dimension includes the frequency of symptom occurs and duration of a persistent symptom, also refer to the timing of a symptom's occurrence relative to specific activities. The distress dimension refers to the degree to which the person is bothered by it. It is also a dimension that most contributes to quality of life. Quality is to describe what the symptom feel like, also include description of the location of a given sensation, as well as the degree to which a patient responds to a particular intervention (Lenz et al., 1997).

The factors affecting symptoms include: 1) physiological factors; 2) psychological factors; and 3) situational factors. Physiological factors including normal body systems, pathologic problems, and energy substates, factors like an alteration in nutrition or amount of sleep could influence symptoms (Blakeman, 2019). Psychological factors including mental state/mood, affective reaction to illness, and degree of uncertainty/knowledge about symptoms and their meaning such as state anxiety (Blakeman, 2019). Situational factors including social environment and physical environment, such as social support or socioeconomic status (Blakeman, 2019). Performance is the consequences of this experience; performance has two

dimensions: functional performance and cognitive activities. Functional performance including physical activities, activities of daily living, and social activities and role performance. Cognitive activities including concentrating, thinking, and problem solving (Lee et al., 2017).

The TOUS was one of the first theories to represent influencing factors on the simultaneous occurrence and interaction of multiple symptoms (Silva-Rodrigues et al., 2019). From the theory, symptom influences performance directly, influencing factors influences symptoms directly and influencing performance indirectly. Performance feedback the symptoms and influencing factors, symptoms also feedback the influencing factors. Symptoms interact with each other, influencing factors also interact with each other. This theory illustrates the complex nature of the symptom experience, which involves innumerable potential variables (Gholami et al., 2020). Symptom cluster including three or more concurrent symptoms that are somehow related but possibly of different etiologies and likely synergistic in outcome (Moore, 2021). Notably, symptoms may interact with one another, perhaps catalyzing each other (Silva-Rodrigues et al., 2019). Not only do these three influencing factors have an impact on symptoms, but also these factors may have a relationship with one another (Blakeman, 2019). Moreover, moderating effects may be present between influencing factors and symptoms (Blakeman, 2019). Performance is the consequences of the symptom experience, such as activities of daily living and quality of life (Blakeman, 2019). Symptoms themselves can affect individual's ability to perform but also that influencing factors can affected performance indirectly (Blakeman, 2019).

Altogether, the TOUS provides a comprehensive framework through which to consider the symptom experience. It offers a holistic way for investigators to conduct symptom research. TOUS is a mechanism that provides a structured, comprehensive approach to symptom understanding that can help describe, explain, and predict phenomena (Kim et al., 2020). Moreover, this theory allows researchers from diverse perspectives to conduct symptom research on any number of symptoms and to advance symptom science (Blakeman, 2019). There is an interaction between it and practice, as these theories can help practice, and practice can inform theory and further theory development (Ozel et al., 2018).

In this study, post-concussion syndrome (PCS) are symptoms the individual is experiencing, and the functional performance is the consequences of this experience. PCS such as headaches, poor memory and depression often lead to poor functional performance to some extent, such as failing to resume work or study (Mollayeva et al., 2017). The timing of PCS in this study was 2 weeks, the intensity, distress, and quality of PCS in this study was measured by the Rivermead Post-Concussion Symptoms Questionnaire (RPQ), the functional performance was measured by the Rivermead Head Injury Follow Up Questionnaire (RHFUQ).

Given that patients with mTBI often have multiple PCS that co-occur, interact with each other, and exacerbate symptoms, understanding the relationship between symptom presentation and function may be more important than simply identifying the etiology of individual symptoms (Herrold et al., 2019). PCS could influence functional performance directly, However, functional limitations will feedback the symptoms themselves in turn, such as depression caused by poor ability and poor relationships with family and friends. What's more, symptoms themselves can interact with each other, exacerbate PCS, then lead to worse outcomes.

Post-concussion syndrome including 16 symptoms are divided into three clinical domains: physical symptoms, cognitive symptoms, and behavioral symptoms, these symptoms interact with each other and exacerbate symptoms. The relationship between these three symptoms with functional performance among persons with mild traumatic brain injury need to be understand. This study explained the relationship between physical symptoms, cognitive symptoms, behavioral symptoms with performance outcomes.

Relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavior symptoms) and functional performance among persons with mild traumatic brain injury

Post-concussion syndrome (PCS) following mTBI seriously affect functional performance and then affect the ability to resume work or study, which will make it difficult for them to reintegrate into society and can result in low levels of satisfaction with quality of life (Fineblit et al., 2016). PCSs are associated with functional limitations and reduced quality of life. Symptoms such as headache,

fatigue, dizziness, tinnitus, poor concentration, depression, sleep disturbance, memory impairment, disorientation, irritability, and anxiety can all affect the functional performance of people with mTBI and their ability to live (Chen et al., 2016). Functional magnetic resonance imaging (fMRI) was able to detect functional differences in individuals after mTBI, and these differences were correlated with PCS (Dean et al., 2015).

Physical symptoms appear early after the injury, also most frequent and most severe. Physical symptoms have obvious impact on the patient's social functioning performance. Fatigue, headache are all very common symptoms in patients with mTBI, they affect many aspects of life and lead to a substantial decline in social and occupational functions (Losoi et al., 2016). 40% of mTBI patients still complain of fatigue and headaches after one year, and this chronic distress often has an impact on physical performance such as the patient's ability to travel (Johansson & Rönnbäck, 2017). Changes in vision can affect the individual's ability to complete activities of daily living and instrumental activities of daily living. In addition, sleep disorders can lead to impaired executive function performance, which can have a significant impact on the lives of mTBI patients (Killgore et al., 2020).

Cognitive symptoms like working memory deficits can contribute to problems in other aspects of academic, vocational, and social functioning (Westfall et al., 2015). Changes in cognition can affect the individual's ability to complete activities of daily living and instrumental activities of daily living of mTBI patients (Killgore et al., 2020). Cognitively impaired patients reported poorer abilities on the physical, social role and emotional role functioning, and mental health domains, post-TBI cognitive impairment has negative effects on functional outcome, (Gorgoraptis et al., 2019). Cognitive deficits, which often reported by the mTBI may affect the continuous rehabilitative and therapeutic process and affect the activities of daily living as well as the quality of life (Devi et al., 2020). Some of individuals who returned to work within 1 month had mild cognitive impairment, this leads to a decrease in work efficiency (Killgore et al., 2020).

Behavior symptoms such as depression can affect the patient's functional performance in the social domain, and the more severe the depression, the more difficult it is for people with mTBI to integrate socially (Herrold et al., 2019). The

effect on the social functioning performance of patients with mTBI is particularly significant when patients have 2 or more behavioral symptoms at the same time (Di Battista et al., 2014). Depression, and daytime sleepiness are common consequences of mTBI, which can also affect cognitive function (Gorgoraptis et al., 2019).

Meanwhile, severe PCS can cause a slow recovery of functional performance (McMahon et al., 2014). Patients with more severe symptoms tend to have more severe function impairment at one year (McMahon et al., 2014). Similarly, patients who complain of having more PCS often have worse recovery of functional performance (Herrold et al., 2019). Patients with mTBI often have multiple symptoms, and it is more important to understand the impact of these symptoms together on functional performance than to study individual symptoms (Herrold et al., 2019). A study showed that PCS alone may not significantly affect functional performance in patients with mTBI, however the combination of multiple symptoms often results in significant functional impairment (Herrold et al., 2019). One symptom can also affect other symptoms of the tract, pain that may cause depression, sleep disturbances can cause fatigue and headaches (Stein et al., 2016), depression and irritability can lead to increased physical symptoms such as lack of sleep and headaches (Stein et al., 2016). The interplay between different symptoms plays an important role in the way symptom clusters influence functional performance (McCrory et al., 2009).

Summary

Mild traumatic brain injury (mTBI) accounts for a large proportion of TBI, 70-90% patients with TBI are diagnosed with mTBI. Because of the mild degree of injury, patients and health care providers often do not attach importance to the recovery process of mTBI. However, many patients experience post-concussion syndrome and impaired functional performance after the trauma and these are most frequent in the early stage, ones have more severe PCS tend to have worse functional performance, which affects mTBI recovery from functional impairment and fail to return to society. Considering that mTBI accounts for the vast majority of TBI patients in China, the economic burden of prolonged treatment and decreased

productivity, it is important to promptly identify mTBI persons who are at high risk of long-term consequences and make assessment and intervention in the early stages.

From the literature review, we found that physical, cognitive, and behavioral symptoms have a very significant impact on functional performance in mTBI patients. This study guided by TOUS will bridge the gap and provide a scientific basis for relationship between PCS and functional performance in Chinese persons with mTBI at 2 weeks post-trauma for improving nursing practice and nursing research development.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter presented the research methodology of the study that included information of research design, population, and sampling, setting of the study, research instruments, protection of human rights, data collection and data analysis process.

Research design

A descriptive correlational research design was used to investigate post-concussion symptoms, functional performance at 2 weeks after the trauma, and the relationship between physical symptoms, cognitive symptoms, and behavioral symptoms with functional performance among persons with mild traumatic brain injury at 2 weeks after the trauma.

Population and sample

Population

The population of this study were persons with first-ever mild traumatic brain injury who were treated in the neurosurgery wards, and after discharge from hospital, they came to visit the neurosurgery outpatient department (OPD) of the First Affiliated Hospital of Wenzhou Medical University, after trauma 2 weeks for follow up their condition. It was estimated 45 patients with mild traumatic brain injury had been serviced at this department per month.

Sample

The samples of this study were patients with first-ever mild traumatic brain injury who were treated in the neurosurgery wards, and after discharge, they came to visit the neurosurgery outpatient department (OPD) of the First Affiliated Hospital of Wenzhou Medical University, after trauma 2 weeks for follow up their condition. These samples were recruited follow these inclusion criteria:

1. ≥ 18 years of age.
2. Consciousness, have a good orientation to person, place, and time

(GCS =15).

3. Have ability to read and write in Chinese.

4. No history of other injury.

5. No history of psychiatric illness (from medical record).

6. No alcohol addict before injury.

7. No history of disability or physical impairment (weakness, blindness, etc.)

Termination criteria:

During collecting data, if the samples had any symptoms of physical discomfort such as headache, dizzy, etc. The researcher would stop the collecting data process and provide basic standard nursing care, moreover, notified the nurses to continue providing care according to the standards of the hospital.

Sample size

Sample size was calculated using the G*Power 3.1.9.7 program for correlational design (Faul et al., 2009). Effect sizes from previous studies ranged from 0.22-0.46 (Petchprapai, 2017; Voormolen, Polinder, et al., 2019; Yousefzadeh-Chabok et al., 2019). In this study, the effect size of 0.27 was from the rang and more suitable (Guty & Arnett, 2018), therefore, the correlation bivariate normal model would choose as type of statistical test in G*Power program with a significance level of .05, statistical power of .80, and an estimated moderate effect size (0.27). The power analysis showed that appropriate sample size for this study was to have at least 105 participants. Considering possible dropouts or potential outlier data, it was increased by 10% from the calculated result (Martínez-Mesa et al., 2014). So, the sample size was 115, however, there were 7 participants stopped from the data collection because of the symptoms, 4 of them got headache, 2 of them got dizzy, 1 of them got vomiting. So, the sample size in this study was 108 participants at the end.

Sampling technique

Study participants were recruited from all patients with mTBI who came to visit the neurosurgery OPD of the First Affiliated Hospital of Wenzhou Medical University. Sampling technic by determining the period, the selection was completely accidental, and everyone had the same opportunity to be selected. First, researchers recruited patients who meet inclusion criteria. The researchers asked these patients whether they were willing to participate in the study. Patients who agreed to

participate in the study become participants of the study after signing the consent form. 1-5 patients were recruit daily to participate in the study. Recruitment took place from Monday to Sunday. When participants reached the required sample size, recruitment cease, and the next phase of the study proceeded.

Research Setting

This study was conducted in neurosurgery OPD of the First Affiliated Hospital of Wenzhou Medical University in Wenzhou, China. Neurosurgery OPD opened six days a week from 8 a.m. to 4:30 p.m. and received an average of 50-75 patients per day and 1-5 patients were mild traumatic brain injury. Patients with mTBI came to the first-time follow-up at 2 weeks after discharge, they followed up 2-3 times within 3 months if they got some abnormal conditions. Most of mTBI came to neurosurgery OPD alone or accompanied by one person, they signed in at the consulting desk of the OPD on the day of the appointment, then waited to be called the queue number.

There was one doctor and one nurse on duty in neurosurgery OPD every day. Doctor examined and treated patients according to their symptoms, if the patient's condition changed, the doctor would conduct relevant examinations. Nurse observed the patient's vital signs, introduced the patient to different doctor's consultation directions according to the symptoms and helped the patient to make an appointment for the next follow-up visit.

Research Instruments

The data for the study were collected using 3 questionnaires. The details of the research instruments were as follows:

The Demographic Questionnaire

The specific Demographic Questionnaire of this study was developed by researcher and consisted of two parts. Part 1 of the Demographic Questionnaire contained general information about the participants, including age, sex, marital status, occupation, educational background, living condition, income level, and working status. Part 2 of the Demographic Questionnaire contained health information about the participants, including the cause of injury, the time of injury,

duration of admission, GCS, wound at head, CT scan brain, history of unconscious after accident, history of memory loss after accident, current treatment options, comorbidity, and the date that the participant start working, etc. The information in Part 1 was self-reported by the participants, and the information in Part 2 was recorded by researcher from the participants' medical record information and interviewed the participants.

The Rivermead Post-Concussion Symptoms Questionnaire [RPQ]

In this study, The RPQ scale developed by King and coworkers (1995) was used to measure the frequency and severity of post-concussion symptoms among persons with mTBI at 2 weeks after trauma in this study (King et al., 1995). The Chinese version was translated by Ling Zong (Zong & Zhu, 2011). The RPQ scale consists of 16 items to assess the severity and disturbance of daily life of 16 different PCS symptoms that typically occur follow TBI. There are 3 dimensions including:

1) Physical symptoms 9 items: headaches, feelings of dizziness, nausea and/or vomiting, noise sensitivity, sleep disturbance, fatigue, blurred vision, light sensitivity, double vision. Physical symptoms dimension scale was used to measure the frequency and severity of physical symptoms among persons with mTBI at 2 weeks after trauma.

2) Cognitive symptoms 3 items: forgetfulness, poor concentration, taking longer to think. Cognitive symptoms dimension scale was used to measure the frequency and severity of cognitive symptoms among persons with mTBI at 2 weeks after trauma.

3) Behavior symptoms 4 items: being irritable, feeling depressed or tearful, feeling frustrated or impatient, restlessness. Behavior symptoms dimension scale was used to measure the frequency and severity of behavior symptoms among persons with mTBI at 2 weeks after trauma.

The scale uses five numerical categories, which 0=not experienced at all, 1=it is no longer a problem, 2=a mild problem, 3=a moderate problem and 4=a severe problem. Therefore, total scores using the sum of all items and range from 0 (representing no change in symptoms since the head injury) to 64(most severe symptoms).

The Chinese version scales show good reliability of Cronbach's alpha .86 (Zong, 2009).

The Rivermead Head Injury Follow Up Questionnaire [RHFQO]

In this study, the RHFQO developed by Crawford et al (1996) was used to measure functional performance among persons with mTBI at 2 weeks after trauma (Crawford et al., 1996). The Chinese version of this measure was translated by Ling Zong (Zong & Zhu, 2011). The RHFQO was designed to measure functional and social outcomes following mild to moderate TBI, focusing on participation rather than impairment. This self-report questionnaire contains 10 items and covers a perceived difficulties and/or changes in the ability to perform activities in daily life, since prior to their head injury, including the ability of engaged in home and social activities, which were communication, mobility, behavior skills, social skills, and daily living skills (Chen et al., 2016).The scale uses five numerical categories, which, giving a potential total score range of 0-40, high scores on the RHFQO are indicative of poor recovery. The score 0=no change, 1=no change, but more difficult, 2=a mild change, 3=a moderate change and 4=a very marked change. The reliability for the Chinese version of the Rivermead Head Injury Follow Up Questionnaire is .84 (Zong, 2009)

Psychometric property of the instruments

The original versions of the scales used in this study were widely used internationally. Chinese translated versions had been tested and verified by experts in some studies, and internal consistency and reliability had been tested. As shown by construct validity in previous studies, the reliability of all instruments was found to be excellent. However, before the researchers started the study, the reliability of the instruments was checked by calculating Cronbach's alpha in 30 mTBI patients who had the same characteristics as the sample of the study, and Cronbach's alpha of RPQ was .86, Cronbach's alpha of physical dimension is .83, the cognitive dimension is .86, the behavior dimension is .88. The Cronbach's alpha of RHFQO was .83. For this study with 108 participants, the Cronbach's alpha for RPQ was .87, Cronbach's alpha of physical dimension is .77, the cognitive dimension is .83, the behavior dimension is .86. The Cronbach's alpha of RHFQO was .89.

Protection of human rights

This research was carried out only after the research proposal had been approved by the Institutional Review Board (IRB), Burapha University (Protocol code G-HS 049/2564) and the research ethical board of the First Affiliated of Wenzhou Medical University (Protocol code 2021-zz-103). The data collection process could only begin if the concerned authorities of the hospital and department allowed researchers to collect data in the hospital.

During data collection, all participants were informed about the purpose and procedures of the study involved when the researchers collect the data. Researchers can only collect data from patients who sign a written informed consent. The participants were informed that they can refuse to participate in the study without any adverse consequences, that they had the right to withdraw from the study at the any time after participating in the study. When participants changed their minds, the researchers stopped using them as part of the study immediately and will no longer use their data in the study. During data collection and document processing, the identity information of all participants was kept completely confidential.

To protect the privacy of participants, all paper documents containing data were locked in secure locations, all electronic data containing were password protected, and only allowing the researchers to view them at the same time. All documents involved in data collection would be destroyed one year after the publication of the study report.

Data collection

The data collection process for the study were carried out by the researcher as follows:

1. After the researcher got proposal approval from the Faculty of Nursing in Burapha University [BUU], the researcher submitted the research proposal to Institutional Review Board [IRB] in BUU and IRB in the First Affiliated Hospital of Wenzhou Medical University, China for ethical review.

2. The researcher asked the faculty of nursing of BUU and the First Affiliated Hospital of Wenzhou Medical University in China for permission to collect data regarding the objectives and procedures of the study information.

3. The letter for permission to collect data from Faculty of nursing of BUU was given to the First Affiliated Hospital of Wenzhou Medical University in Wenzhou, China. After got permission from the First Affiliated Hospital of Wenzhou Medical University, the researcher explained the data collection procedures to the head nurse of neurosurgery outpatient department [OPD] where the data had been collected.

4. The process of data collection was explained to the staffs in the neurosurgery OPD. The researcher talked with doctors and nurses in advance and ensured that if the patient was occupied when the queue number was called, the patient' s visit to the doctor would be protected.

5. Researcher went to the neurosurgery OPD on Monday to Saturday from 8:00 am to 11: 30 am, 1:30 pm to 4:30 pm during the times of providing queue number to the patients.

6. The researcher followed the registration record, asked the head nurse for help to find the patients appropriate with the inclusion criteria. For simple random sampling, the queue number was randomly selected to recruit the participants, then the head nurse asked the participants who met the inclusion criteria whether they were interested in participating in this study. If they were interested and agreed, the head nurse would allow the researcher to approach the patients. The individual was taken by the outpatient nurse to the special private room when waiting for the doctors.

7. Participants were approached by the researcher. Then the researcher explained the aims, ethical issues, and human protection of the study to the participants. Written consents were taken if they were willing, and questionnaire was distributed.

8. The data was collected through self-reported questionnaires in the special private room, each participant took approximately 30 minutes to complete the whole set of self-report questionnaires. First filled in The Demographic Questionnaire and then The Rivermead Post-Concussion Symptoms Questionnaire [RPQ] and The Rivermead Head Injury Follow Up Questionnaire [RHFQO]. During collecting data, the researcher closely observed, if the samples had any symptoms developed, stopped data collection, and notified the nurses and the doctor immediately.

9. The guidelines for preventing COVID-19 during data collection process was concern by:

9.1 The researcher and the participants wore masks correctly throughout the data collection process.

9.2 A safe distance of at least 1 meter were maintained between the researcher and the participants.

9.3 Participants needed to wash their hands with alcohol before and after data collection.

9.4 Items touched by participants were cleaned and disinfected before being given to the next participant.

9.5 Completed questionnaires were kept in a separate archive bag.

10. The researcher checked if the questionnaires had been completed before the participants left.

11. This process was repeated until met the sample size was reached 108 participants.

Data analysis

Data was analyzed using statistic software (SPSS 26.0) at alpha (α) level of .05. The following statistical function was used for analysis of the data:

1. Descriptive statistics including frequencies, percentages, means, and standard deviations were used to describe the demographic characteristics, physical symptoms, cognitive symptoms, behavioral symptoms, and functional performance of patients with mTBI.

2. The normality of all variables were examined with the Kolmogorov-Smirnov test.

3. Correlation analyses were performed using Pearson’s product moment correlation coefficient to explore the relationship between physical symptoms, cognitive symptoms, and behavioral symptoms with functional performance of patients with mTBI.

CHAPTER 4
RESULTS

This chapter presents the results of data analysis. The purpose of this study was to examine post-concussion syndrome and functional performance among persons with mild traumatic brain injury 2 weeks after the trauma and to examine the relationship between physical symptoms, cognitive symptoms, and behavioral symptoms with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China. The finding of the study is presented under three sections as follows:

1. Description of participants characteristics and health information.
2. Description of post-concussion syndrome (physical symptoms, cognitive symptoms, behavioral symptoms, and functional performance) among persons with mild traumatic brain injury.
3. Relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavioral symptoms) with functional performance among persons with mild traumatic brain injury in Wenzhou, China.

Description of demographic characteristics and health information

Demographic characteristics

A total number of 108 persons with mild traumatic brain injury. The participants consisted of 66 males (61.1%) and 42 females (38.9 %). The age of participants ranged from 18 years old to 85 years old with a mean age of 49.26 years, 38% of them were under 18-44 years old, 31.5% of them were under 45-60 years old. Majority of the participants were married (78.7%) and living with family members (84.3%). Almost half of the participants had education level with secondary/high school (46.3%), 33.3% had finished primary school, while small percentage of participants (4.6%) were illiterate, but they could read and write. For individual income, there were 46.3% of the participants having income that less than RMB 2,000 per month. For occupation before injury, more than half of the participants (59.3%) were employed, while 40.7% were unemployed. For the employed participants, the

largest proportion was laborer (25%), followed by business (18.5%) and farmer (10.2%). For unemployed participants, the largest proportion was house working (25%), followed by retired (9.3%), and 6.5% of the participants were student. For the occupational status after injury for those who employed, most of them returned to work within 2 weeks after the trauma (62.5%), 28.1% of them had a temporary leave from work, while 9.4% of them were unable return to work because of injury. Then for the student, 71.4% of them had returned to school within 2 weeks after the trauma, only 28.6% had a temporary leave from school. Demographic characteristics of the participants were shown in Table 1.

Table 1 Frequency, percentage, mean, and standard deviation of demographic characteristics of the participants (n=108)

Characteristics	**Number (n)**	**Percentage (%)**
Age		
18 - 44 years	41	38
45 - 60 years	34	31.5
61 - 75 years	27	25
76 - 85 years	6	5.5
(M = 49.26, SD = 17.89, min = 18, max = 85)		
Gender		
Male	66	61.1
Female	42	38.9
Marital status		
Single	15	13.9
Married	85	78.7
Divorced	6	5.6
Widowed	2	1.8
Living condition		
Living alone	17	15.7
Living with family members	91	84.3

Table 1 (Continued)

Characteristics	Number (n)	Percentage (%)
Level of education		
Illiterate	5	4.6
Less than primary	9	8.4
Primary school	36	33.3
Secondary/High school	50	46.3
Bachelor's degree and higher	8	7.4
Individual income (income/month in RMB, 6.47 RMB=1 USD)		
Less than ¥ 2,000	50	46.3
¥ 2,000 - 4,999	19	17.6
¥ 5,000 - 8,000	24	22.2
More than ¥ 8,000	15	13.9
Occupation		
Employed	64	59.3
Business	20	18.5
Government/civil service	6	5.6
Farmer	11	10.2
Laborer	27	25
Unemployed	44	40.7
Student	7	6.5
Retired	10	9.2
House working	27	25
Occupational status after injury for those who employed (n=64)		
Return to work	40	62.5
A temporary leave from work	18	28.1
Unable to return to work	6	9.4
Study status after injury for student (n=7)		
Return to study	5	71.4
A temporary leave from study	2	28.6

Health information

For the cause of injury, almost all the participants due to fall (51.9%) and car accident (42.6%). For the GCS on admission day, 93.5% of the participants was at full mark 15, only 6.5% was 13-14. All the participants were at full mark 15 (100%) on discharge day. The results found that 15.7% of participants' injury related to drinking. Most of the participants had no open wound at head (75.9%), 20.4% had only 1 wound. However, 66.7% participants' CT showed abnormal brain lesion, 12.9% CT showed fracture skull. For the participants who had 1 abnormal condition (51.9%), most of them were subarachnoid hemorrhage (25.9%), next was subdural hemorrhage (23.2%). For the history of the unconsciousness, 55.6% of the participants had unconsciousness after the injury, and 33.4% lasted for 1-5 minutes (M=4.79, SD=7.24). However, most of the participants had no memory loss (92.6%), for those who had history of memory loss, time of duration was all within 5 minutes (M=0.19, SD=0.81). Most of the participants had no comorbidity (74.1%), 23.1% of the participants had only 1 comorbidity, 12% of the participants were hypertension and 9.3% were diabetes. For the duration of admission, 58.3% of the participants were hospitalized for 4-7 days (M = 6.35, SD = 2.12). For the occur of post-concussion syndrome, 90.7% had post-concussion syndrome at 2 weeks after the trauma. Health information of the participants were shown in Table 2.

Table 2 Frequency, percentage, mean, and standard deviation of health information of the participants (n=108)

Health information	**Number (n)**	**Percentage (%)**
The cause of injury		
Falling	56	51.9
Car accident	46	42.6
Body assaulted	6	5.5
GCS on admission day		
15	101	93.5
13 - 14	7	6.5

Table 2 (Continued)

Health information	Number (n)	Percentage (%)
GCS on discharge day		
15	108	100.0
Whether the injury related to drinking		
Yes	17	15.7
No	91	84.3
Wound at head		
None	82	75.9
Yes	26	24.1
1 wound	22	20.4
Parietal area	2	1.8
Occipital area	6	5.6
Temporal area	6	5.6
Frontal area	8	7.4
2 wounds	4	3.7
Parietal area and occipital area	4	3.7
CT scan brain		
CT showed no abnormality	22	20.4
CT showed fracture skull	14	12.9
CT showed abnormal brain lesions	72	66.7
1 brain lesion	56	51.9
SAH*	28	25.9
SDH*	25	23.2
EDH*	3	2.8
2 brain lesions	13	12.0
SAH*＆SDH*	12	11.1
SAH*＆EDH*	1	.9
3 brain lesions	3	2.8
SAH*＆SDH*＆EDH*	3	2.8

Table 2 (Continued)

Health information	Number (n)	Percentage (%)
History of unconscious after accident		
Always conscious	48	44.4
Have history of unconsciousness	60	55.6
1 - 5 minutes	36	33.4
6 - 10 minutes	4	3.7
11 - 15 minutes	5	4.6
16 - 20 minutes	14	13
21 - 25 minutes	1	.9
(M = 4.79, SD = 7.24, min = 0, max = 25)		
History of memory loss after accident		
No memory loss	100	92.6
Have memory loss at first 5 minutes	8	7.4
Co-morbidities		
None	80	74.1
1 co-morbidity	25	23.1
Hypertension	13	12
Diabetes	10	9.3
Heart disease	2	1.8
More than 1 co-morbidity	3	2.8
Hypertension and diabetes	3	2.8
Duration of admission		
2 - 3 days	11	10.2
4 - 7 days	63	58.3
8 - 12 days	34	31.5
(M = 6.35, SD = 2.12, min = 2, max = 12)		

* SAH: Subarachnoid hemorrhage; SDH: Subdural hemorrhage; EDH: Extradural hemorrhage.

Description of post-concussion syndrome (physical symptoms, cognitive symptoms, and behavioral symptoms)

Post-concussion syndrome including physical symptoms, cognitive symptoms, and behavioral symptoms. In physical symptoms, headache was most frequent (59.3%), for severity and disturbance, 10.2% had a mild problem, however, 9.3% had a moderate problem, 5.6% had a severe problem. The second was feeling of dizziness (46.3%), for severity and disturbance, 11.1% had a mild problem. Another frequent symptom after the trauma was fatigue (41.7%), 15.7% had a mild problem, 4.6% had a moderate problem, while 5.6% had a severe problem. The last relatively frequent symptom was sleep disturbance (34.3%), for severity and disturbance, 5.6% had a moderate problem, 9.3% had a severe problem, scores with a mean of 0.47 (SD = 0.51). In cognitive symptoms, forgetfulness, poor memory was most frequent (33.3%), for severity and disturbance, 12% had a mild problem, however, 4.2% had a moderate problem, 1.9% had a severe problem. The second was poor concentration (29.6%), for severity and disturbance, 8.3% had a mild problem, however, 3.7% had a moderate problem, 2.8% had a severe problem. The last was taking longer to think (27.8%), for severity and disturbance, 9.3% had a mild problem, 5.6% had a moderate problem, scores with a mean of 0.55 (SD = 0.84). In behavior symptoms, being irritable, easily angered was most frequent (30.6%), for severity and disturbance, 9.3% had a moderated problem, 5.6% had a severe problem. The second was feeling frustrated or impatient (27.8%), for severity and disturbance, 8.3% had a mild problem, 3.7% had a moderate problem. Next was feeling depressed or tearful (24.1%), for severity and disturbance, 6.5% had a moderated problem, 2.8% had a severe problem. Last was restlessness (21.3%), for severity and disturbance, 4.6% had a moderated problem, 4.6% had a severe problem, scores with a mean of 0.55 (SD = 0.90).

Table 3 Frequency, percentage of post-concussion syndrome, mean and standard deviation of the scores of post-concussion syndrome (physical symptoms, cognitive symptoms, and behavioral symptoms) (n = 108)

Post-concussion syndrome	**Whether experienced**		**Severity and disturbance of life**					
	No (n/%)	Yes (n/%)	1 (no more problem (n/%)	2 (mild problem) (n/%)	3(moderate problem) (n/%)	4(severe problem) (n/%)	**M**	**SD**
Physical symptoms	14/13	94/87					.47	.51
Headache	44/40.7	64/59.3	37/34.3	11/10.2	10/9.3	6/5.6	1.05	1.18
Feelings of dizziness	58/53.7	50/46.3	35/32.4	12/11.1	2/1.9	1/.9	.64	.83
Fatigue, tiring easily	63/58.3	45/41.7	17/15.7	17/15.7	5/4.6	6/5.6	.83	1.19
Sleep disturbance	71/65.7	37/34.3	12/11.1	9/8.3	6/5.6	10/9.3	.81	1.33
Nausea and/or vomiting	90/83.3	18/16.7	16/14.8	2/1.9	0/0	0/0	.19	.44
Noise sensitivity, easily upset by loud noise	90/83.3	18/16.7	13/12	5/4.6	0/0	0/0	.21	.51
Blurred vision	92/85.2	16/14.8	11/10.2	2/1.9	2/1.9	1/.9	.23	.66
Light sensitivity, easily. upset by bright light	92/85.2	16/14.8	11/10.2	4/3.7	1/.9	0/0	.20	.54
Double vision	100/92.6	8/7.4	8/7.4	0/0	0/0	0/0	.07	.26
Cognitive symptoms	63/58.3	45/41.7					.55	.84
Forgetfulness, poor memory	72/66.7	36/33.3	16/14.8	13/12	5/4.2	2/1.9	.60	.99
Poor concentration	76/70.4	32/29.6	16/14.8	9/8.3	4/3.7	3/2.8	.54	.99
Taking longer to think	78/72.2	30/27.8	13/12	10/9.3	6/5.6	1/.9	.51	.94
Behavior symptoms	67/62	41/38					.55	.90
Being irritable, easily angered	75/69.4	33/30.6	13/12	4/3.7	10/9.3	6/5.6	.69	1.23
Feeling frustrated or impatient	78/72.2	30/27.8	16/14.8	9/8.3	4/3.7	1/.9	.46	.87
Feeling depressed or tearful	82/75.9	26/24.1	10/9.3	6/5.6	7/6.5	3/2.8	.51	1.05
Restlessness	85/78.7	23/21.3	4/3.7	9/8.3	5/4.6	5/4.6	.53	1.12

Description of functional performance among persons with mild traumatic brain injury

In this study, the functional performance (perceived difficulty and/or change in functional performance) total scores ranged from 0 to 2.6, and the mean score was .55 (SD = 0.70). Each item's possible score was ranged from 0-4. The item with the lowest score (lowest perceived difficulty and/or change in functional performance) was "Ability to participate in conversation with one person" ranged from 0 to 2 with a mean score of .11 (SD=0.34). Followed by "Ability to participate in conversation with 2 or more people" ranged from 0 to 3 with a mean score of .37 (SD=0.68). The highest score (highest perceived difficulty and/or change in functional performance) was "Ability to participate in previous social activities" ranged from 0 to 4 with a mean score of .90 (SD=1.28). Followed by "Ability to maintain your previous workload or quality of work" ranged from 0 to 4 with a mean score of .87 (SD=1.24).

Table 4 Range, mean and standard deviation of functional performance (n = 108)

Functional performance	Range		M	SD
	Possible score	Actual score		
Ability to participate in conversation with one person.	0 - 4	0 - 2	.11	.34
Ability to participate in conversation with 2 or more people	0 - 4	0 - 3	.37	.68
Relationship with previous friends	0 - 4	0 - 4	.38	.84
Performance of routine domestic activities	0 - 4	0 - 4	.49	.91
Finding work more tiring	0 - 4	0 - 4	.54	.96
Ability to cope with or handle family demands	0 - 4	0 - 4	.59	.96

Table 4 (Continued)

RHFQO	Range		M	SD
	Possible score	Actual score		
Ability to enjoy previous leisure activities	0 - 4	0 - 4	.60	1.09
Relationship with your partner	0 - 4	0 - 4	.61	1.20
Ability to maintain your previous workload or quality of work	0 - 4	0 - 4	.87	1.24
Ability to participate in previous social activities	0 - 4	0 - 4	.90	1.28
Total scores	0 - 4	0 – 2.6	.55	.70

Relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavioral symptoms) and functional performance among persons with mild traumatic brain injury

The normal distribution of the variables was tested through skewness/ standard error and Kolmogorov-Smirnov test. All variables conform to a normal distribution. Correlations of post-concussion syndrome (physical symptoms, cognitive symptoms, and behavior symptoms) with functional performance of participants with mild traumatic brain injury used Pearson's product-moment test to analyze, and the results are displayed in Table 5.

There was a significant positive correlation between physical symptoms (r=.68, P<.001), cognitive symptoms (r =.58, P < .001), behavioral symptoms (r =.76, P < .001) and functional performance (perceived difficulty and/or change in functional performance) of persons with mild traumatic brain injury 2 weeks after trauma.

Table 5 Relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavioral symptoms) and functional performance (perceived difficulty and/or change in functional performance) (n = 108)

	functional performance	**p-value**
Physical symptoms	.68***	< .001
Cognitive symptoms	.58***	< .001
Behavior symptoms	.76***	< .001

*** $p < .001$

CHAPTER 5
CONCLUSION AND DISCUSSION

This chapter provides the summary and discussion of the study. Conclusion, the implication of the findings, and recommendations for future research are also provided in this chapter.

Summary of the study

This research aimed to describe post-concussion syndrome and functional performance and to examine the relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavior symptoms) and functional performance among persons with mild traumatic brain injury 2 weeks after the trauma in Wenzhou, China. Lenz et al. (1997)' s the theory of unpleasant symptoms [TOUS] was used as a conceptual framework to guide the study. Sampling by defining a collecting data period and recruit samples follow inclusion criteria. The total of 108 participants were recruit from neurosurgery outpatient department (OPD) of the first affiliated Hospital of Wenzhou Medical University in Wenzhou, China. Data were collected by self-reported questionnaires using the Demographic Questionnaire, the Chinese version of Rivermead Post-Concussion Symptoms Questionnaire [RPQ] (Zong, 2009) and the Chinese version of Rivermead Head Injury Follow Up Questionnaire [RHFQO] (Zong, 2009). The Cronbach's α for these two instruments were .87 and .89, respectively.

The results found that participants' age ranged from 18 to 85 years, with a mean age of 49.26 (SD = 17.89), 38% of them were under 45 years old. And they consisted of 66 males (61.1%) and 42 females (38.9 %). Majority of the participants were married (78.7%) and living with family members (84.3%). Almost half of them had secondary/ high school level of education (46.3%) and having income that less than RMB 2,000 per month or no income (46.3%). More than half of the participants (65.7%) were employed before the injury, the largest proportion was laborer (25%), followed by business (18.5%). For unemployed participants, the largest proportion was house working (25%), and 6.5% of the participants were student. Most of

participants those who employed (87.5%) and student (85.7%) had returned to work or school within 2 weeks after the trauma after injury.

In terms of health information, the results found that almost all the participants' trauma due to fall (51.9%) and car accident (42.6%), and 15.7% of participants' injury related to drinking. Most participants' GCS was at full mark 15 on admission day (93.5%), while all participants' GCS was at full mark 15 on discharge day (100%), which meant all the participants were conscious on discharge day. Most of the participants had no open wound at head (75.9%). However, 81.5% participants' CT showed abnormality, 44.4% of the participants' CT showed 1 abnormal condition. 44.4% of the participants were always conscious after the injury, 37% of the participants had unconsciousness which lasted for 1-10 minutes (M=4.79, SD=7.24). Most of the participants had no memory loss (92.6%). Most of the participants had no comorbidity (75.9%), 58.3% of the participants were hospitalized for 4-7 days (M = 6.35, SD = 2.12).

For the post-concussion syndrome. In physical symptoms, headache was most frequent (59.3%), for severity and disturbance, 34.3% had no longer a problem, 10.2% had a mild problem, however, 9.3% had a moderate problem, 5.6% had a severe problem. The second was feeling of dizziness (46.3%), for severity and disturbance, 32.4% had no longer a problem, 11.1% had a mild problem. Another frequent symptom after the trauma was fatigue, 41.7% of the participants had experienced fatigue, for the severity, 15.7% had a mild problem, 4.6% had a moderate problem, while 5.6% had a severe problem. The last relatively frequent symptom was sleep disturbance, 34.3% of the participants had experienced sleep disturbance, for severity and disturbance, 11.1% had no longer a problem, however, 5.6% had a moderate problem, 9.3% had a severe problem. In cognitive symptoms, forgetfulness, poor memory was most frequent (33.3%), for severity and disturbance, 14.8% had no longer a problem, 12% had a mild problem, however, 4.2% had a moderate problem, 1.9% had a severe problem. The second was poor concentration (29.6%), for severity and disturbance, 14.8% had no longer a problem, 8.3% had a mild problem, however, 3.7% had a moderate problem, 2.8% had a severe problem. The last was taking longer to think (27.8%), for severity and disturbance, 12% had no longer a problem, however, 9.3% had a mild problem, 5.6% had a moderate problem. In behavior

symptoms, being irritable, easily angered was most frequent (30.6%), for severity and disturbance, 12% had no longer a problem, however, 9.3% had a moderated problem, 5.6% had a severe problem. The second was feeling frustrated or impatient (27.8%), for severity and disturbance, 14.8% had no longer a problem, however, 8.3% had a mild problem, 3.7% had a moderate problem. 24.1% of the participants had feeling depressed or tearful, for severity and disturbance, 9.3% had no longer a problem, however, 6.5% had a moderated problem, 2.8% had a severe problem. 21.3% of the participants had restlessness, for severity and disturbance, 3.7% had no longer a problem, however, 4.6% had a moderated problem, 4.6% had a severe problem.

For the range, mean and standard deviation of scores for the post-concussion syndrome. Physical symptoms scores ranged from 0 to 2.33, with a mean of 0.47 (SD = 0.51). Cognitive symptoms scores ranged from 0 to 3, with a mean of 0.55 (SD = 0.84). Behavior symptoms scores ranged from 0 to 3.5, with a mean of 0.55 (SD = 0.90).

The functional performance (perceived difficulty and/or change in functional performance) scores ranged from 0 to 2.6, and the mean score was .55 (SD = 0.40), indicating that most participants' functional performance at 2 weeks after the trauma was no change, but more difficult than before the injury. The item with the lowest score (lowest perceived difficulty and/or change in functional performance) was "Ability to participate in conversation with one person" (M=.11, SD=0.34), followed by "Ability to participate in conversation with 2 or more people" (M=.37, SD=0.68), which meant there is little change in ability of conversation at 2 weeks after the trauma. The highest score (highest perceived difficulty and/or change in functional performance) was "Ability to participate in previous social activities" (M=.90, SD=1.28), followed by "Ability to maintain your previous workload or quality of work" (M=.87, SD=1.24). Which meant many persons with mTBI had more difficulties to participate in previous social activities and maintain your previous work at 2 weeks after the
trauma.

The result indicated that there was a significant positive correlation between physical symptoms (r=.68, P<.001), cognitive symptoms (r =.58, P < .001),

behavioral symptoms (r =.76, P < .001) and functional performance (perceived difficulty and/or change in functional performance).

Discussion

The discussions of the findings were presented based on objectives and hypothesis of the study. The first objective was to describe post-concussion syndrome and functional performance, the second was to examine the relationship between physical symptoms, cognitive symptoms, and behavior symptoms with functional performance among persons with mild traumatic brain injury in Wenzhou, China.

Post-concussion syndrome among persons with mTBI

For the three dimensions of post-concussion syndrome (PCS), physical symptoms were most frequent (87%), next were cognitive symptoms (41.7%), the last was behavior symptoms (38%). For the severity and disturbance, physical symptoms scores of RPQ ranged from 0 to 2.33, with a mean of 0.47 (SD = 0.51). Cognitive symptoms scores of RPQ ranged from 0 to 3, with a mean of 0.55 (SD = 0.84). Behavior symptoms scores of RPQ ranged from 0 to 3.5, with a mean of 0.55 (SD = 0.90). The results were consistent with previous studies, a study showed that the frequency of physical symptoms, cognitive symptoms, behavior symptoms of mTBI patients at 2 weeks after injury of the samples got physical symptoms at 2 weeks after injury were 88.9%, 48.9%, 39.9%, respectively (Barker-Collo et al., 2018). Another study showed that physical symptoms were the most common in the early stage (2 weeks), cognitive and behavior symptoms were relatively rare (de Guise et al., 2016).

The results of this study can be explained through the theory of unpleasant symptoms (TOUS) (Blakeman, 2019). In this study, PCS are symptoms the individual is experiencing. Symptoms include four dimensions: timing, intensity, quality, and distress. Time of PCS was 2 weeks after the trauma, intensity, quality and distress of PCS were measured by The Rivermead Post-Concussion Symptoms Questionnaire [RPQ] (King et al., 1995), the higher the score on the questionnaire, the more greater the intensity of the PCS. The factors affecting symptoms include: 1) physiological factors; 2) psychological factors; and 3) situational factors, which may affect the symptom experience (Silva-Rodrigues et al., 2019).

In physical symptoms, 87% of the participants got physical symptoms at 2 weeks after injury, consisted with other studies. Among physical symptoms, the most

frequent symptom was headache (59.3%), for the severity, 49.4% of the participants had mild to moderate problem. A previous study showed that 60.87% suffered from moderate-to-severe headaches at 2 weeks after injury (de Guise et al., 2016). The frequency consisted with other studies, but the severity was a little bit lower than other studies. Next was feeling of dizziness (46.3%), which is less than the findings of some previous studies, a study presented the prevalence of dizziness at 2 week was 50.8% (Barker-Collo et al., 2018). Another frequent symptom was fatigue (41.7%), 15.7% had a mild problem, 4.6% had a moderate problem, while 5.6% had a severe problem. A previous study's results showed that 78.72% of patients with mTBI 2 weeks after injury complained about moderate to severe fatigue (de Guise et al., 2016), the frequency and severity of fatigue in this study were lower than previous studies. The last relatively frequent symptom was sleep disturbance (34.3%). The frequency was lower than the findings of some previous studies, a study showed that 43.1% of mTBI having sleep disturbance at 2 weeks after the trauma (Barker-Collo et al., 2018). In summary, the frequency of physical symptoms consisted with other studies, the severity of physical symptoms in this study were lower than other studies.

For the frequency of physical symptoms, according to TOUS, the physiological factor such as brain lesions may contribute to the occurrence of physical symptoms (Blakeman, 2019). A study demonstrated that patients had brain lesions after mTBI report significantly physical symptoms, the confirmation of structural damage to the brain showing traumatic abnormalities might lead to a higher rate of self-reported physical symptoms (Voormolen, et al., 2019). Another study showed that brain lesions often lead to auditory and vestibular symptoms in the group with mTBI (Fure et al., 2021). In this study, 66.7% of participants' CT showed abnormal brain lesions, this may could explain 87% of participants got physical symptoms after injury.

For the severity of physical symptoms, According to TOUS, age was physiological factor influencing physical symptoms. Age has been cited in the literature as a risk factor for physical symptoms, a study showed that participants age >65 years-old endorsed headaches, noise/light sensitivity at a greater frequency than younger participants (Karr, et al., 2020). Another study indicated that young adults had a better adaptability from headache, dizziness, and fatigue than elderly

(Skandsen et al., 2021). In this study, 38% of the participants were 18-44 years old, 31.5% of the participants were 45-60 years old, the mean age was 49.26. However, in Barker-Collo's study, the mean age of the samples was 56.28 (Barker-Collo et al., 2019). The age of the participants was younger than other studies. This may explain the severity of physical symptoms of participants in this study were relatively low.

Educational level was situational factor influencing physical symptoms. A study showed that highly educated people generally have improved coping skills, cognitive and financial reserves, and a wider social network to deal with symptoms of mTBI (Cnossen et al., 2017). They understand information from health providers well after discharge, so they could avoid physical symptoms result from doing not follow doctor's advice (Fehr et al., 2019). In this study, 33.3% of the participants had completed primary school, 46.3% of the participants had completed high school, and 7.4% of the participants had got bachelor's degree and higher, the participants in the study had a relatively high education level, which may explain the severity of physical symptoms of participants were relatively low.

In cognitive symptoms, 41.7% of the participants got cognitive symptoms at 2 weeks after injury, the result was consistent with other studies. The most frequent symptom was forgetfulness, poor memory. 33.3% of the participants had experienced forgetfulness at 2 weeks after the trauma. Follow by, 29.6% of the participants had experienced poor concentration, 27.8% of the participants had experienced taking longer to think. The results were consistent with other studies. A study showed that 33.82% reported moderate to severe concentration difficulties at 2 weeks (de Guise et al., 2016). Another study showed that the prevalence of forgetfulness, poor concentration, and taking longer to think 2 weeks after injury were 32.8%, 28.7%, 28.9%, respectively (Barker-Collo et al., 2018).

A study's results suggest that LOC may contribute to post-concussion cognitive dysfunction and may be a factor for cognitive symptoms (Merritt et al., 2021). There are substantial changes in the physiological and pathological aspects of the brain because of loss of consciousness in mTBI, and often lead to cognitive impairment (McMahon et al., 2014). In this study, 55.6% of the participants had experienced unconsciousness, according to TOUS, loss of consciousness was

physiological factor influencing cognitive symptoms, this could explain 41.7% of the participants got cognitive symptoms.

In behavior symptoms, 38% of the participants got behavior symptoms at 2 weeks after injury, the result was consistent with other studies. The most frequent symptom was being irritable, easily angered. 30.6% of the participants had experienced irritability at 2 weeks after the trauma, for the severity and disturbance, 9.3% of the participants had a moderate problem about irritability, 5.6% had a severe problem. The second was feeling frustrated or impatient (27.8%), for severity and disturbance, 8.3% had a mild problem, 3.7% had a moderate problem. 24.1% of the participants had feeling depressed or tearful, for severity and disturbance, 6.5% had a moderated problem, 2.8% had a severe problem. 21.3% of the participants had restlessness, for severity and disturbance, 4.6% had a moderated problem, 4.6% had a severe problem. The results were consistent with the findings of some previous studies, a study showed that the prevalence of irritability, depressed or tearful, frustrated, and restlessness at 2 week was 27.2%, 29.9%, 29.7%, 20.1% (Barker-Collo et al., 2018). A study in Thailand reported that 18.5% of mTBI samples having irritability at 24 hours after the trauma, and 44.2% of mTBI samples having irritability at 1 month after the trauma (Samartkit, 2018). Another study showed that 30% reported moderate to severe irritability at 2 weeks after injury(de Guise et al., 2016).

According to TOUS, brain lesion was physiological factor influencing behavior symptoms. Brain lesions lead to damage to the frontal lobes, particularly left middle frontal gyrus and middle temporal gyrus, then influence the information process of emotions (McMahon et al., 2014). In this study, 67% of the participants experienced brain lesions, this could explain 38% of the participants got behavior symptoms in this study.

Functional performance among persons with mTBI

The results showed the functional performance (perceived difficulty and/or change in functional performance) scores ranged from 0 to 2.6, and the mean score was .55 (SD = 0.40). It indicated that the participants reported difficulty and /or change in their functional performance but have not many problems, however, they felt that it was more difficult to perform activities of daily living than before their injury. Which is consistent with the findings of previous studies, a study showed that

80% of the patients with mTBI often have lower functional performance than before in the first 2 weeks after injury, they had a little bit change in normal life as before, most of them (75%) could return to work but have more difficulties (Karr, et al., 2020). Like this study, 62.5% of participants for those employed had return to work, 71.4% of students had returned to school. These results were consistent with the findings of some previous studies. According to the TOUS, the physiological factors such as brain lesions may influence the functional performance, the changes on functional performance may depend on the severity of brain lesions. The more severe condition about the brain lesions, the more changes on functional performance.

Brain lesions is considered a factor to be related to functional performance. A study showed that a higher percentage of CT brain positive patients reported functional impairment (61%) compared with the mTBI CT brain negative group (Nelson et al., 2019). Another study demonstrated that traumatic subarachnoid hemorrhage, in isolation or combination with other features, is strongly associated with functional outcome in mTBI (Yuh et al., 2021). A study found that returning to full-time work was predicted by absence of additional intracranial injuries (de Guise et al., 2016). Karr et al (2020) indicated that macrostructural abnormality on CT was associated with worse functional outcome at one week post mTBI (Karr, et al., 2020). We also found that patients with intracranial abnormalities had worse memory function than the patients with normal CT scan brain (Fure et al., 2021). In this study, 81.5% participants' CT showed abnormality, most of them were pathology inside brain (37%), so it can explain 75.9% of the participants had had impairment functional performance in this study.

In this study, the most perceived difficulty in functional performance was "ability to participate in previous social activities" and "ability to maintain your previous workload or quality of work", the mean score was .90 of 4, .87 of 4, respectively, and 62.5% of participants who were employed had returned to work at 2 weeks after injury. Indicated that the ability to participate in previous social activities of mTBI patients 2 weeks after the trauma had no change, but more difficult than before. Which is consistent with the findings of some previous studies, a study showed that patients with mTBI receive some impact on their functional performance in the social domain (work/school, family maintenance, leisure/recreation, social

integration, standard of living, financial independence) at 2 weeks after injury (Chen et al., 2016). Another study showed that approximately half of mTBI patients return to work at early stage after injury, but the work efficiency is lower than before (Karr, et al., 2020).

According to TOUS, age and gender were physiological factor influencing PCS and can also directly influence functional performance, educational level was situational factor.

Age is an important factor related to functional performance. A study suggested that younger age leads to a minor disability after mTBI, patients who are in the youngest age group are likely to have had reduced functionality prior to the mTBI and subsequently experience a smaller relative change in function (Booker et al., 2019). Another study showed that the association was non-linear, with complete recovery rates that were higher in patients aged 40–64 years than in those aged 65 years and older, this finding reported a generally good outcome for patients aged 40 years and younger (van der Naalt et al., 2017). The lower recovery rates for the age group of 65 years and older might be explained by a combination of increased age and lower body function (van der Naalt et al., 2017). Younger age group are likely to have a good adaptability to return to previous social activities and return to work or study (Booker et al., 2019). In this study, 38% of the participants were 18-44 years old, 31.5% of the participants were 45-60 years old, most of the participants were young. Thus, the participants in this study reported that their functional performance 2 week after injury were not much change as before.

Gender may be a reason for not much change in functional performance among mTBI persons. Generally, systematic reviews and syntheses of studies found worse outcomes in females (Mikolić, et al., 2021). Following mTBI, women had poorer outcomes, a study in North American found that although males were found to have greater risk for mTBI, females have a greater chance of mortality and poor functional outcomes, it may be due to varying sex hormone levels, brain cortical thickening and complexity can differ between sexes (Yue et al., 2019). Males had better recovery than females, they returned to previous social activities and return to work or study easily (Booker et al., 2019). In this study, 61.1% of the participants

were male, this may explain the functional performance of participants were not much change in this study.

Educational level may be an important factor for not much change in functional performance. A study found that returning to full-time work was predicted by educational levels of more than 11 years, the high education persons tend to have good self-management (de Guise et al., 2016). Highly educated people generally have improved coping skills, and a wider social network to deal with possible consequences of mTBI, higher education is associated with return to society in several studies and return to work in several studies (Cnossen et al., 2017). In this study, 33.3% of the participants had completed primary school, 46.3% of the participants had completed high school, and 7.4% of the participants had got bachelor's degree and higher, the participants in the study had a relatively high education level, which may explain the functional performance of participants were not much change in this study.

Relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavior symptoms) and functional performance among persons with mTBI

This study found that physical symptoms and cognitive symptoms have positive moderate relationship with functional performance (perceived difficulty and/or change in functional performance) (r=.68, P<.001, r =.58, P < .001 respectively). Moreover, behavioral symptoms have positive high relationship with functional performance (perceived difficulty and/or change in functional performance) **(**r =.76, P < .001).

There was a significant correlation between physical symptoms and functional performance, consistent with the hypothesis of this study. This mean that the more physical symptom disturbance, the more perceived difficulty and/or change in functional performance. This result was consistent with previous studies, a study found that physical symptoms such as headache, fatigue often has an impact on physical performance such as the patient's ability to travel and lead to a substantial decline in social and occupational functions (Losoi et al., 2016). Killgore et al.(2020) indicated that if mTBI patients suffer from symptoms like sleep disorder, elementary

cognitive performance declines rapidly and is accompanied by judgment, decision-making, and executive functions. Another study found that physical symptoms such as headache and fatigue predicted worse attention/executive functioning performance (Guty et al., 2021). The TOUS theory explained that the symptoms may interact with one another, perhaps catalyzing each other (Blakeman, 2019). A study showed that physical symptoms as most frequent symptoms for post-TBI, more than half of patients complained of headache and dizziness, noise sensitivity, light sensitivity, and sleep disturbances, which often have most severe impact on people with mTBI in the early stage, their overall body function declines because these symptoms interact with each other (Killgore et al., 2020).

There was a significant positive correlation between cognitive symptoms and functional performance (perceived difficulty and/or change in functional performance), consistent with the hypothesis of this study. This result was consistent with many studies, a study found that cognitive deficits present at 2 weeks post-mTBI may take 6 months to 1 year to disappear completely, patients tend to experience functional impairment during this time (de Guise et al., 2016). A study showed that cognitive symptoms like working memory deficits can contribute to problems in other aspects of cognitive, academic, vocational, and social functioning (Westfall et al., 2015). A study showed that their social functioning was also impaired by prolonged unemployment when cognitive decline prevented them from returning to work (Killgore et al., 2020). Because a degraded work or study environment due to cognitive symptoms may make a decline in confidence, resulting in lower functional performance.

There was a significant positive correlation between behavior symptoms and functional performance (perceived difficulty and/or change in functional performance), consistent with the hypothesis of this study. This result was consistent with many studies. Broshek et al. (2015) found that behavioral symptoms are often caused by damage to the frontal lobes, and these symptoms can lead to additional distress and make it difficult for patients to return to normal life. A study showed that those who present with greater emotional stress are more likely to have functional impairment (de Guise et al., 2016). Another study showed that a higher behavior symptoms like depression and anxiety was found to be significant predictors of an

incomplete function recovery at 2 weeks after injury (van der Naalt et al., 2017). The TOUS explained that functional performance can also influence symptoms, so the functional impairment can exacerbate emotional symptoms in turn, and the symptoms may interact with one another (Blakeman, 2019). A study showed that behavior symptoms such as depression can affect the patient's functional performance in the social domain, decline in social skills can lead to worse depression or more symptoms like anxiety (Herrold et al., 2019). The effect on the social functioning performance of patients with mTBI is particularly significant when patients have 2 or more behavioral symptoms at the same time, so the functional performance of this population is lower than before.

These results of this study showed that physical symptoms and cognitive symptoms have positive moderate relationship with functional performance (perceived difficulty and/or change in functional performance) (r=.68, P<.001, r =.58, P < .001 respectively). Moreover, behavioral symptoms have positive high relationship with functional performance **(**perceived difficulty and/or change in functional performance) (r =.76, P < .001). The results were in line with the hypothesis of this study. Therefore, control post-concussion syndrome (physical symptoms, cognitive symptoms, behavior symptoms) can promote functional performance in persons with mild traumatic brain injury in Wenzhou, China.

Implications of the findings

Findings of the current study might be useful in the following areas:

1. Nursing practice

The findings of the study provided deeper insight regarding post-concussion syndrome and functional performance, and the relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavior symptoms) and functional performance among persons with mild traumatic brain injury 2 weeks after the trauma. This information can be useful in developing appropriate nursing intervention to improve functional performance among mTBI patients by targeting on treat and control physical symptoms, cognitive symptoms, and behavior symptoms in early stage to prevent persistent post-concussion syndrome and suboptimal functional performance.

2. Nursing education

Findings from the present study provide nursing knowledge about the relationship between post-concussion syndrome (physical symptoms, cognitive symptoms, and behavior symptoms) and functional performance among persons with mild traumatic brain injury 2 weeks after the trauma. It can provide a valuable reference for teaching patients or health providers the importance of regularly follow-up in early stage. It can also be useful for nurse educator to enhance nursing student's knowledge on early evaluation and intervention.

Recommendations for future research

Since the study was conducted in a single setting, the findings may not be generalized to other areas. To the purpose of generalization of results among Chinese mild traumatic brain injury population, we recommend replicating the study in other multiple settings of China.

Finally, future study should explore appropriate predicting and interventional program to carry out further research, to determine causal relationship.

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APPENDICES

APPENDIX A

Questionnaires in English version

QUESTIONNAIRES
POST-CINCUSSION SYMPTOMS AND FUNCTIONAL PERFORMANCE AMONG PERSONS WITH MILD TRAUMATIC BRAIN INJURY 2 WEEKS AFTER THE TRAUMA

The questionnaires include three parts as follows:

1. The Demographic questionnaire with 20 items
2. The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) with 16 items
3. The Rivermead Head Injury Follow Up Questionnaire (RHFOQ) with 10 items

1. The Demographic Questionnaire

Direction: Please read the questions in part 1 and part 2 carefully and give an honest answer. Please choose the answer as follow by tick ☑ or write down your answers in the space provided.

Part 1: General information (To be completed by the participant)

1. Age: ____years____months
2. Gender:
   □ Male □ Female
3. Marital status
   □ Single □ Married □ Divorced □ Widowed
4. ……
5. ……
6. ……
7. ……
8. ……
9. How many family members living with?
   □ no □ 1 □ 2 □ 3 or more

Part 2: Health information (To be collected by the researcher from their medical record information)

1. The cause of injury: □ fall □ A car accident □ Other causes
2. The time of injury:_____whether it's related to drinking: □ yes □ no
3. Duration of admission: _____
4. ……
5. ……
6. ……
7. ……
8. ……
9. ……
10. Comorbidity:_____Weather start working: □ no □ yes, time: _____

2. The Rivermead Post-Concussion Symptoms Questionnaire (RPQ)

Direction: After a head injury or accident some people experience symptoms which can cause worry or nuisance. We would like to know if you now suffer from any of the symptoms given below. As many of these symptoms occur normally, we would like you to compare yourself now with before the accident. For each one, please circle the number closest to your answer.

0= Not experienced at all

1= No more of a problem

2= A mild problem

3= A moderate problem

4= A severe problem

Compared with before the accident, do you now (i.e., over the last 24 hours) suffer from.

Symptoms	Not experienced at all	No more of a problem	A mild problem	A moderate problem	A severe problem
1. Headaches	0	1	2	3	4
2. Feelings of dizziness	0	1	2	3	4
3. Nausea and/or vomiting	0	1	2	3	4
4. …	0	1	2	3	4
5. …	0	1	2	3	4
6. …	0	1	2	3	4
7. …	0	1	2	3	4
8. …	0	1	2	3	4
9. …	0	1	2	3	4
10. …	0	1	2	3	4
11. …	0	1	2	3	4
12. …	0	1	2	3	4
13. …	0	1	2	3	4
14. …	0	1	2	3	4
15. Double vision	0	1	2	3	4
16. Restlessness	0	1	2	3	4
Are you experiencing any other difficulties? Please specify, and rate as above					
1. …	0	1	2	3	4
2. …	0	1	2	3	4
3. …	0	1	2	3	4

3. The Rivermead Head Injury Follow Up Questionnaire (RHFOQ)

Direction: After a head injury or accident some people experience problems which can cause worry or nuisance. We would like to know if you have difficulties with any of the activities listed below. We would like you to compare yourself now with before the accident/injury. For each one please circles the number closest to your answer.

4 = No change - I'm that same as before the injury
3 = No recent change but still more difficult than before injury
2 = A mild change in my ability compared to before injury
1 = A moderate change in my ability compared to before injury
0 = A very marked change in my ability compared to before injury

Compared with before the accident/injury, has there been a change in your...?

	No change	No recent change	A mild change	A moderate change	A very marked change
1.Ability to participate in conversation with one person	4	3	2	1	0
2.Ability to participate in conversation with 2 or more people	4	3	2	1	0
3.Performance of routine domestic activities	4	3	2	1	0
4. …	4	3	2	1	0
5. …	4	3	2	1	0
6. …	4	3	2	1	0
7. …	4	3	2	1	0
8. …	4	3	2	1	0
9.Relationship with your partner	4	3	2	1	0
10.Ability to cope with or handle family demands	4	3	2	1	0
Other difficulties					
1.	4	3	2	1	0
2.	4	3	2	1	0
3.	4	3	2	1	0

APPENDIX B

Permission letters

Permission letter to use The Rivermead Post-Concussion Symptoms Questionnaire (RPQ)

The original version:

From <nigel.king@hmc.ox.ac.uk>

Tue 6/29/2021 22:21 PM

To Yuhang Huang

Subject: Request permission to use “The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) for conducting research

Yes, that is fine. Best of luck with your research.

BW

Nigel

The Chinese version of:

From Ling Zong <zong-liner@163.com>

Sun 06/27/2021 14:23 PM

To Yuhang Huang

Subject: Request permission to use “The Chinese version of The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) for conducting research

可以使用

Permission letter to use The Rivermead Head Injury Follow Up Questionnaire (RHFOQ)

The Chinese version of:

From Ling Zong <zong-liner@163.com>

Sun 06/27/2021 14:23 PM

To Yuhang Huang

Subject: Request permission to use “The Chinese version of The Rivermead Head Injury Follow Up Questionnaire (RHFOQ) for conducting research

可以使用

APPENDIX C

Participant’s information sheet and consent form

Participant Information Sheet

IRB approval number: .....……..…….……

Title of study: Relationship between post-concussion symptoms and functional performance in persons with mild traumatic brain injury in Wenzhou, China

Dear participants

I am Ms. Yuhang Huang, a postgraduate student at Faculty of Nursing, Burapha University Thailand. I am conducting a study entitled "Relationship between post-concussion symptoms and functional performance in persons with mild traumatic brain injury in Wenzhou, China". The research objectives are to describe post-concussion syndrome and to determine the relationship between post-concussion syndrome with functional performance among persons with mild traumatic brain injury 2 weeks after the trauma at Neurosurgery outpatient department (OPD) of The First Affiliated Hospital of Wenzhou Medical University in Wenzhou, China.

This study will be a survey study. Participating in this study is voluntary. If you agree to participate in this study, you will answer the following questionnaires, which will take approximately 30 minutes. During the data collection period, if you have any questions, you can ask the researcher freely, the researcher will clarify the language or content. Participating in this study will not bring you any direct benefits. However, the information collected from this study may be valuable for the subsequent improvement of care models and interventions which can help the health care workers to provide advanced and better care for mild traumatic brain injury persons. There will be no identified physical and psychological risk to the person participating in the study and no risk to the society.

You have the right to terminate your participation in this study at any time without notifying the researcher, and it will not affect the quality of services you receive from the neurosurgery OPD. Any information collected from this study, including your identity, will be kept confidential. A coding number will be assigned to you and your name will not be used. Findings from the study will be presented as a group of participants and no specific information from any individual participant will

be disclosed. All data will be accessible only to the researcher which will be destroyed one year after publishing the findings. if you wish,.you will receive a further explanation of the nature of the study upon its completion,

The research will be conducted by Ms. Yuhang Huang under the supervision of my major-advisor, Associate Professor Dr. Niphawan Samartkit. If you have any questions, please contact me at mobile number: + 8615168758212 or by my e-mail: 1936678772@qq.com, and/or my advisor's e-mail address nsamartkit@gmail.com, or you may contact Burapha University Institutional Review Board (BUU-IRB) telephone number +66-38-10-2620 or BUU IRB's email address buuethics@buu.ac.th. Your cooperation is greatly appreciated. You will be given a copy of this consent form for retention.

Yuhang Huang

Consent Form

IRB approval number: .....…….....…….……

Title of study: Relationship between post-concussion symptoms and functional performance in persons with mild traumatic brain injury in Wenzhou, China

Date of data collection …….....…Month….....…….……Year …….

Before giving my signature below, I have been informed by researcher, Ms. Yuhang Huang about the purposes, method, procedures, benefits, and possible risks associated with participation in this study thoroughly, and I understood all of the explanations. I consent voluntarily to participate in this study. I understand that I have the right to leave the study any time I want, without fearing that it might affect the quality of health care services that I will receive from the hospital and neurosurgery OPD hereafter.

The researcher Ms. Yuhang Huang has explained to me that all data and information of the participants will be kept confidential and only be used for this study. I have read and understood the information related to participation in this study clearly and I am signing this consent form.

Signature

……..……..

Participant

(…….)

APPENDIX D

Ethical approval letter and data collection letter

สำเนา

ที่ IRB3-086/2564

เอกสารรับรองผลการพิจารณาจริยธรรมการวิจัยในมนุษย์

มหาวิทยาลัยบูรพา

คณะกรรมการพิจารณาจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยบูรพา ได้พิจารณาโครงการวิจัย

รหัสโครงการวิจัย : G-HS049/2564

โครงการวิจัยเรื่อง : Relationship between post concussion symptoms and functional performance in persons with mild traumatic brain injury in Wenzhou, China

หัวหน้าโครงการวิจัย : Ms.YUHANG HUANG

หน่วยงานที่สังกัด : คณะพยาบาลศาสตร์

BUU Ethics Committee for Human Research has considered the following research protocol according to the ethical principles of human research in which the researchers respect human's right and honor, do not violate right and safety, and do no harms to the research participants.

Therefore, the research protocol is approved (See attached)

1. Form of Human Research Protocol Submission Version 2 : 29 June 2021
2. Research Protocol Version 1 : 22 June 2021
3. Participant Information Sheet Version 2 : 29 June 2021
4. Informed Consent Form Version 2 : 29 June 2021
5. Research Instruments Version 1 : 22 June 2021
6. Others (if any) Version - : -

วันที่รับรอง : วันที่ 21 เดือน กรกฎาคม พ.ศ. 2564

วันที่หมดอายุ : วันที่ 21 เดือน กรกฎาคม พ.ศ. 2565

ลงนาม *นางสาวรมร แย้มประทุม*

(นางสาวรมร แย้มประทุม)

ประธานคณะกรรมการพิจารณาจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยบูรพา

ชุดที่ 3 (กลุ่มคลินิก/ วิทยาศาสตร์สุขภาพ/ วิทยาศาสตร์และเทคโนโลยี)

温州医科大学附属第一医院临床研究伦理委员会审查批件

（Review of Ethics Committee in Clinical Research (ECCR) of the First Affiliated Hospital of Wenzhou Medical University）

临床研究伦审 Issuing Number（2021）第（103）号

项目名称 Project	温州地区轻度创伤性脑损伤人群脑震荡后症状和功能表现的关系 Relationship between post concussion symptoms and functional performance among persons with mild traumatic brain injury in Wenzhou, China.		
申办者 Applicant	泰国东方大学	试验目的 Objective	临床科研 Clinical research
试验科室 Department	护理部		
试验项目负责人 Principal Investigator	陈瑜		
审查方式和时间 Form and Date	☐ 会议审查 Review Conference，时间：_____ ☑ 快速审查 Fast track，时间：2021 年 06 月 14 日		
审查地点 Review Site	新院 1-4A18 会议室		
审查材料 Documents for Review	1、医学临床科研项目及伦理审查申请表，v1.0 版； 2、临床研究方案，v1.0 版，2021.03.31； 3、受试者知情同意书，v1.0 版，2021.03.31； 4、研究者团队成员目录（职责）； 5、主要研究者、团队成员简历及 GCP 证书，v1.0 版； 6、研究者责任声明； 7、CRF/临床观察表样板，v1.0 版。		
审查意见 Comments	根据国家卫健委《涉及人的生物医学研究伦理审查办法》(2016)、WMA《赫尔辛基宣言》和 CIOMS《人体生物医学研究国际道德指南》的伦理原则，经本伦理委员会审查，同意该项目开展。 According to the Regulations and Rules of "Ethical Reviews for Biomedical Research Involving Human Subjects" (2016) the National Health Commission of PRC , "Declaration of Helsinki" of WMA, and "International Ethical Guidelines for Human Biomedical Research" of CIOMS , the project was **approved** by ECCR .		
主任委员/副主任委员签字 Signature of the ECCR Chair		签发日期 Date	2021.6.15
温州医科大学附属第一医院临床研究伦理委员会（盖章） Ethics Committee in Clinical Research of the First Affiliated Hospital of Wenzhou Medical University (Seal)			

温州医科大学附属第一医院 临床研究伦理委员会 专用章

MHESI 8137/ 1557

Graduate School, Burapha University
169 Longhaad Bangsaen Rd.
Saensuk, Muang, Chonburi
Thailand, 20131

August 5th, 2021

Dear President of The First Affiliated Hospital of Wenzhou Medical University

Enclosure: 1. Certificate ethics document of Burapha University
2. Research Instruments (Try Out)

On behalf of the Graduate School, Burapha University, I would like to request permission for Ms. YUHANG HUANG to collect data for testing the reliability of the instruments.

Ms. YUHANG HUANG ID 62910085, a graduate student of the Master of Nursing Science Program (International Program), Major in Adults Nursing Pathway, Faculty of Nursing, Thailand, was approved her thesis proposal entitled: "Relationship Between Post Concussion Symptoms and Functional Performance Among Persons with Mild Traumatic Brain Injury in Wenzhou, China" under supervision of Assoc. Prof. Dr. Niphawan Samartkit as the principle advisor. She proposes to collect data from 30 persons with mild traumatic brain injury, who are conscious with GCS = 15 in Neurosurgery Outpatient Department, The First Affiliated Hospital of Wenzhou Medical University.

The data collection will be carried out from August 10th, 2021 - August 30th, 2021. In this regard, you can contact Ms. YUHANG HUANG via mobile phone +86-1516-8758-212 or E-mail: 1936678772@qq.com

Please do not hesitate to contact me if you need further relevant queries.

Sincerely yours,

(Assoc. Prof. Dr. Nujjaree Chaimongkol)
Dean of Graduate School, Burapha University

Graduate School Office
Tel: +66 3810 2700 ext. 701, 705, 707
E-mail: grd.buu@go.buu.ac.th
http://grd.buu.ac.th

MHESI 8137/1558

Graduate School, Burapha University
169 Longhaad Bangsaen Rd.
Saensuk, Muang, Chonburi
Thailand, 20131

August 5th, 2021

Dear President of The First Affiliated Hospital of Wenzhou Medical University

Enclosure: 1. Certificate ethics document of Burapha University
2. Research Instruments

On behalf of the Graduate School, Burapha University, I would like to request permission for Ms. YUHANG HUANG to collect data for conducting research.

Ms. YUHANG HUANG ID 62910085, a graduate student of the Master of Nursing Science Program (International Program), Major in Adults Nursing Pathway, Faculty of Nursing, Thailand, was approved her thesis proposal entitled: "Relationship Between Post Concussion Symptoms and Functional Performance Among Persons with Mild Traumatic Brain Injury in Wenzhou, China" under supervision of Assoc. Prof. Dr. Niphawan Samartkit as the principle advisor. She proposes to collect data from 100 persons with mild traumatic brain injury, who are conscious with GCS = 15 in Neurosurgery Outpatient Department, The First Affiliated Hospital of Wenzhou Medical University.

The data collection will be carried out from September 1st, 2021 - December 15th, 2021. In this regard, you can contact Ms. YUHANG HUANG via mobile phone +86-1516-8758-212 or E-mail: 1936678772@qq.com

Please do not hesitate to contact me if you need further relevant queries.

Sincerely yours,

(Assoc. Prof. Dr. Nujjaree Chaimongkol)
Dean of Graduate School, Burapha University

Graduate School Office
Tel: +66 3810 2700 ext. 701, 705, 707
E-mail: grd.buu@go.buu.ac.th
http://grd.buu.ac.th

BIOGRAPHY

NAME	Yuhang Huang
DATE OF BIRTH	21 September 1996
PLACE OF BIRTH	ShaoXing, ZheJiang Province, China.
PRESENT ADDRESS	WenZhou, ZheJiang Province, China.
POSITION HELD	Student
EDUCATION	2015-2019 Bachelor of Nursing (B.S.N), Wenzhou Medical University, Wenzhou, China. 2019-2022 Master of Nursing Science (International Program)(M.N.S), Faculty of Nursing, Burapha University, Chonburi, Thailand.