Exploring fear avoidance behaviour in individuals who sustain a mild traumatic brain injury and the impact on outcomes

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Abstract

Background: Fear avoidance behaviour and its association with poor functional outcomes is a well-established phenomenon in musculoskeletal pain. However, there is limited research on fear avoidance in mild traumatic brain injury (mTBI). The current study aimed to expand upon earlier research by exploring the effects of fear avoidance behaviour on outcomes, whilst accounting for factors that may impact recovery in individuals who have sustained a mTBI. Additionally, it investigated potential predictors of individuals who may be at risk of developing fear avoidance behaviour.

Methods: One hundred and sixty nine participants (aged 18-69 years) with mTBI were recruited via specialist concussion services throughout the North Island of Aotearoa/New Zealand (NZ). Post-concussion symptoms, fear avoidance behaviour, psychological functioning and functional disability measures were administered at clinic intake (M = 8.74 weeks since injury) and at approximately three-months follow-up (M = 22.91 weeks since injury). Twenty-three participants were lost to follow-up at the three-month time-point.

Results: Findings indicate significant predictors for developing fear avoidance behaviour included, a lower level of education and traumatic injury circumstances (assault), with pre-injury mental health history approaching significance (p = .08). Generalised linear modelling found fear avoidance behaviour at clinic intake significantly contributed to both post-concussion symptoms and functional disability at clinic intake and at three-months follow-up, even when factors known to impact these outcomes (e.g., psychological functioning, age, gender) were included in the model. Psychological functioning was also found to contribute to post-concussion symptoms and functional disability.

Conclusions: These findings are consistent with previous studies and support an association of fear avoidance with negative outcomes in mTBI. Early identification of the factors that increase the risk of developing fear avoidance will inform implementation of psychological interventions to prevent or modify avoidance behaviour. This has the potential to improve recovery and reduce the personal and societal burden following a mTBI.

Keywords: fear avoidance behaviour, mild traumatic brain injury, persistent post-concussion symptoms, functional disability, psychological functioning.

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Glossary

Accident Compensation Corporation (ACC)	NZ government department, assesses compensation for accident-related injury or illness.
Acceptance and Commitment Therapy (ACT)	A psychological intervention that uses acceptance and mindfulness strategies with commitment and behavioural strategies to increase psychological flexibility.
Acquired Brain Injury (ABI)	Brain damage that happens after birth (e.g., trauma to the brain, stroke, and alcohol and/or drug use).
American Congress of Rehabilitation Medicine (ACRM)	A medical body that promotes a multidisciplinary approach to rehabilitation and research. Aims to enhance the lives of people living with a disability.
Aotearoa	New Zealand (Māori)
Bionic Brain Injury Outcomes New Zealand in the Community (BIONIC)	TBI burden in New Zealand: a population-based incidence and outcomes study.
Beck Depression Inventory (BDI-II)	A measure of depression symptoms.
Centres for Disease Control and Prevention	An American public health institute.
Cognitive Behavioural Therapy (CBT)	Structured psychotherapy aimed at awareness of inaccurate or negative thinking to enable the individual to view challenging situations more clearly and respond to them in a more effective way.
Depression, Anxiety and Stress Scale (DASS-21)	A self-report measure of symptom severity comprising 21-items in relation to depression, anxiety and stress.
Fear Avoidance Behaviour	Fear-related avoidance of activities (cognitive and behavioural).
Fear Avoidance Behaviour after TBI Questionnaire (FAB-TBI)	A self-report measure of 16-items related to avoidance behaviour following a TBI, over the past month.
Fear Avoidance Model (FAM)	A model describing the effects of fear avoidance behaviour in individuals with (chronic) pain.
Glasgow Coma Scale (GCS)[3]	Assessment of motor skills in traumatic brain injury.

Loss of consciousness (LOC)	A state which an individual lacks normal awareness of self and the surrounding environment.
Mild traumatic brain injury (mTBI)	Trauma to the brain from a direct or indirect force resulting in neurological symptoms that may affect the individual cognitively, physically and/or psychosocially. A milder form of TBI.
New Zealand (NZ)	
Persistent Post-concussion symptoms	Post-concussion symptoms lasting longer than three-months following a mTBI/concussion.
Post-traumatic amnesia (PTA)	A state of confusion or disorientation following a traumatic brain injury when an individual has difficulty remembering events that occurred after the injury.
Post-Traumatic Stress Disorder (PTSD)	A trauma and stressor-related disorder arising as a delayed and protracted response to experiencing or witnessing a traumatic event.
Psychological Processes	Human behavioural, cognitive and emotional relationships and interactions within the external and internal environment.
Retrograde amnesia	Loss of memory for events or experiences before a traumatic event or incident.
Rivermead Post-Concussion Questionnaire (RPQ)	A self-report measure of 16 post-concussion symptoms experienced over the past 24 hours.
Rivermead Post-Concussion Symptoms Questionnaire-3 (RPQ-3)	Describes an early post-concussion symptom cluster of three symptoms (incudes headaches, dizziness and nausea/vomiting).
Rivermead Post-Concussion Symptoms Questionnaire-13 (RPQ-13)	Describes an enduring post-concussion symptom cluster of 13 symptoms (includes mood, emotional, cognitive, noise, visual and sleep disturbances and fatigue).
Traumatic Brain Injury (TBI)	Trauma to the brain from an external force. May lead to temporary or permanent cognitive, physical and/or psychosocial impaired functioning.
Whānau	Family (Māori).
World Health Organisation (WHO)	Agency of the United Nations concerned with international public health.
World Health Organisation Disability Assessment Schedule 2.0 (WHODAS 2.0)	A 12-item self-report assessment over the past 30 days of general health and disability.

Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning."

Signature

Date: 08 December 2021

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Chapter 1 Introduction

Traumatic Brain Injury (TBI) is a significant cause of trauma-related death and disability worldwide (Rubiano, Carney, Chesnut & Puyana, 2015; Spencer et al., 2019). Globally, it is estimated, 56 million individuals per year sustain a TBI (Dewan et al., 2019). Mild traumatic brain injury (mTBI), a subtype of TBI, comprises 80-95% of all TBIs (Skandsen et al., 2019; Forrest, Henry, McGarry & Marshall, 2018; Feigin et al., 2013). In Aotearoa/NZ the Accident Compensation Corporation (ACC) (2019) reported approximately 30,000 mTBI/concussion claims per year from 2013 to 2019. However, this figure is believed to be grossly underestimated (Theadom et al., 2016; Forrest et al., 2018; Maas et al., 2017; Coronado et al., 2012) as approximately 36% of individuals may not recognise mTBI symptom manifestation and therefore, do not seek medical assistance (Feigin et al., 2013; Dewan et al., 2018; Uhl, Rosenbeum, Czajka, Mulligan & King, 2013).

Mild TBI is commonly caused by falls, mechanical forces, transport accidents and assaults (Feigin et al., 2013) which result in direct or indirect external forces being transmitted to the brain (Menon, Schwab, Wright & Maas, 2010; ACC, 2017). These forces have the capacity to cause short or long term cognitive, behavioural, emotional and/or physical post-concussion symptoms (ACC, 2017; Ponsford et al., 2019). Symptom manifestation has the potential to result in social (e.g., reduction in quality of life (Galea, O'Leary & Treleaven, 2019; McMahon et al., 2014)) and/or economic burdens (e.g., unemployment, lost productivity and work restrictions (Theadom et al., 2017) for the affected individual, their whānau/family and society (Feigin et al., 2013; Forrest, Henry, McGarry & Marshall, 2018).

Several studies have shown that symptoms generally resolve within the first three-months of injury (Tator, 2013; Iverson et al., 2017; Polinder et al., 2018).

However, approximately 40-60% of individuals may have post-concussion symptoms which persist beyond three-months to one-year (Barker-Collo et al., 2016; Snell et al., 2017) or even longer, post-injury (Rubiano, Carney, Chesnut & Puyana, 2015; Carroll et al., 2020). These ongoing symptoms are referred to as persistent post-concussion symptoms (Rickards, Cranston & McWhorter, 2020). The reasons for persisting sequelae are varied and complex, with many contributing factors which may include: the mechanism of injury and other injuries sustained (Uhl et al., 2013; Snell, Martin, Surgenor, Siegert & Hay-Smith, 2017); history of trauma (Stein et al., 2019); pre- and post-injury mental and physical health (Silverberg et al., 2015; Sandel et al., 2017); low education levels (Galili et al., 2017; Chu et al., 2019); sleep disturbances (Bramley et al., 2017); age (McMahon et al., 2014); individual personality traits and characteristics (Snell et al., 2017); gender (Cancelliere, Donovan & Cassidy, 2016); poor social support (Theadom et al., 2016; Losoi et al., 2015) and financial and compensation issues (Silver, 2014; Snell et al., 2017).

Multiple studies have shown psychological factors present the most robust risk factors for persistent post-concussion symptoms (Snell, Surgenor, Hay-Smith, Williman & Siegert, 2015; Wardlaw, Hicks, Sherer & Ponsford, 2018; Silverberg, Panenka & Iverson, 2018; Silverberg et al., 2015). For example, pre- and post-injury mental health symptomatology such as anxiety, depression and Post Traumatic Stress Disorder (PTSD) contribute to the development of persistent symptoms (Barker-Collo et al., 2015; Haagsma et al., 2015). However, several studies have demonstrated that psychological processes, which are recurring behavioural patterns with associated cognitive and emotional responses (Tamayo, 2011), may underlie these psychological factors. Examples of psychological processes include: illness and recovery beliefs; perceptions and expectations; coping abilities; psychological inflexibility; and fear avoidance. These processes may contribute to the maintenance of these psychological

symptoms and thereby, contribute to persistent symptomatology in mTBI (Barker-Collo et al.,2015; Cunningham, Brison & Pickett, 2011; Jones et al., 2016; Scott, Strong, Gorter & Donders, 2016; Snell et al., 2017; Sandel, Reynolds, Cohen, Gille & Kontos, 2017; Van Pelt et al., 2019; Faulkner et al., 2020).

Recent research, however scant, has shown that fear avoidance behaviour is a possible strong contributor to persisting symptoms in mTBI (Snell, Siegert, Debert, Cairncross & Silverberg, 2019; Silverberg, Panenka & Iverson, 2018). Fear avoidance behaviour is briefly described as an individual's negative appraisals about pain and symptoms and their consequences, including catastrophic thoughts, which may result in feelings of pain-related fear, avoidance of daily activities, and body hypervigilance (Lethem et al., 1983). It has been shown to negatively impact functional outcomes in chronic pain (Uddin et al., 2018; Gatchel, Neblett, Kishino & Ray, 2016; Jay et al., 2018) and other conditions (Nijs et al., 2013; Silver et al., 2002), but there is limited research of its impact in mTBI.

Understanding the underlying psychological processes that contribute and maintain persistent symptomatology in mTBI, such as fear avoidance behaviour, is crucial as it has the ability to inform and target specific therapeutic modalities for individuals who sustain mTBI (Theadom et al., 2016). The current study sought to investigate the relationship between fear avoidance and its effects in mTBI, and identify those individuals who may be at risk of developing fear avoidance behaviour. Therefore, the objectives of this study were:

1. To identify who is most likely to present with fear avoidance behaviours after sustaining a mTBI.
2. To examine if fear avoidance behaviour affects the initial outcomes for individuals who sustain a mTBI whilst accounting for factors known to impact mTBI recovery.

3. To examine the unique contribution fear avoidance behaviour has on post-concussion symptoms differentiated as an early symptom cluster (RPQ-3) and an enduring symptom cluster (RPQ-13) at two time points.
4. To examine if fear avoidance at clinic intake, and changes in fear avoidance over time, is associated with mTBI functional outcomes at three-months follow-up.

Chapter 2 Literature Review

The purpose of this chapter is to provide an overview of mTBI and fear avoidance behaviour, and its potential impacts in the mTBI population. More specifically, the aim is to review the evidence of persistent symptomatology (symptoms lasting longer than three months post-injury) and the processes that underlie persistent symptom manifestation and their association with fear avoidance in affecting outcomes within the context of mTBI.

2.1 Definition of mTBI

Traumatic brain injury (TBI) is defined as, “an alteration in brain function, or other evidence of brain pathology, caused by an external force” (Menon, Schwab, Wright & Mas, 2010, p.1638). The external force may be direct, such as the head being struck or the head striking an object, or indirect, such as an acceleration/deceleration motion (e.g., whiplash) transmitted to the brain (Harmon et al., 2013; Menon et al., 2010). Alteration in brain function is assessed by at least one of the following parameters: diminished or loss of consciousness (LOC); loss of memory (either retrograde or post-traumatic amnesia); neurological disturbance (e.g., visual, balance or sensory disruption or weakness); and/or a change in mental status at the time of injury (e.g., disorientation, confusion or diminished thinking). Other evidence of brain pathology refers to clinical, neuroimaging or laboratory information (Menon et al., 2010). These manifestations must not be due 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 by penetrating craniocerebral injury” (Carroll, Cassidy, Holm, Kraus & Coronado, 2004, p. 115).

Specifically, mTBI is diagnosed whereby the severity of the injury does not exceed the following: LOC of approximately 30 minutes; an initial Glasgow Coma Scale (GCS) of 13-15 (Teasdale & Jennett, 1974); and post-traumatic amnesia (PTA) not greater than 24 hours (Menon et al., 2010).

2.2 Epidemiology of mTBI

Mild TBI is a milder form of TBI (Harmon et al., 2019) and accounts for approximately 80-95% of all TBIs (Centers for Disease Control, 2019; Levin & Diaz-Arrastia, 2015; Feigin et al., 2013). Worldwide, TBI is a significant cause of trauma-related death and disability among adults and children (Feigin et al., 2013; Forrest, Henry, McGarry & Marshall, 2018). It has been deemed a major public health issue which is vastly underreported and therefore, underestimated statistically (Theadom et al., 2016; Forrest et al., 2018; Maas et al., 2017; Coronado et al., 2012). This is due to a multitude of factors. For example, many individuals do not present for medical assessment, especially individuals with mTBI where symptom manifestation may not be recognised (Feigin et al., 2013; Dewan et al., 2018; Uhl, Rosenbeum, Czajka, Mulligan & King, 2013) and statistically, there is a lack of inclusion of costs incurred by the social services, and the lost income and time for the affected individual and their whānau/family (Barker-Collo & Feigin, 2009; Quaglio, Gallucci, Brand, Dawood & Cobello, 2017). Hence, it is referred to as the “silent epidemic” (Dewan et al., 2018; Uhl, Rosenbaum, Czajka, Mulligan & King, 2013, p. 634).

Previously the World Health Organisation (WHO) estimated the global incidence of TBI at 100-300 cases per 100 000 population (Cassidy et al., 2004). Subsequently, a 2010-2011 population-based Brain Injury Outcomes New Zealand in the Community (BIONIC) study of TBI found considerably higher incidence rates (Feigin et al., 2013) when compared with other high-income European (453 per 100 000

population) and North American (618 per 100 000 population) countries (Cassidy et al., 2004). The incidence for TBI was reported at 709-790 cases per 100 000 population and prevalence of cases at 51-56 million per year (Feigin et al., 2013). Falls (38%) were the most common mechanism of injury for sustaining a TBI, followed by mechanical force (21%), transport accidents (20%) and assaults (17%) (Feigin et al., 2013).

Current global estimates of incidence rates for TBI now concur with the BIONIC study at approximately 740 cases per 100 000 population (24-30 million cases) and prevalent cases at approximately 56 million per year (Dewan et al., 2019). Dewan and colleagues (2019) found the regions with the highest incidence rates were the Southeast Asian Region (18.3 million) and the Western Pacific Region (17.3 million). Falls and transport accidents were found to be the most common causes of TBIs globally (James et al., 2019; Dewan et al., 2019; Skandsen et al., 2018).

Tellingly, the BIONIC study found "the risk of sustaining a mild TBI was more than 18 times greater than the risk for moderate to severe TBI" with the incidence of mTBI at 980 per 100 000 population (Feigin et al., 2013, p. 59). In Aotearoa/NZ the ACC reported approximately 30,000 mTBI/concussion claims per year for the six-years 2013 to 2019 (ACC, 2019). However, Feigin and colleagues (2013) report approximately 36% do not seek medical assistance, therefore this is likely to be statistically underestimated as a claim will not be lodged with ACC. Individuals aged 15-34 years had the highest prevalence (40%) of mTBI and males were nearly twice as likely to sustain a mTBI compared with females (Feigin et al., 2013).

In terms of ethnic differences associated with TBI, in Aotearoa/NZ Māori and Pasifika feature disproportionally. Their rates of TBI are approximately 1.5 times greater than the Aotearoa/NZ European population (Feigin et al., 2013; Lagolago et al., 2015). These ethnic disparities are found in other minority ethnic populations such as African American, Native American and Native Alaskan populations with four times

higher rates of TBI compared with the United States of America (USA) European population (Langlois et al., 2003). Aboriginal and Torres Strait Islander populations are 1.7 times more likely to sustain a TBI than their European counterparts (Pozzato, Tate, Rosenkoetter & Cameron, 2019).

TBI, of which mTBI accounts for the major proportion, is considered an extensive health issue that is underestimated due to a multitude of factors. Falls and transport injuries are the most prevalent causes. Concerningly, ethnic disparities exist, whereby many indigenous/first nations populations sustain TBIs at greater rates, and therefore, assume a greater burden than European populations. Therefore, it is imperative that prevention and interventional strategies are researched and instituted to address TBI and its potential effects, especially within various ethnicities and cultures.

2.3 Burden of mTBI

Although classified as mild the physical, psychological, cognitive, social and economic burden of mTBI may be far-reaching for the affected individual, their whānau/family and society.

A major contributor to the burden of mTBI is a poor outcome (i.e., functional disability, quality of life and/or a reduction in cognitive, occupational and social functioning) (Galea, O'Leary & Treleaven, 2019; McMahon et al., 2014; Nelson et al., 2019). McMahon and colleagues (2014) investigated post-concussion symptoms and functional status in a mTBI sample (n = 375). They found at three and six-months a third of individuals reported post-concussion symptoms associated with functional impairment (i.e., reduced activities of daily living and at work). At one-year, nearly a quarter of individuals continued to experience problematic post-concussion symptoms and functional impairment, and nearly a third of individuals reported a poor sense of well-being. Overall, the authors found these results "underscore the substantial public

health outcomes after mTBI" (McMahon et al., 2014, p.31). Consistent results were found when Nelson and colleagues (2019) investigated recovery after mTBI (n = 1154). They found 86% of individuals at two-weeks post-mTBI reported post-concussion symptoms and limitations of daily living activities and relationships, within and outside the home, and at work. At 12-months only 47.2% of individuals reported having returned to full pre-injury functioning capacity (Nelson et al., 2019). Higher levels of post-concussion symptoms were also found to be associated with higher unemployment at one-month post-mTBI. This was also associated with a reported reduction in quality of life (Chiang, Guo, Huang, Lee & Fan, 2016). Cnossen et al., (2018) found the reporting of three or more post-concussion symptoms at two-weeks was a significant predictor of poor functional recovery. An Aotearoa/NZ study found nearly half (47.9%) of individuals reported four or more post-concussion symptoms one-year post-mTBI. They found this limited the ability of the individuals to fully function at home and work (Theadom et al., 2016).

Experiencing post-concussion symptoms has also been found to be associated with an increase in the development of anxiety and depression in individuals post-mTBI (Sandel et al., 2017: Clarke et al., 2012; King & Kirwilliam, 2013; Ponsford et al., 2019; Barker-Collo et al., 2015; Cancelliere & Mohammed, 2019; Sandel et al., 2017; Vikane et al., 2019). These mood changes have the potential to negatively impact outcomes with increased functional disability (King, 2014: Sandel et al., 2017; Scott et al., 2016; Corwin et al., 2014; Lundin et al., 2006) and impaired cognitive functioning (Scott et al., 2016; Mathias & Coats, 2010). Hellewell and colleagues (2020) found the risk of individuals experiencing depression post-mTBI was three-fold compared with non-mTBI individuals. Scott et al., (2016) found individuals reporting post-concussion and depressive symptoms were at an increased risk of cognitive, communication and physical complaints at three-months post mTBI. These findings are consistent with

Iverson et al., (2017), whereby individuals experiencing headaches and depressive symptoms 48 hours post-mTBI were at risk of poorer outcomes (i.e., persistent symptoms, cognition difficulties, and problems returning to school and/or sports). Haagsma and colleagues (2015) assessed functional outcomes (i.e., employment, social and recreational activities and interactions, home life and return to pre-injury life) post-mTBI (*n* = 797). They found depression and PTSD (Post-traumatic Stress Disorder) symptoms were associated with poor functional outcomes and a poorer quality of life at six and 12-months post-mTBI (*n* = 797).

Post-concussion symptoms have also been found to be associated with impaired cognitive functioning (i.e., difficulty with memory and concentration) which are indicative of increased functional disability post-mTBI (Carroll et al., 2014; Clarke et al., 2014; Dean, O'Neill & Sterr, 2012; Rabinowitz et al., 2015; Dikmen et al., 2017; McMahon et al., 2014). Dikmen and colleagues (2017) found individuals who presented with more symptoms at first clinical assessment were on a trajectory of functional limitations and poor cognition (episodic memory) at one-month and 12-months post-mTBI in comparison with those presenting with minimal or no symptoms. Ransom et al., (2015) found students (5 to 18 years) reporting post-concussion symptoms at four-weeks post-mTBI was associated with learning difficulties and an overall reduction in academic performance. A study by Rabinowitz and colleagues (2015) of 87 individuals post-mTBI and 75 control individuals also found an association between persisting post-concussion symptoms and impaired cognitive outcomes (i.e., processing speed, visual memory, immediate recall, delayed recall and symbol-digit span). At three-months post-mTBI more than half of individuals reported persisting post-concussive symptoms with a third exhibiting poor cognitive outcomes. This result was greater in individuals from a lower socio-economic background. Concerningly, this has the potential to further disadvantage these individuals financially (Rabinowitz et al., 2015).

Socio-economic status also impacted healthcare usage. A study of individuals (*n* = 93,517) post-mTBI who reported higher levels of post-concussion symptoms (three or more) at three-months post-injury were found to access healthcare at a greater rate compared with those participants reporting decreased or no symptomatology. This was significantly associated with lower socio-economic status (Galili et al., 2017). Increased healthcare usage was found to last up to one to two-years post-mTBI in individuals who presented with neuropsychological deficits (oculomotor and visuomotor) in the first two-weeks following a mTBI (Carroll et al., 2014). Hunt and colleagues (2016), in a sample of 201 individuals with a mTBI, reported increased healthcare usage in 15-20% of individuals post-mTBI, equating to $500,000 Canadian dollars. Extrapolating this figure, they believed the overall financial burden of excessive healthcare usage was approximately $110 million Canadian dollars for the Ontario region alone. Individuals requiring extended medical care post-mTBI were estimated at 10-30% (ACC, 2017; Gupta & Summerville, 2019; Kara, 2017).

Further economic burden was found by Fallesen and Campos (2020) investigating the socio-economic effects of concussion in working-age adults post-mTBI. The authors found mTBI has the potential to have substantial short and long-term negative effects on salary and employment. Chu and colleagues (2017) investigated employment post-mTBI in 132 individuals with mTBI and 47 control individuals. They found 55% of individuals were unable to return to their pre-injury employment two-weeks post-mTBI and 26% had not returned to work one-month post-mTBI. These findings were associated with physical post-concussion symptoms, such as headache and dizziness, and lower educational levels. Graf et al., (2019) also found lower employment rates post-mTBI. In the study of 19,732 individuals with mTBI they found at six and 12-months post-mTBI 32% and 36% respectively were unable to return to their pre-injury employment. At six and 12-months 18% of individuals received

health-related benefits (e.g., social security, sickness and unemployment benefits, disability pension, vocational rehabilitation and flexible employment options).

The financial societal burden of mTBI in Aotearoa/NZ was found to be approximately US$4,636 per mTBI. Although this was lower than moderate and severe TBI per capita, with the sheer numbers of mTBI (95% of cases) the overall cost was three times that of moderate and severe TBI (Te Ao et al., 2014). Graves and colleagues (2015) reported consistent results when investigating inpatient and outpatient healthcare costs of TBI in a paediatric population (n = 319) in the USA. Individual costs of moderate and severe TBI were highest, but once again, the overall cost of individuals with mTBI was far greater (88% and 75% higher than moderate and severe TBI respectively) and estimated at US$695 million for the first three-months post-mTBI. The authors commented "mild TBI cannot be thought of as a low-cost, temporary problem with little or no long-term sequelae". They found the cost of mTBI created a disproportionate societal financial burden (Graves, Rivara & Vavilala, 2015, p.e39).

Hence, mTBI presents considerable physical, psychological, social, cognitive and financial burdens for the individual. It also presents societal economic ramifications with increased healthcare usage and increased health, unemployment and sickness/disability benefits. However, the true burden may be underestimated, due to indirect costs of lost productivity, diminished quality of life and disability which not only burdens the individual but incurs secondary losses for their whānau/family and society.

2.4 Biomechanics, Pathophysiology and Symptom Overview of mTBI

Mild TBI is a complex condition with heterogeneous presentation, involving underlying biomechanics and pathophysiology. Linear and rotational acceleration

(inertial) and/or deceleration (impact) forces are primarily responsible for the damage and dysfunction in mTBI (Meaney & Smith, 2011; Stemper et al., 2015). These forces may result from a fall, a transport accident, a sporting or recreational injury, a workplace injury, a blast injury, or an assault (Ontario Neurotrauma Foundation, 2018; Lifshitz, 2015). The forces directly or indirectly generate increased pressure and shearing forces within the brain resulting in shear-induced tissue damage to cerebral microstructures (e.g., axons, dendrites, astrocytes, cell membranes and associated vasculature) (Iverson, Lange, Gaetz & Zasker, 2013; Giza & Hovada, 2014; Lezak et al., 2012; Kenzie et al.,2018; Vagnozzi et al., 2007; Choe, 2014). The damaged cellular membranes induce a neurometabolic cascade effect, with ionic flux and depolarisation (disruption of electrical charge) within the cells. Neurotransmitters, particularly excitatory glutamate, are indiscriminately released generating further ionic flux and damage to mitochondria. This results in increased energy demand from rapid-fire cell initiation generating an increase in energy production by the mitochondria in an attempt to compensate (Giza & Hovada, 2014; Choe, 2016; Andriessen, Jacobs & Vos, 2010). This is associated with a period of metabolic crisis and altered neurotransmission. Cerebral blood flow may be impeded, further compromising energy availability. These cell disruptions are functional, rather than structural (Choe, 2016; Giza & Hovda, 2014; Andriessen et al., 2010; Naess-Schmidt et al., 2017) and therefore, typically undetectable on standard neuroimaging (Choe, 2016; McKenzie et al., 2018; Naess-Schmidt et al., 2017). Accordingly, diagnosis is made based on the injury history, clinical presentation and symptom manifestation seen in mTBI (Choe, 2016; McKenzie et al., 2018; Silverberg et al., 2020).

2.4.1 Symptom Presentation of mTBI

Symptom presentation in mTBI is heterogeneous and manifestation may be subtle. They may vary from, an individual feeling 'not quite right', to obvious signs such as LOC, confusion or difficulty with balance (Elkington et al., 2019; McCrory et al., 2017). The symptoms an individual may experience post-mTBI are classified as: i) physical - headaches, visual, sound and speech disturbances, dizziness, nausea, fatigue and balance problems; ii) cognitive – confusion, diminished memory and concentration, slowness in processing information, lucid-thinking difficulties and reduced reaction times; iii) psychological (emotional/mood) – emotional lability, sadness, irritability, frustration, depression, nervousness and anxiety; and iv) sleep disturbances – trouble falling asleep and sleeping more or less than usual (Harmon et al., 2013; McMahon et al., 2014; Choe, 2016; Ponsford et al., 2019; Centers for Disease Control and Prevention, 2019; Silverberg et al., 2020; Elkington, 2019). The majority of individuals report headaches, fatigue, concentration and memory decline, and disturbances in mood as the predominant symptoms (Canterbury District Health Board, 2006; Quinn, Mayer, Master & Fann, 2018; Barker-Collo et al., 2016; King, Crawford, Wendon, Moss & Wade, 1995). Symptoms may be assessed utilising the Rivermead Post-Concussion Questionnaire (RPQ) which measures the severity of 16 symptoms post-mTBI (Eyres, Gilworth, Neumann & Tennant, 2005). Symptoms can be classified as, an early-onset cluster (referred to as RPQ-3 (reflecting the first 3 items of the RPQ) and include headache, dizziness and nausea/vomiting, or an enduring symptom cluster (reflecting the final 13 RPQ items, referred to as RPQ-13) and include mood, emotional, cognitive, fatigue and noise, visual and sleep disturbances (Eyres et al., 2005).

Symptoms are generally found to resolve spontaneously within the first three-months (Cassidy, Boyle & Carroll, 2014; McCrea et al., 2009; Belanger, Curtiss, Demery, Lebowitz & Vanderploeg, 2005). However, there is now strong evidence that

nearly half of the individuals who sustain a mTBI experience persisting symptoms for three-months to one-year post injury (Theadom et al., 2016; McMahon et al., 2014; Barker-Collo, 2016; Dikmen, Machamer & Temkin, 2017), or even longer (Rubiano et al., 2015; Carroll et al., 2020). Collectively, these ongoing symptoms are referred to as persistent post-concussion symptoms (Rickards et al., 2020).

2.5 Persistent Post-Concussion Symptoms

Persistent post-concussion symptomatology has been found to negatively impact outcomes (Silverberg et al., 2015; van der Naalt et al., 2017). It is associated with increased absenteeism from work (Losoi et al., 2016); higher levels of post-injury unemployment (King & Kirkwilliam, 2011; Cancelliere et al., 2016); poorer health (Losoi et al., 2016); depression (Barker-Collo et al., 2015); increased healthcare-seeking behaviour (Galili et al., 2017); reduced quality of life (McMahon et al., 2014; King & Kirkwilliam, 2011); and is an impediment to returning to education, work, sport, leisure activities and daily functioning (Cancelliere et al., 2016).

A number of studies report the ongoing effects of persistent symptoms. A 2014 study (n = 375) of individuals with mTBI found that 82% reported at least one symptom at six and 12-months post-injury (McMahon et al., 2014). Approximately a third of the individuals at three and six-months, and a quarter (22%) at one-year post-injury reported reduced functioning. At 12-months, nearly 30% reported physical and cognitive symptoms and a compromised sense of well-being. These results were irrespective of the mechanism and severity of mTBI sustained (McMahon et al., 2014). Other studies support these findings, with 44% of individuals presenting to hospital at one-year post-mTBI reporting three or more new or worsening symptoms (Dikmen, MacHamer, Fann & Temkin, 2010).

Barker-Collo et al., (2016) found a third of individuals with mTBI experienced cognitive difficulties at one-year post-injury. A further 2016 study found nearly half of individuals reported four or more symptoms one-year post injury, and 10% reported poor cognitive functioning (Theadom et al., 2016). Barker-Collo and colleagues (2015) found 20% of participants with persistent symptomatology scored below average on neuropsychological functioning (attention, cognitive flexibility and processing speed) assessment at six to 12-months post-mTBI (Barker-Collo et al., 2015).

Carrol et al., (2020) conducted a longitudinal study at five time points (two-weeks, three-months, six-months, one-year and two-years) post-mTBI (n =61). They found individuals reported post-concussion symptoms and impairment at all time points. However, at two-years a third still reported headaches, fatigue and sleep disturbances, and one-fifth had functional impairment. These findings were associated with depression, psychological distress, reduced memory, functioning disability, excessive alcohol intake, and psychological distress (Carroll et al., 2020).

Nonetheless, some studies have found common subjective post-concussion symptoms (e.g., headache, fatigue, irritability, sleep disturbance and dizziness) are not specific to individuals with mTBI (Cassidy et al., 2014; Marshall, Vernon, Leddy & Baldwin 2015; Meares et al., 2015; Balalla, Kragelogh, Medvedev & Siegert, 2020). Cassidy et al., (2014) performed a systematic review (299 articles) which showed, due to their generic nature, post-concussion symptoms arise in other injuries (Marshall, Vernon, Leddy & Baldwin 2015; Balalla, Kragelogh, Medvedev & Siegert, 2020) and in healthy children and adults (Barlow, 2016; Wang, Chang & Deng, 2006; Polinder et al., 2018). However, despite the fact post-concussion symptoms may be generic the authors found evidence to support higher rates of persistent symptomatology in mTBI. They suggested further research was needed to identify interventions “targeting modifiable prognostic factors” (Cassidy et al., 2014, p. 5150).

Overall, persistent symptomatology of mTBI has been shown to have the potential to negatively impact psychological and cognitive functioning, symptom severity and an individual's home, sport/leisure and employment activities, and quality of life.

2.5.1 Factors Associated with Persistent Post-Concussion Symptoms

There is a plethora of studies which have examined factors that may contribute to persistent symptomatology in mTBI. There are numerous potential factors, with no one factor being the sole cause, which therefore, makes it a complex issue.

Studies have shown demographic characteristics such as lower educational achievement and socioeconomic status (McCrea et al., 2009; McCauley et al., 2013; Snell, Surgenor, Hay-Smith, Williman & Siegert, 2015); lower employment status (Chiang, Guo, Huang, Lee & Fan, 2016; Kirsch et al., 2010); higher age (Schmidt et al., 2019; King & Kirkwilliam, 2011; King, 2014); and female gender (Ponsford et al., 2012; Silverberg et al., 2015; Cancelliere, Donovan & Cassidy, 2016) may influence the development of persistent symptomatology. Injury and post-injury characteristics such as injury severity, mechanism of injury, legal and compensatory issues (McCrea et al., 2009; McCauley et al., 2013; Snell, Surgenor, Hay-Smith, Williman & Siegert, 2015); increased acute symptom presentation (Lundin, de Boussard, Edman & Borg, 2009; Rabinowitz et al., 2015); traumatic cause of injury (Lingsma et al., 2014); poor physical functioning post-injury (Barker-Collo et al., 2015); lack of information and support (Snell et al., 2017); and prolonged rest post-mTBI (De Kruijk, Leffers, Meerhoff, Rutten & Twijnstra, 2002; Silverberg & Iverson, 2013) may also contribute.

Pre-injury mental health and medical history, and current psychological status have also been found to be possible contributors to persistent symptomatology. These include: previous disability, drug or alcohol use (Kirsch et al., 2010); neurotic

tendencies, such as anxiety, depression, hypochondria, self-doubt and negative affectations (Sandel et al., 2017); pre-injury physical health, injury beliefs about illness, and recovery expectations, poor coping mechanisms, previous TBI history (Wardlaw, Hicks, Sherer & Ponsford, 2018; Snell et al., 2015; Ponsford et al., 2012); psychosocial factors such as, employment, social support and interactions, and mood status (Cancelliere & Mohammed, 2019; Riley, Dennis & Powell, 2010; Lange, Iverson & Rose, 2011; Scott, Strong, Gorter & Donders, 2016); and preinjury stressful life events (Veldhoven et al., 2011). Significantly, Cassidy et al., (2014) found the reporting of post-concussion symptoms was not directly related to the brain injury per se. Rather, the risk factors for the development of persistent symptomatology and poorer outcomes in mTBI were individuals who reported more symptoms initially, associated with psychological factors (Cassidy et al., 2014).

There are a multitude of factors that have been found to be potential contributors to persistent symptoms post-mTBI. However, increasingly research has shown pre- and post-injury psychological elements may be the major contributors to persistent symptoms, and thereby negative functioning outcomes post-mTBI.

2.5.2 Psychological Factors and Persistent Symptomatology

There is strong evidence which has shown that an individual's pre- and post-injury psychological functioning may have a significant impact on outcomes post-mTBI. A pre-injury mental health history and early post-injury anxiety were found to be the strongest predictors of poor outcomes (i.e., post-concussion symptoms, poor neuropsychological and physical functioning, delay in returning to work and poor quality of life) post-mTBI in a review of 182 multivariate prognostic model articles (Silverberg et al., 2015). Veldhoven et al., (2011) found a history of pre-injury stressful life events (e.g. financial hardship, life-threatening accident or illness) was found to

predispose individuals to poorer outcomes post-mTBI. Individuals scoring higher on pre-injury poor functioning, traumatic life events and PTSD also scored higher on outcome measures of depression and anxiety, and quality of health at three-months post-mTBI (Veldhoven et al., 2011). Comparatively, an Australian study (*n* = 343) found a significant association of persistent symptoms post-mTBI with pre-injury mental health. The authors recommended screening for pre-injury mental health as a valuable clinical tool in assessing those most at risk of persistent symptoms (Ponsford et al., 2019). The impact of pre-injury mental health history on outcomes was investigated in a sample of individuals who sustained a mTBI, with and without a psychiatric history (*n* = 79 and 226 respectively). Lower processing speed and reduced functional status were found in the individuals with a psychiatric history. These results were found irrespective of treatment and neurological history (Bertisch et al., 2018). Research by Karr and colleagues (2020) also examined pre-injury mental health (anxiety and depression) and post-injury physical, cognitive and emotional symptoms in a sample (*n* = 297) of individuals with mTBI. The authors found increased post-concussion symptoms were associated with a history of pre-injury mental health (Karr et al., 2020).

Ponsford et al., (2012) researched predictors of post-concussive symptoms at three-months post-injury. Assessments were performed at one-week and three-months post-injury in individuals (*n* = 123) with mTBI, matched with controls (*n* = 100). Higher levels of depression and anxiety were associated with persistent symptomatology in the mTBI group. Further research by Ponsford and colleagues (2019) found an association between post-concussion symptoms and pre-injury psychological history in a sample of individuals (*n* = 343) with mTBI. Overall this was associated with a reported reduction in quality of life. Cancelliere and Mohammed (2019) found depression and anxiety aggravated symptoms such as fatigue, dizziness and cognitive functioning post-mTBI. van der Naalt et al., (2017) found emotional distress contributed to incomplete

functional recovery at six-months post-mTBI. Head injury symptoms, anxiety and depression, and functionality post-mTBI were assessed at two-weeks and six-months post-injury (n = 910). At six-months anxiety and depression and/or post-traumatic stress were associated with post-traumatic symptoms (amnesia, emotional distress and increased symptom reporting) and poor recovery (van der Naalt et al., 2017). In a large sample of individuals (n = 1919) with a mTBI, functional status, quality of life, and depression and PTSD symptoms were assessed at six and 12-months. Depression and PTSD were found to be associated with a marked decrease in functional ability and quality of life (Haagsma et al., 2015).

A 2012 study investigated the role of cognitive and affective factors in predicting persistent symptoms in mTBI (Clarke, Genat & Anderson, 2012). The sample included 21 individuals with mTBI; 19 with spinal injury, but no head trauma; and 20 trauma-free and neurologically sound students. They found subtle cognitive deficits, but the major contributors to persistent symptomatology were psychological symptoms of depression, anxiety and neuroticism (Clarke et al., 2012). Mood (depression and anxiety) was also found to be one factor that contributed to diminished cognitive functioning (memory, processing speed, executive functioning, psychomotor speed/reaction time, complex attention and cognitive flexibility) 12-months post-mTBI in over 20% of participants (Barker-Collo et al., 2015). Interestingly, depression was found to be most significant in the early period (one-month post-mTBI) and then remained relatively stable, whereas anxiety was found to increase up to six-months and then decline in the six to 12-months post-mTBI (Barker-Collo et al., 2015).

Psychological factors, such as pre-injury mental health history and post-injury psychological presentations of anxiety, depression, emotional distress and PTSD symptoms, have been found to be significant contributors to persistent symptomatology in mTBI. These have the potential to negatively impact an individual's quality of life.

Therefore, the challenge for researchers is to investigate the underlying causes of these psychological factors to enable early intervention, and thereby enhance the individual's physical and mental functioning and quality of life post-mTBI.

2.5.3 Psychological Processes and Persistent Symptoms

Despite the strong evidence that psychological factors contribute to mTBI recovery, currently prognostic models are still limited in their ability to fully explain the manifestation of persistent symptoms in mTBI (Silverberg et al., 2015). From a psychological perspective, an alternative and more explanatory method, may be to investigate specific psychological processes that underlie these broad psychological factors.

Psychological processes explain human behavioural, cognitive and emotional relationships and interactions within the internal and external environment (Tamayo, 2011). Raeff (2020) explains, from birth we operate in a whānau/family structure which functions within accepted cultural norms. Within this structure we are exposed to visual, auditory, olfactory, gustatory, vestibular (movement and balance), proprioception and tactile sensory experiences which shape key psychological processes (KIlic, 2015). Key processes include sensation, perception, attention, cognition, reasoning, problem solving, learning, memory, attitudes, social interaction, motivation and self/identity (Raeff, 2020). Consciously or unconsciously various processes are used for all activities performed, and develop into recurring behavioural patterns with associated cognitive and emotional responses (Tamayo, 2011). Although described as recurring, they are still considered dynamic, whereby they evolve over time (Kilic, 2015) and therefore, are potentially modifiable (Raeff, 2020; Kilic, 2015).

Psychological processes that may impact cognitive, emotional and behavioural responses in persistent symptomatology in mTBI may also be potentially modifiable

(Polinder et al., 2018; Donovan et al., 2014). Examples of such responses include: coping mechanisms (Snell et al., 2015; Vos, Poritz, Ngan, Luis-Novelo & Sherer, 2019); psychological resilience (Losoi et al., 2014; McCauley et al., 2013; Wardlaw et al., 2018; Vos, Poritz, Ngan, Leon-Novelo & Sherer, 2019); fear avoidance (Cairncross et al., 2021; Chrisman et al., 2019; Wijenberg et al., 2017; Cassetta, Cairncross, Brasher, Panenka & Silverberg, 2021; Silverberg, Panenka & Iverson, 2018); and psychological flexibility (Faulkner et al., 2020; Whiting, Deane, Simpson, McLeod & Ciarrochi, 2017).

An individual's coping abilities post-mTBI may contribute to persistent symptomatology. Coping is the individual's adaptability to manage internal and external stressful or traumatic events (Scheenen et al., 2017). The basis of coping lies in the individual's injury beliefs and the capacity to problem solve and make sense of their illness (Leventhal, Leventhal & Contrada, 1998). Coping mechanisms may have a protective factor, but equally maladaptive coping may be detrimental to positive outcomes (Algorani, Gupta, 2021).

There is a small body of research on the impact of various coping strategies in mTBI. Snell and colleagues (2015) investigated individuals with mTBI (n = 147) at clinic intake (M = 32.3 days since injury) and at six-months follow-up. They found that post-concussion symptoms were associated with the individual's ability to be flexible and adapt under stressful conditions. Three distinctive groups were found. The high adapters had lower post-concussion symptoms at both time points and mostly recovered by six-weeks. The medium and low adapters both showed some reduction in post-concussion symptoms. Medium adapters continued to have a reduction in post-concussions symptoms and improved by six-months. However, low adapters continued to exhibit many post-concussion symptoms, emotional distress and poor recovery expectations beyond six-months which substantially affected their outcome. The authors

noted the ability to identify those individuals at risk of persistent symptomatology would enable early intervention (Snell et al., 2015). These findings supported earlier research conducted by Snell and colleagues (2011) whereby poorer outcomes post-mTBI were found to be associated with maladaptive coping mechanisms generated by, negative beliefs about their injury and recovery (Snell, Siegert, Hay-Smith & Surgenor, 2011). Passive coping, whereby the individual tends not to react in the face of adversity, has been shown to contribute to negative outcomes post-mTBI (Boosman et al., 2017). A prospective study of individuals with mTBI (n = 820) investigated risk factors for poor outcomes at two-weeks post-mTBI (Scheenen et al., 2017). The authors found passive coping strategies, along with mental distress had the greatest predictive value for risk of persistent symptoms in mTBI (Scheenen et al., 2017).

An individual's health/illness beliefs have been found to impact the development of positive or negative coping strategies. Broadly, coping strategies have been shown to aid or hinder recovery following mTBI. One coping strategy that may be of particular importance is fear avoidance.

2.5.4 Fear Avoidance Coping Strategy

A coping strategy that has been found to be a possible contributor to persistent symptomatology in mTBI is fear avoidance behaviour. Fundamentally, the individual avoids activities they fear will exacerbate their symptoms. However, to understand the phenomenon of fear avoidance it is helpful to review Lethem and colleagues' (1983) Fear Avoidance Model (FAM) of Pain developed through investigations of fear avoidance behaviour in chronic low back pain.

Pain has a sensory (pain sensation) and an emotional component (pain experience), therefore, the aim of Lethem et al., (1983) was to investigate the relationship between pain sensation, emotions and avoidance behaviour. Lethem and

colleagues (1983) found pain-related avoidance behaviour was an initial expected adaptive response which abated once the pain sensation had diminished. However, in some individuals (particularly in chronic pain) the pain experience (emotions) and the avoidant behavioural response was inconsistent with the pain sensation. These individuals developed an ongoing exaggerated avoidant response to pain driven by their emotions, rather than the pain sensation. The avoidant behaviour then led to disuse with resulting disability, negative affect and the adoption of an 'invalid status' which perpetuated the avoidance (Lethem, Slade, Troup & Bentley, 1983; Slade, Troup, Lethem & Bentley, 1983).

Hence, the psychological process of fear avoidance behaviour may cause a cyclic manifestation of pain, disuse, disability and negative affectation. Fear avoidance behaviour may conceivably be a significant contributor to predisposing and maintaining persistent symptomatology in mTBI, but requires further investigation. Feasibly, this has the potential of being modifiable, through early targeted interventions, with the possibility of reducing the risk of developing persistent symptoms, and thereby improving outcomes (i.e., physical, cognitive, psychological and social functioning, and employment and sport/leisure activities and interactions) post-mTBI.

2.6 The Fear Avoidance Model of Pain

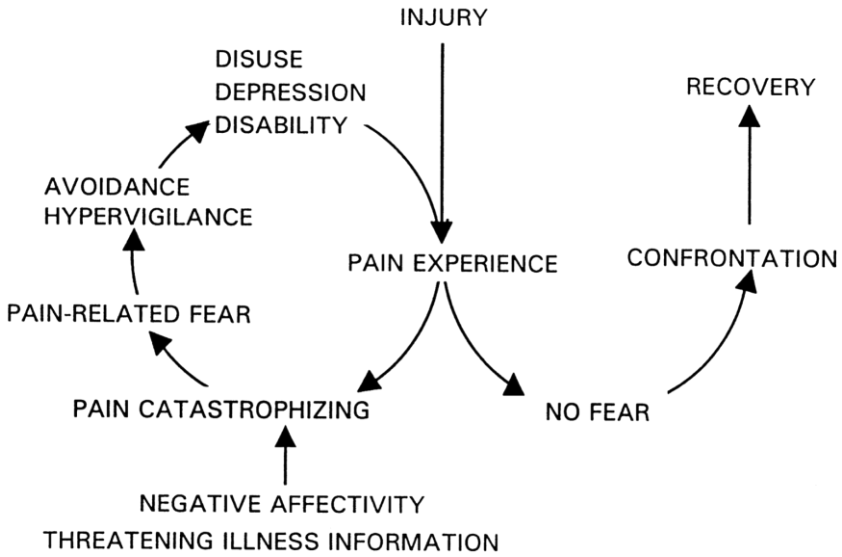
As highlighted in the previous paragraph, the FAM was established to identify how individuals develop chronic pain, especially an exaggerated perception of pain, and as a result exhibit avoidance behaviour (based on fear). The model states that negative appraisals about pain and its consequences, including catastrophic thoughts, may result in feelings of pain-related fear, avoidance of daily activities, and body hypervigilance.

Lethem et al., (1983) define exaggerated pain perception as, "Pain experience and/or pain behaviour (and/or physiological responses to pain stimulation) which are

(is) out of all proportion to demonstrable organic pathology or current levels of nociceptive stimulation" (Lethem et al., 1983, p. 402). It was hypothesised that individuals who confronted fear associated with musculoskeletal pain developed an adaptive response, with a resultant reduction in perceived pain. However, individuals responding to pain in an avoidant (maladaptive) manner exacerbated their fearful response and maintained high levels of perceived pain (Lethem et al., 1983). A fear avoidance response causes the individual to avoid physical, cognitive, psychosocial activities perceived as causing or exacerbating pain. This results in physical and psychosocial consequences such as, reduced mobility and muscular strength, weight gain, reduced social interaction, limited or no opportunity to reframe experiences and beliefs about pain or illness, and an increased risk of adopting the 'invalid status'. Consequently, the cycle of avoidance-disuse-disability is maintained and perpetuated (Lethem et al., 1983) (see Figure 1).

Figure 1

Fear Avoidance Model (FAM)



Note: Fear Avoidance Model (FAM). Reprinted from fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art, by J. A. Vlaeyen & S. J. Linton, 2000, Pain. Copyright (2000) by Elsevier Science. Reprinted with permission of Wolters Kluwer Health, Inc. and Copyright Clearance Center.

To explain the underlying processes of the FAM Vlaeyen and Linton (2000) extrapolated on the model. They described the individual with fear avoidance behaviour as catastrophising (overreacting, ruminating on the worst possible outcomes or misperceiving symptoms as dangerous) toward the pain sensation. Catastrophising is often associated with negative affectivity and anxiety sensitivity (fear of anxiety) and is influenced by the individual's fear avoidance beliefs. This increases the pain-related fear and results in the individual becoming hypervigilant to any physical or psychosocial manifestations of pain for fear of exacerbation. Hypervigilance increases the likelihood of the individual noticing any bodily changes and interpreting them as dangerous and unmanageable. This again, elicits a fear avoidant response to activities the individual perceives may exacerbate the pain. Thus, the hypervigilance and avoidant behaviour is perpetuated. Avoidance of activities leads to disuse, disability and increased negative affectation. This avoidant behavioural response offers minimal opportunity for the individual to challenge their beliefs and behaviour, and so the fear avoidance behavioural cycle continues, unabated with increasing debilitation and poor psychological functioning (Vlaeyen & Linton, 2000). As Helsen and colleagues (2011) commented, "the fear of pain can be more disabling than pain itself" (p.1230).

The FAM explains and describes the development of fear avoidance behaviour in musculoskeletal pain. The individual exhibiting fear avoidance behaviour becomes entrenched in a cycle of pain-related fear associated with disuse, disability and negative affectations and results in poor functional outcomes.

2.6.1 The Role of Emotional and Behavioural Responses in Pain

The basis of the FAM of Pain is the premise that pain and the emotion of fear cause a maladaptive avoidance behavioural response. Pain has the potential to elicit

various emotional responses (e.g., feelings of fear, anger, sadness, anxiety and/or loneliness).

Pain is described as a subjective sensory and emotional experience (Fong & Schug, 2014) and "is exquisitely sensitive to a broad range of emotional, environmental, and cognitive factors" (Seymour, 2019, p.1029). The relationship between fear and pain was first noted by Aristotle, "Let fear, then, be a kind of pain or disturbance resulting from the imagination of impending danger, either destructive or painful" (Eysenck as cited in Vlaeyen & Linton, 2000, p.318). Research on the pain experience (emotions) and its relationship with pain sensation over the past five decades has shown individuals' behavioural responses to pain vary widely (Sternbach, 1975; Rachman & Philips, 1975; Gray, 1971; Rachman & Hodgson, 1974; Lethem, Slade, Troup & Bentley, 1983; Slade, Troup, Lethem & Bentley, 1983; Vlaeyen & Linton, 2000).

Lethem and colleagues (1983) explained four varying emotional and behavioural responses found in individuals experiencing musculoskeletal pain. Firstly, natural remission, whereby the pain resolves resulting in the joint reduction of the sensory and emotional components of pain. Secondly, an increase in physiological pain stimulation elicits a rise in the sensory and emotional components. Both these scenarios are described as 'synchronous' (concordant). Thirdly, the plateauing of the pathological pain source and the sensory component (neither improving nor worsening), but there is a resulting increase in the emotional component of pain. Lastly, the emotional component increases even though the pathological cause and sensory component have resolved. The third and last scenarios are referred to as 'desynchronous' (discordant). All scenarios evoke a fear of pain but elicit extremes of coping, either confrontation (adaptive) or avoidance (maladaptive) (Lethem et al., 1983) as shown in Figure 1 (Vlaeyen & Linton, 2000).

An individual with an adaptive response is described as seeing pain as an interim nuisance, is highly motivated to return to usual work and activities, and prepared to confront and adjust to the barriers, pain and its management impose (Lethem et al., 1983). The individual with a maladaptive response is driven to reduce/eliminate exposure to pain by avoiding the pain experience (psychological avoidance) or avoiding painful activities (behavioural avoidance). Consequently, the individual reduces physical activity, which is often counterproductive to recovery, and reinforces the avoidance behaviour. Psychological and physical avoidance reduces exposure to the perceived painful stimuli and restricts opportunities to re-evaluate and alter beliefs and behavioural responses toward pain, and thereby further reinforces the avoidant behaviour (Lethem et al., 1983).

Responses to chronic musculoskeletal pain vary greatly between individuals. An individual's interpretation of the pain sensation is markedly affected by the emotional aspect (fear) of pain. The fearful response results in the individual avoiding activities perceived as exacerbating or causing pain, hence the individual exhibits fear avoidance behaviours.

2.6.2 Fear Avoidance Beliefs

An individual's illness/injury/health beliefs contribute to the emotional (threat) perception of pain and the development and perpetuation of pain catastrophising and pain-related fear with resultant avoidance behaviour.

Beliefs are "convictions of the truth of propositions without their verification and as such, are subjective mental interpretations derived from perceptions, reasoning or communication" (Ranville et al., 2011, p. 896). Fear avoidance beliefs are generally deduced from the emotional aspects of pain and the individual's knowledge gleaned from various sources (Ranville et al., 2011). Beliefs may develop from direct experience

with the stimuli, or knowledge that a certain activity will elicit pain (e.g., information from medical personnel), or indirect experiences through observation (modelling) (Vlaeyen & Linton, 2000). For example, observing an individual performing a task or activity which elicits a painful expression, regardless of the pain sensation. The observer will avoid the associated activity, without personal experience, believing it will cause pain (Goubert, Vlaeyen, Crombez & Craig, 2011).

Fear avoidance beliefs have been found to significantly influence an individual's pain experience (Gatchel, Neblett, Kishino & Ray, 2016) and are predictive of outcomes in musculoskeletal pain (Wertli et al., 2014). Ranville and colleagues (2011) found them to contribute significantly to negative outcomes (greater pain and increased disability) in individuals with low back pain. Individuals could be categorised into three subgroups of the origin of the fear avoidance beliefs. The groups were misinformed avoiders, learned pain avoiders, and affective avoiders. They found specifically targeted interventions for each group reduced pain and improved functional outcomes (Ranville et al., 2011).

Fear avoidance beliefs were found to be associated with work absence in individuals with musculoskeletal pain. In a two-year Danish Work Environment Cohort Study (DWECS) study (n = 8319) the authors found a high level of fear avoidance was a risk factor for long-term absence from work, regardless of the level of occupational physicality and pain intensity. They suggested fear avoidance beliefs may not only mediate activity and psychosocial occupational functioning but is an "independent explanatory variable". They hypothesised a multifactorial interventional approach (physical and cognitive behavioural) would be of benefit in addressing fear avoidance beliefs to reduce workplace absence in this population (Jay et al., 2018, p. 4).

Accordingly, fear avoidance beliefs, gleaned throughout an individual's lifetime experiences, have the capacity to contribute to fear avoidance behaviour and negatively impact physical, cognitive, psychological and social functioning.

2.6.3 Psychosocial Factors Influencing Avoidance Behaviour in Response to Pain

An individual's fear avoidance beliefs are also affected by psychosocial factors. These factors can also aid or hinder the development of positive coping strategies when an individual encounters fear related to pain. Lethem and colleagues (1983) hypothesised four possible psychosocial factors influencing avoidance beliefs and behaviour in chronic back pain. Firstly, previous stressful life events which erode the individual's coping strategies causing the individual to avoid rather than confront the pain (Lethem et al., 1983). This is fundamentally a passive response and necessitates minimal effort. It is often associated with internal and external reinforcers. For example, an external reinforcer may be that the individual perceives a sense of gain from the 'invalid status' or the extra special care pain elicits (Lethem et al., 1983). Whereas a child touching something hot for the first time (unconditioned stimulus) quickly learns to avoid (conditioned response) future situations they perceive may evoke a similar painful experience (internal reinforcer). It was also hypothesised the avoidant response to pain is further reinforced by a reduction in life stresses. The individual takes on an 'invalid status' and is therefore, exposed to less opportunity to experience the stresses of life (Meyers & Lyon, as cited in Lethem et al., 1983).

Secondly, memories of previous pain experiences may influence the fear, intensity and coping abilities towards pain. If previously, the individual had experienced acute and debilitating pain causing a fearful response, then the likelihood of an avoidant response is increased when further bouts of pain are experienced. However, if the

individual's initial pain experience is perceived as less severe and of shorter duration, the individual may be desensitised to the pain. Consequently, the risk of an avoidant response with subsequent bouts is reduced (Lethem et al., 1983).

Thirdly, an individual's coping strategies for managing pain. These strategies are unique to the individual and develop from a blend of modelling (observation), imitating, personal experiences, and/or interactions with parents and significant others throughout their life. Coping strategies may be active, whereby the individual engages in activities and exercise attempting to ignore and distract from the pain. Conversely, the individual may have a passive response seeking rest and pain relief. Individuals typically utilise a combination of both strategies. Evidence has shown those individuals who predominantly engage active coping strategies have greater ability to manage further pain and are less likely to develop fear avoidance behaviour. Inversely, those individuals who engage passive coping strategies are at a greater risk of employing fear avoidant behaviour (Lethem et al., 1983).

Lastly, the personality traits of the individual. Individuals scoring high on the various scales of the Minnesota Multiphasic Personality Inventory (MMPI), were shown to develop reinforced negative behaviours towards pain (Sternbach, 1974). Individuals who displayed neurotic tendencies such as anxiety, depression, hypochondria, self-doubt and negative affectations, were at greater risk of developing maladaptive avoidance behaviours when encountering pain (Lethem et al., 1983; Nishi, Osumi, Nobusako, Takeda & Morioka, 2019).

In summary, psychosocial factors such as stressful life events, the individual's pain history, coping strategies and personality traits can influence an individual's beliefs and ability to experience pain either with confrontational (adaptive) or avoidant (maladaptive) behavioural coping strategies.

2.6.4 The Use of the Fear Avoidance Model in Other Conditions

Much of the research conducted of the FAM has focused on musculoskeletal pain, but there is limited research which has examined fear avoidance behaviour and its relationship to negative outcomes in other conditions.

Several studies have shown fear avoidance behaviour to impact functional ability in individuals with chronic fatigue syndrome (CFS) (also known as myalgic encephalomyelitis (ME)) and fibromyalgia (FM) (Nijs et al., 2013; Silver et al., 2002; Chalder et al., 2015; Martinez et al., 2011; Peñacoba, López-Gómez, Pastor-Mira, López-Roig & Ecija, 2021). A 2013 study reviewed measures of fear of movement and avoidance behaviour in individuals diagnosed with CFS and FM (Nijs et al., 2013). The authors found that fear of movement and avoidance behaviour were associated with a reduction of physical activity in both conditions. These findings are consistent with a previous study of individuals with FM, whereby fear avoidance of pain contributed to the amount of pain experienced (Martinez et al., 2011). A 2015 study investigated potential interventions for individuals with CFS. It found fear avoidance beliefs and behaviour contributed to maintaining fatigue and disability, and would be beneficial as a focus of intervention (Chalder et al., 2015). However, the ME Association of the United Kingdom (2015) disputed these findings stating the research did not fully account for the complexities of CFS.

Fear avoidance beliefs and behaviour have also been found to impact activity and fatigue levels within multiple sclerosis (MS) populations. Kayes and colleagues (2011) conducted a mixed-methods study (n = 282) to investigate barriers to engaging in physical activities for individuals with MS. They found fear avoidance beliefs and behaviour were not significant predictors of barriers to physical activity. However, at interview they found fear avoidant beliefs and behaviours did impact the individual's physical activities. The authors acknowledged that the assessment tool used to measure

avoidance did not fully cover all dimensions of fear avoidance within the context of MS. Hence, they noted the need to develop and utilise assessment scales to capture the subtle differences specific to individual illnesses and injuries (Kayes et al., 2011). A further study of individuals with MS found fear avoidance contributed to increased levels of fatigue (Wijenberg, Stapert, Kohler & Bol, 2016).

Fear avoidance behaviour in individuals with rheumatoid arthritis (RA) (*n* = 2569) was investigated. The authors found three levels of fear avoidance beliefs, low, medium and high. The high-level group were found to have higher levels of anxiety and depression, and higher levels of fear avoidance of physical activity. The researchers highlighted the importance of not only looking at physical and mental health functioning, but to consider the actual processes (i.e., negative cognitions and beliefs about physical activity) that may contribute to fear avoidance behaviour (Demmelmaier, Bjork, Dofour, Nordgren & Opava, 2018).

Fear avoidance behaviour was also found to be a significant factor in cancer survivors, with those who had high fear avoidance reporting higher levels of pain and symptoms (Velthuis et al., 2012; Gencay Can et al., 2019; Van der Gucht et al., 2020; Gutierrez-Sanchez, Roldan-Jimenez, Pajares, Alba & Cuesta-Vargas, 2021).

Fear avoidance behaviour has been shown to impact pain levels, symptom presentation, and physical and mental health functioning in conditions other than musculoskeletal pain. It has the potential to negatively impact the individual's ability to adapt to living with a disease or chronic illness, and thereby negatively affect their overall quality of life.

2.7 Fear Avoidance in mTBI

Research on fear avoidance in mTBI, although limited, has shown it to be a possible contributor to persistent symptomatology, and poorer outcomes (i.e., physical,

psychological, cognitive and social functional disability) within this population. Riley and colleagues (2004) investigated threat appraisal and avoidance behaviour in a sample of 50 individuals post-TBI (classification of TBI was not reported). They found threat appraisal with resultant fear avoidance behaviour in 80% of individuals. The authors recommended the core criteria of TBI management should focus on encouraging individuals to re-engage in activities and valued roles.

Silverberg and colleagues (2017) examined cogniphobia in mTBI. Cogniphobia is described as, fear and avoidance of cognitive exertion believed to elicit a headache following a post-traumatic experience, such as a mTBI. Results from Siverberg's study showed that avoidance of cognitive exertion was associated with poor memory performance, and avoidance of physical activity at two to three-months post-injury. A later study by the same authors (2019) investigated headache trigger sensitivity in mTBI. They found individuals, post-mTBI, were advised to avoid triggers (e.g., stress, mental exertion and poor sleep) that were believed to elicit a headache. However, paradoxically, they found these triggers are commonplace in life and avoiding them resulted in a highly restricted lifestyle which perpetuated fear avoidance behaviour. It was, therefore, found to be an ineffective management post-mTBI. They also found avoidance was not associated with headache severity, but individual characteristics such as coping strategies and illness beliefs.

The FAM was used to identify persisting symptoms in a sample of 31 individuals with mTBI (Wijenberg et al., 2017). The authors found significant associations of post-concussion symptoms with fear avoidance behaviour, catastrophising and depression. However, although significant, the levels of catastrophising and fear avoidance behaviour were low in relation to post-concussion symptoms. The authors recommended the need for validated measures of avoidance and catastrophising within mTBI populations. Fear avoidance and clinical outcomes in

mTBI were also investigated in a 2018 study by Silverberg and colleagues. Fear avoidance severity was shown to be associated with an increased risk of depression and anxiety disorders post-mTBI.

In contrast, Greenberg and colleagues (2020) investigated whether pain catastrophising and avoidance of exercise and usual activities mediated anxiety and post-concussion symptoms. They found avoidance behaviour partially mediated anxiety and post-concussion symptoms. However, it was noted this may be a bi-directional relationship, whereby post-concussion symptoms may lead to avoidance behaviours and increased anxiety. The authors recommended targeted interventions to improve engagement in activities regardless of symptom severity, particularly for individuals who have high levels of anxiety (Greenberg et al., 2020).

These studies demonstrate the potential association of fear avoidance behaviour with persistent post-concussion symptomatology and the negative physical, cognitive, mental and social functioning outcomes following mTBI. In a more recent study Cassetta and colleagues (2021) recruited participants from two outpatient clinics in British Columbia. Assessments were completed at three time points, baseline (n = 88) (M = 40.2 days since injury), and at one-month (n = 79) and three-months follow-up (n = 69). The authors hypothesised that avoidance at baseline would be associated with disability at three-months follow-up, and that increases in avoidance behaviour (between baseline and one-month follow-up) would be associated with disability at three-months follow-up. Fear avoidance behaviour was found to decrease in 80% of participants from clinic intake to one-month, with the remaining 20% reporting ongoing or increased fear avoidance. Higher levels of fear avoidance at baseline were associated with greater levels of functional disability at three-month follow-up. The authors commented this result refutes reverse causality, that is, participants avoid activity due to

symptom severity. Instead, avoidance behaviour increased functional disability, despite stable symptom severity (Cassetta et al., 2021).

There were several limitations to this study, including the lack of follow-up assessments over a longer period of time, the results could not determine causality and were therefore not generalisable, and finally they did not control for pre- and post-injury mental health functioning. There was also a lack of controlling for demographic variables that have also been shown to predict outcomes. Nevertheless, the findings were consistent with previous studies and highlight the need for interventions specifically targeted to manage fear avoidant coping behaviour to improve outcomes of symptom severity, functional disability, cognitive functioning, mental health and quality of life for individuals who sustain a mTBI.

In summary the current research on fear avoidance within mTBI populations has shown to contribute to persistent symptomatology. It has the potential to negatively impact outcomes causing physical, psychological, cognitive and social dysfunction and financial burden. However, gaps in the current literature have highlighted the need to further examine the relationship between fear avoidance behaviour and mTBI outcomes whilst controlling for factors known to impact persistent symptomatology. Identification of factors which increase an individual's risk of developing fear avoidance behaviour can enable early interventions to be implemented post-mTBI. This has the possibility of improving outcomes for the individual, whānau/family and reducing the societal burden of mTBI.

Chapter 3 Methodology

This chapter describes the study rationale and aims, study methods and procedures, data collection, predictor and outcome variables, and ethics.

3.1 Rationale

Based on the current literature, there is limited data which examines the contribution of fear avoidance behaviour to symptomatology in mTBI, and its impact on outcomes. There is also a need to understand the characteristics of individuals who are at greatest risk of developing such behaviours. Early interventions are imperative to prevent persistent symptomatology and improve outcomes for those who sustain mTBI, but there is limited research in this area. Targeting fear avoidance behaviour in mTBI may mitigate those on a trajectory of experiencing persistent symptoms following mTBI.

This study has the potential to inform concussion service providers of those individuals who are at risk of developing fear avoidance behaviour which may lead to persistent symptoms and poorer outcomes in mTBI. It will also provide valuable insight into fear avoidance behaviour in mTBI, and the implications this has on outcomes following this type of injury. Identifying those who are at risk of fear avoidance behaviour can ensure that early intervention processes are implemented and outcomes improved. Additionally, and most importantly, it would benefit the affected individual, their whānau/family and society with reduced psychological, physiological and economic burden.

3.2 Study Aims

The overall objective of this study was to explore the role of fear avoidance behaviour on outcomes in individuals who sustain a mTBI. The specific aims of this study were:

1. To identify who is most likely to present with fear avoidance behaviour after sustaining a mTBI.
2. To examine if fear avoidance behaviour affects the initial outcomes for individuals who sustain a mTBI, whilst accounting for factors known to impact mTBI recovery.
3. To examine the unique contribution fear avoidance behaviour has on post-concussion symptoms, differentiated as early symptom cluster (RPQ-3) and enduring (fatigue/affective/mood) symptom cluster (RPQ-13), at two timepoints.
4. To examine if fear avoidance at clinic intake and changes in fear avoidance over time is associated with mTBI outcomes at three-months follow-up.

This study hypothesises that:

1. Individuals with pre-injury mental health conditions, lower educational status and traumatic circumstances of injury will have higher levels of fear avoidance behaviour post mTBI.
2. Individuals with mTB who present with higher levels of fear avoidance behaviour will have worse outcomes, including depression, stress, anxiety, post-concussion symptoms, and functional disability following mTBI.
3. We also hypothesise that fear avoidance will make a significant and unique contribution to post-concussion symptoms and functional status whilst considering factors known to exert an influence on mTBI recovery (i.e., mood status).

4. We hypothesise that there will be a significant association between fear avoidance behaviour and RPQ-3 symptomatology at clinic intake, however, at follow-up there will be a significant association between fear avoidance behaviour and RPQ-13 symptomatology.
5. We hypothesise that individuals with higher post-concussion symptoms and functional disability at follow-up will have had higher levels of fear avoidance at clinic intake and their fear avoidance would have increased at follow-up.

3.3 Ethics

Ethics approval has been granted by the Auckland University of Technology Ethics Committee on 19 February 2020. AUTEC Reference number 20/32. Data has been collected and stored via a password protected database, specifically REDcap online (Harris & LaPolla, 2018) research tool. The confidentiality of all participants has been protected by de-identifying participant information. Participants were classified using a unique participant identification (ID) number. Participant's contact details were initially stored on a password protected device and following contact were deleted. Access to study data was limited to key personnel. All data will be stored for six years and then destroyed. Participants were offered a $20 voucher to recompense and thank them for their time. This project is funded by the Health Research Council (ID Number 20-041) – Clinical Research Fellowship (Foxley Fellowship).

3.4 Methods

This research used a quantitative approach, and is a sub-study of a parent research project which examines the role of psychological flexibility in recovery

following concussion. This research was supported by Proactive Rehabilitation Concussion services and the Health Research Council of New Zealand (20-041).

3.4.1 Procedure

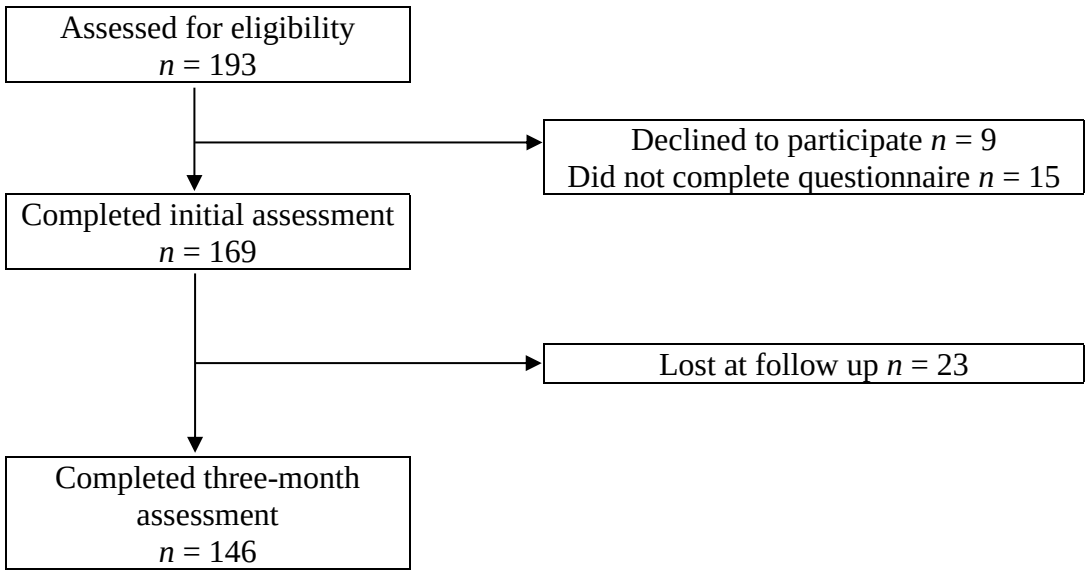
Individuals were recruited via the Proactive Concussion service clinics throughout the North Island of Aotearoa/NZ between March 2020 and September 2020. The geographic location and the recruitment site numbers in each location are as follows: Auckland (3), Bay of Plenty Region (3), Gisborne (1), Hawke's Bay Region (3), Manawatu and Whanganui region (2), and Wellington region (4). Written consent was gained prior to individuals partaking in the study. All individuals automatically qualify for the Aotearoa/NZ Government 'no fault' injury insurance ACC scheme. This scheme covers most treatment costs and financial employment compensation whilst unable to work. All individuals were 18 years and over, with a history of mTBI and referred to concussion services. The definition of mTBI was that, endorsed by ACC and is based on the World Health Organisation (WHO) Neurotrauma Task Force criteria, whereby an external, direct or indirect, force causes "altered brain function, or other evidence of brain pathology." The injury severity does not exceed 30 minutes (approximately) of LOC, and PTA no greater than 24 hours (Menon, Schwab, Wright & Mas, 2010, p.1638). Individuals were recruited into the study within 30 days of their entry to the concussion service. Exclusion criteria included: not being fluent in English, prior neurological condition, and having a severe unstable medical condition.

When individuals were referred to Proactive Concussion Service, they completed an initial assessment with an occupational therapist. Occupational therapists were educated on the inclusion criteria of this study and if patients met the criteria, they provided a description of the study to the patient, as well as an

information sheet. Consent was obtained from interested individuals for their contact details to be shared with a researcher. A researcher contacted the individual to provide more information regarding the study and any questions about participation were answered. If the individual wished to participate, they were formally enrolled in the study and the electronic consent form and questionnaires were sent to the indivdiual. This occurred within 30 days of entry to the concussion service. A total of 193 individuals were eligible for recruitment. However, nine individuals declined and 15 did not complete the questionnaires. The final sample of 169 individuals met criteria and responded to the questionnaires (M = 8.74 weeks since injury). At a three-month time point (follow-up) post-clinic intake individuals were offered the opportunity to repeat the questionnaires. A total of 146 individuals completed the second round of questionnaires, at follow-up (M = 22.91 weeks since injury), with a loss of 23 individuals to the study. Figure 2 shows an overview of individuals in the study at both time points.

Figure 2

Overview of individuals eligible for this study and subsequent numbers completing the study at two time points.



3.4.2 Data Collection - Measures

Predictor and outcome (dependent) data was collected through individuals completing online questionnaires at two time points (at clinic intake and follow-up). The variables and questionnaires used to measure these variables are outlined below in Table 1.

Table 1

Summary of the predictor and outcome variables and corresponding questionnaires.

Predictor Variables	Outcome Variables
Demographic variables (i.e., age, gender, ethnicity) – at clinic intake.	Post-concussion symptoms (RPQ) – at clinic intake and 3 months.
Injury details (i.e., time since injury, mechanism of injury, other injuries sustained) - at clinic intake.	
Fear avoidance (FAB-TBI) – at clinic intake and 3 months.	Functional Disability (WHODAS 2.0) – at clinic intake and 3 months.
Psychological Functioning (DASS-21) – at clinic intake and 3 months.	

Predictor Variables

Predictor variables were assessed at clinic intake once consent was obtained.

Demographic and Injury variables

Demographic variables included: age, gender, ethnicity, education level, occupation, pre-injury employment status, relationship status, previous concussion history, prior history of medical conditions and mental health conditions. Injury characteristics included: time since injury, mechanism of injury, and if other injuries were sustained.

Psychological Functioning

The Depression Anxiety Stress Scale-21 (DASS-21) was utilised to measure post-injury mood in the current study. The DASS-21 is a self-report measure of the symptom severity associated with depression, anxiety and stress over the previous seven days. It comprises 21 items with seven items for each scale. The individual scores statements for depression (e.g., "I felt down-hearted and blue"), anxiety (e.g., "I felt I was close to panic") and stress (e.g., "I felt that I was using a lot of nervous energy") utilising a four-point Likert scale (0 = did not apply to me at all; 1 = applied to me to some degree, or some of the time; 2 = applied to me a considerable degree, or a good part of the time; and 3 = applied to me very much, or most of the time) (Psychology Foundation of Australia, 2018; Crawford, Cayley, Loviband, Wilson & Hartley, 2010). DASS-21 cut-off scores for depression, anxiety and stress are: normal (0-4, 0-3 and 0-7 respectively); mild (5-6, 4-5 and 8-9 respectively); moderate, (7-10, 6-7 and 10-12 respectively); severe (11-13, 8-9 and 13-16 respectively); and extremely severe (14+, 10+ and 17+ respectively). These are not a measure of clinical diagnoses, but a useful tool to assess emotional disturbance within the broader clinical assessment (Crawford & Henry, 2003; Szabó, 2011; Psychology Foundation of Australia, 2018). The DASS-21 has been found to have strong reliability across all three scales. Internal consistency results in non-clinical samples: depression α = 0.88, anxiety α = 0.82, and stress α = 0.92 (Henry & Crawford, 2005) and in a clinical sample: depression α = 0.94, anxiety α = 0.87, and stress α = 0.91 (Antony, Bieling, Cox, Enns, & Swinson, 1998). It demonstrated good convergent and discriminant validity properties when compared to the other depression and anxiety measures such as the Hospital Anxiety Depression Scale (HADS) (Zigmond & Smith, 1983) and the Personal Disturbance Scale (Bedford & Foulds, 1978).

The DASS's use in the acquired brain injury (ABI) population has been researched. Onsworth et al., (2008) investigated the DASS-42 and DASS-21 in acquired brain injury (ABI) with a sample of 48 individuals with a brain tumour (n = 25) and TBI (n = 23), and a non-clinical control (n = 29). They found acceptable internal consistency ($r > 0.70$) with the depression and stress scales, but poor ($r < 0.70$) for anxiety. They postulated this may be due to difficulties in discriminating between symptoms associated with TBI (i.e., irritability, apathy, emotional disruption and fatigue). Test-retest reliability for depression was sound ($r >.0.70$), but lower, although significant, for anxiety and stress (r = 0.60-0.73, $p < 0.01$). Concurrent validity was significant with the HADS ($p < 0.05$). Overall, they found support for its clinical use post-ABI, but recommended further investigation was required. Dahm and colleagues (2013) examined the DASS-42, DASS-21 and HADS for use as a screening tool for anxiety and mood disorders post-TBI in a sample of 123 participants with a mild to severe TBI. They found large and significant concurrent validity with the HADS (both $r = 0.76$, $p > 0.001$), as was discriminant validity (r = 0.68- 0.84, $p < 0.001$) with the respective scales of HADS ($r = 0.70$, $p < 0.001$). DASS-21 was "highly correlated with its full-scale equivalent ($r = 0.95$, $p > 0.001$)" (p.394). In further research Randall and colleagues (2017) retrospectively investigated the structure and construct validity of the DASS-21 in 504 participants with moderate to severe TBI. They found strong support ($\alpha = 0.82$ and $\alpha = 0.90$ respectively) for the fit of the three-factor (Lovibond & Lovibond, 1995) and the four-factor (Henry & Crawford, 2005) models, validating its valuable use as a screening tool for psychological functioning in TBI rehabilitation.

Fear Avoidance

The Fear Avoidance Behaviour after Traumatic Brain Injury Questionnaire (FAB-TBI) is a relatively new 16-item TBI-specific questionnaire developed from the

Fear Avoidance Behavior Questionnaire (FABQ) which assesses avoidance behaviour in back pain (Waddell et al., 1993). Statements were modified to incorporate the brain and post-concussion symptoms experienced, such as: “My headaches put my head and brain at risk for the rest of my life”, and “I worry that when I have to think or concentrate too hard that I will bring on a headache” (Silverberg et al., 2018). The FAB-TBI utilises a four-point Likert scale (0 = strongly disagree; 1 = disagree; 2 = agree; 3 = strongly agree) in response to 16 statements in relation to the past month. The maximum score on the FAB-TBI is 48, with higher scores indicative of higher levels of fear avoidance. Twelve items were confirmed with principal component analyses and four additional items incorporated from a widely used fear avoidance measure (Silverberg et al., 2018) in chronic pain, the Patterns of Activity Measure-Pain (Kindermans et al., 2011) with modification for TBI (Silverberg et al., 2018).

The FAB-TBI showed strong internal consistency ($\alpha = 0.90$) (Silverberg et al., 2018). Two distinct dimensions emerged from exploratory factor analysis, the general avoidance of activities and the avoidance of activities that elicited a headache (Silverberg et al., 2018). However, Snell et al., (2019) achieved one-dimensionality through the combination of items, without altering the response format, to fit the Rasch model. This enabled conversion of total scores from ordinal to interval data. Thus, in accordance with the recommendations made by Snell et al., (2019), in the current study, raw scores were converted to interval scores to improve the psychometric properties of the measure (Krageloh et al., 2016). The FAB-TBI has been shown to be a robust measure of fear avoidance behaviour in mTBI (Snell et al., 2019; Silverberg, Panenka & Iverson, 2018). To support clinical interpretation of the FAB-TBI for adults within the mTBI population, normative data has been developed (Cairncross et al., 2021).

Fear avoidance may present initially post-injury as it provides a protective effect for the individual (Fong and Schug; 2014; Lethem et al., 1983; Vlaeyen & Linton, 2012; Gatchel, Neblett, Kishino & Ray, 2016). However, ongoing fear avoidance behaviour has been found to be a possible contributor to persistent symptomatology in mTBI (Silverberg et al., 2018; Wijenberg et al.,2017). Therefore, this study collated the change in scores of the FAB-TBI from clinic intake to follow-up at three months, to account for differences in scores. Negative values indicate a reduction in fear avoidance and conversely, positive scores indicate ongoing or increasing avoidant behaviour.

Dependent Variables

Post-concussion symptoms

The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) is a well-researched tool to measure cognitive (e.g., memory, concentration), somatic (e.g., headache, fatigue, light sensitivity) and emotional/mood (e.g., feeling depressed, irritable, anxious) symptom severity in mTBI (Eyres, Gilworth, Neumann & Tennant, 2005). Individuals are asked to rate 16 of the most common post-concussion symptoms (headaches, dizziness, nausea/vomiting, noise sensitivity, sleep disturbance, fatigue, irritability/easily angered, depressed/tearful, frustration/impatience, poor memory and concentration, slow to think, double vision, light sensitivity, and restlessness) over the past 24 hours in comparison to their pre-injury status (King et al., 1995; Eyres, Carey, Gilworth, Neumann & Tennant, 2005). Each item is rated utilising a five-point Likert scale (0 = not experienced at all; 1 = no more a problem; 2 = a mild problem; 3 = a moderate problem; and 4 = a severe problem). The total score range is from 0 to 64. In the current study, scores of 1 (“no more of a problem than before injury”) were recoded to zero as per the

recommendations of King et al., (1995). The higher the score the greater the severity of the symptoms (Thomas, Skilbeck, Cannan & Slatyer, 2017). Guise et al., (2016) proposed a cut-off score value >35 within the first three-months post-mTBI (sensitivity = 90%, specificity = 60%) to aid planning of interventions and rehabilitation. However, inconsistencies have been found in reporting RPQ scores with some studies reporting total scores or specific symptom item scores (Barker-Collo, Theadom, Starkey, Jones & Feigin, 2018). Reported scores may be influenced by the RPQ's evaluation of symptoms over the past 24 hours. Given that symptoms may be quite variable (Dean & Sterr, 2013) this may not echo the individual's true experience. Therefore, Barker-Collo et al., (2018) proposed averaging symptoms over the past week to give a more realistic picture of the individual's experience.

Further to this, researchers have proposed classification of symptoms as either enduring (relatively stable over a longer time period of 6-12 months) or dynamic (unstable and may fluctuate substantially within days or months). This would enable a more accurate assessment relative to the timeframe post-injury (Thomas et al., 2017; Barker-Collo et al., 2018; Carroll et al., 2004; Sveen et al., 2010). Examples of enduring symptoms: sensitivity to noise, impatience, nausea and vomiting, and sleep disturbance; and dynamic symptoms: diminished concentration, fatigue, restlessness and irritability (Medvedev et al., 2018).

The original research showed high inter-rater reliability (r = 0.91) and high test-retest reliability across a seven-day interval (r = .87) of the total score and individual item score (King et al., 1995; Tate, 2010). However, Medvedev and colleagues (2018) noted the inaccuracy of test-retests with merely adding scores may not reflect an accurate clinical presentation. For example, if an individual scores one on feelings of depression, two on sleep disturbance and four on fatigue in the first test and then on a subsequent test scores one on fatigue, two on sleep disturbance and four

on depression this gives the same score, but it does not indicate important clinical changes. It also does not differentiate whether it is enduring or dynamic symptomatology. They found the RPQ showed strong reliability in assessing enduring symptoms, but limited ability in the assessment of dynamic symptomatology (Medvedev, Theadom, Barker-Collo & Feigin, 2018).

The RPQ has shown to have excellent concurrent validity at 7-10 days with the Hospital Anxiety Depression Scale (HADS) (Zigmond & Snaith, 1983) (r = .61, p <.005) and adequate with the Impact of Event Scale (IES), an evaluation of post-traumatic stress symptoms such as Intrusions (r =.33, p <.05) and Avoidance (r =.50, p <.005) (Horowitz, Wilner & Alvarez, 1979). At six-months the HADS Anxiety (r=.45, p<.05) and HADS Depression (r =.32, p <.05) score and the IES intrusions (r =.33, p<.05) and IES Avoidance (r =.37, p <.05) were most highly correlated with total RPQ scores (King, Crawford, Wendon, Caldwell & Wade, 1999). Convergent validity was shown to have excellent correlation with the Mayo-Portland Adaptability Inventory 4 (MPAI-4), an outcome measure for individuals with an ABI (Kean, Malec, Altman, & Swick, 2011), (r=.612, p<.001) (de Guise et al., 2016).

Nevertheless, there is much discussion regarding the factor structure of the RPQ and unidimensionality. Some researchers have found the structure changes over time (Medvedev et al., 2018; Barker-Collo et al., 2018; Lannsjö et al., 2011; Potter, Leigh, Wade & Fleminger, 2006; Ryan & Warden, 2003). Medvedev and colleagues (2018) found strong reliability for the RPQ when assessing enduring symptomology. However, they suggested cautious use of the RPQ when tracking dynamic symptom change over time. Barker and colleagues (2018) found three factors at one-month. Factor one comprised cognitive and physiological disturbances; factor two included mood, sleep and nausea/vomiting symptoms; and factor three covered visual disturbances. However, from six-months onwards they found factors one and two

commingled to one factor of mood/cognitive, and a second factor comprising visual disturbance and symptoms such as, headaches, nausea/vomiting and dizziness which are considered an early symptom cluster post-mTBI (Barker-Collo, 2018). A four-factor structure of subscales: vision; vertigo; mood/somatic; and cognitive was found to provide valuable clinical information of functioning post-mTBI (Thomas et al., 2017). This four-factor model is supported by previous studies (Franke, Czarnota, Ketchum & Walker, 2015; Lannsjö et al., 2009). Eyres and colleagues (2005) found the 16 items of the RPQ was a poor fit to the Rasch model and therefore, lacked unidimensionality. They found some items of the RPQ did not measure the same construct. Therefore, they proposed a two-factor structure with each factor measuring a unidimensional construct. Factor one comprises headaches, dizziness and nausea/vomiting (referred to as RPQ-3) and considered an early symptom cluster. Factor two is described as an enduring symptom cluster and comprises mood, emotional, cognitive, noise, visual and sleep disturbances and fatigue (referred to as RPQ-13). These scales were found to have good test-retest reliability and reasonable construct validity (Eyres et al., 2005). Although post-concussion symptoms may be differentiated as RPQ-3 and RPQ-13 clusters, they may manifest interrelatedly and are not distinctively bound within a timeframe post-mTBI. For example fatigue, and noise and light sensitivity may exacerbate headaches at any point in the recovery period (Silverberg et al., 2019). Needless, the current study aimed to investigate the influence of the specific clusters of RPQ-3 and RPQ-13 on fear avoidance following a mTBI to ascertain if there was a difference.

Consideration must be given to the generic nature of post-concussion symptoms when assessing symptoms post-mTBI (Balalla, Krägeloh, Medvedev & Siegert, 2020). Post-concussion symptoms are not specific to mTBI and are experienced in individuals with chronic pain (Fow, Kant & Franzen, 2003),

orthopaedic injuries (Mickevvciene et al., 2004), psychological disorders (Iverson, 2006) and the general population (Theadom et al., 2018). However, overall, the RPQ has been found to be a sound and valuable tool in assessing and predicting the individual's limitations, adaptations and participation in daily activities post mTBI.

Functional Disability

The WHO Disability Assessment Schedule 2.0 (WHODAS 2.0) is a 12-item self-report assessment over the past 30 days of general health and disability at clinical or general population level. It covers six domains of cognition, mobility, self-care, interactions, activities and participation, indicating an individual's functionality. Questions such as, "How much have you been emotionally affected by your health condition?" and "Taking care of your household responsibilities?" are rated using a five-point Likert scale (none; mild; moderate; severe; and extreme or cannot do) (World Health Organisation, 2019; Saltychev, Katajapuu, Bärlund & Laimi, 2019). It has norms available and has been widely used in Aotearoa/NZ health and injury research (Snell, Iverson, Panenka & Silverberg, 2017). It is suitable for use in multiple health conditions, countries, and cultures (Tate, 2010). A systematic review of diverse samples found WHODAS 2.0 to be internally consistent with reliable test-retest results. It had good correlation with other disability measures (Saltychev et al., 2019) such as the Karnofsky Performance Status scale which assesses the functioning abilities of individuals with cancer (Mor, Laliberte, Morris & Wiemann, 1984). Schiavolin et al., (2014) found the one factor structure was acceptable with $\alpha = 0.88$. This was supported in a Spanish study with $\alpha = 0.89$ (Luciano et al., 2010c). The researchers found discriminate validity in its ability to differentiate between individuals with and without depression, and with and without comorbidities. These results confirmed previous research whereby the 12-item WHODAS 2.0 was found to be a valid and reliable measure for assessment of functioning and disability (Luciano

et al., 2010 a,b). Moderate correlations were found with other assessment tools which support convergent validity (Schiavolin et al., 2014).

However, there is limited research on its use in the population with mTBI (Snell et al., 2020). Hence, Snell and colleagues (2020) conducted preliminary research of the 12-item WHODAS 2.0 in mTBI in a sample of 79 adults post mTBI. Accounting for the accumulative effect of comorbidities the research showed high internal consistency ($\alpha = 0.92$) and adequate construct and concurrent validity. Exploratory factor analyses found three factors. Factor one reflected participation barriers and limitations; factor two described physical restrictions such as walking; and factor three characterised self-care constraints such as showering. The scale discriminated between individuals with positive and negative outcomes, in relation to symptomatology, psychological functioning and pain in mTBI. Support for concurrent validity was shown with individuals returning to work having lower WHODAS 2.0 scores than those who had not. This preliminary data validated the measure as a sensitive tool for use in mTBI assessment (Snell et al., 2017). In accordance with the recommendations of Snell et al., (2020), in the current study, ordinal scores on the WHODAS 2.0 were converted to interval scores using the conversion table provided, to improve the psychometric properties of the measure.

3.4.3 Data Analysis

For all statistical analyses Statistical Package for Social Sciences (SPSS) Version 25 was used with a significant level set at .05 to signify statistical significance. A power analysis using the G*power software was used to ensure adequate sample size for the regression analysis. Assuming a medium effect size (f^2) of 0.15, an α of 0.80, and a maximum of 11 predictors, power analysis suggested a minimum sample of 127 participants (Faul et al., 2009). Descriptive analysis and

Pearson's product correlations were conducted to broadly characterise the sample (age, gender, ethnicity, education, pre-injury employment and relationship status, medical and mental health history, and injury characteristics). Descriptive statistics are reported as numbers and percentages for categorical variables, means and standard deviations for continuous variables.

In accordance with our first aim, which is to identify the clinical and demographic variables associated with fear avoidance, exploratory analyses using Welch's independent sample *t*-tests, one-way ANOVA, and Pearson's product correlations were conducted. Specifically, Welch's independent sample *t*-tests were computed to determine if there was a statistically significant association between FAB-TBI scores and the following demographic variables: gender, education, relationship status, pre-injury employment, as well as medical, concussion and mental health history; and the following clinical variable: other injury sustained. One-way ANOVA were used to examine the association between ethnicities and mechanisms of injury and FAB-TBI scores. Post hoc comparisons were performed using Tukey HSD tests. Finally, Pearson's product correlation was used to examine the relationship between age and time since injury and FAB-TBI scores. Guidelines for interpreting Pearson's product correlations are as follows: "small: r = .10 to .29; medium: r = .30 to .49; and large: r = .50 to 1.00" (Cohen,1988, p. 79-81).

Regarding our second aim, which is to examine if fear avoidance will predict mTBI initial outcomes even when factors known to impact mTBI recovery are accounted for, multiple linear regression was used. Specifically, we first used descriptive statistics to describe the FAB-TBI post-concussion symptoms, psychological functioning and functional disability at clinic intake. We then performed exploratory analyses, computing Pearson's product correlations to explore the relationship between FAB-TBI at clinic intake with post-concussion symptoms, psychological functioning

and functional disability at clinic intake. Hierarchical multiple linear regression analyses were computed to identify the contribution of FAB-TBI to mTBI outcomes at clinic intake. Specifically, two regression analyses were run for post-concussion symptoms and functional disability at clinic intake (*M* = 8.74 weeks since injury). Significant variables and risk factors such as fear avoidance (Chrisman et al., 2019; Wijenberg et al., 20120), age (Wardlaw et la., 2018; Schmidt et al., 2018; King, 2014), gender (Cancelliere et al., 2016; King, 2014), medical history (Van Pelt et al.,2019), mental health history (Broshek et al., 2015; Cassidy et al., 2004; Ponsford et al., 2019) and other injuries sustained (Ryan and Warden, 2003) were included in the models. Variables also known to exert an influence on mTBI outcomes were entered into our multiple linear regression model analyses. This included concussion history (Putukian et al., 2021; Iverson et al., 2017) and psychological functioning such as, depression, anxiety and stress (Sandel et al., 2017; Vos et al., 2019; Snell et al., 2015; Scott et al., 2016). These selected predictor variables were entered into a hierarchical multiple regression model to identify the factors that made a significant contribution to RPQ or WHODAS 2.0 at clinic intake.

Furthermore, in accordance with the third aim, to examine the unique contribution of initial fear avoidance behaviour on differentiated post-concussion symptoms (RPQ-3 and RPQ-13) at both time points further multiple regressions were run. Specifically, two regression analyses were run for PRQ-3 and PRQ-13 at clinic intake (*M* = 8.74 weeks since injury) and follow-up (*M* = 22.91 weeks since injury). Predictor variables of fear avoidance, age, gender, other injury, medical, concussion and mental health history, and psychological functioning at clinic intake were included in the models with RPQ-3 and RPQ-13 at both time points.

Finally, the role of fear avoidance on mTBI outcomes at clinic intake was examined. Hierarchical multiple linear regression analyses were computed to determine

if fear avoidance at clinic intake made a significant contribution to post-concussion symptoms and functional disability at follow-up. Additionally, change scores in fear avoidance from clinic intake to follow-up were also entered into the regression to examine their contribution to mTBI outcomes at follow-up. The variables from the previous regression that are known to contribute to mTBI outcomes were also entered into the regression models. Finally, the severity of post-concussion symptoms at clinic intake was also entered into the regression model given the evidence that acute symptomatology is a risk factor for incomplete recovery (Ponsford et al., 2012). The assumptions for regression analysis were met for each analysis including checks for homoscedasticity, linearity, independence, and normality of residuals (Field, 2013).

Chapter 4 Results

A total of 193 participants were recruited through the concussion service, with nine participants subsequently declining and 15 not completing the questionnaires. The final sample of 169 participants met criteria and responded to the questionnaires (demographic and injury characteristics, FAB-TBI, DASS-21, RPQ and WHODAS 2.0) at clinic intake. At follow-up 23 participants were lost to the study with a total of 146 participants completing the questionnaires (FAB-TBI, DASS-21, RPQ and WHODAS 2.0) at follow-up. Categories within demographic and injury characteristic variables with small numbers were collapsed (eg., ethnicity, education, relationship status, employment and mechanism of injury to ensure similar size groupings for analyses (Utley, 2019).

At clinic intake participants ranged in age between 18 and 69 years, with mean 35.20 years (*SD* 12.79). The majority of participants were Aotearoa/NZ European (63.8%). Approximately two-thirds of participants were female (65.7%). The majority of participants had completed university/tertiary level education (63.9%) and 68% of participants were in a relationship. The majority of participants were in paid employment pre-injury (84.0%). Nearly half of participants had a history of mental health (49.1%). The cause of the current injury for the majority of participants was a fall (40.2%). The mean time since injury was 8.74 weeks (*SD* 10.57) and ranged from 2 to 103 weeks. There were no significant differences in the demographics and injury characteristics of the sample at clinic intake (n = 169) versus those at follow-up (n = 146). However, as expected, participants at follow-up were all greater than eight weeks post-injury with the mean time since injury 22.91 weeks (*SD* 10.50) and a range between 14 to 109 weeks. Further demographic and injury characteristics from clinic intake and follow-up are outlined in Table 2.

Table 2

Demographic and clinical characteristics for mTBI sample at clinic intake.

Demographic Characteristics	Clinic intake	Frequency (%)
Gender		
Female	111	(65.7)
Male	58	(34.3)
Age Groups		
18-29 years	78	(46.2)
30-44 years	46	(27.2)
45+ years	45	(26.6)
Ethnicity		
NZ European	108	(63.8)
Māori	21	(12.4)
Other	40	(23.8)
Education		
University/tertiary	108	(63.9)
High school and less	61	(36.1)
Relationship status		
In a relationship	115	(68.0)
Not in a relationship	54	(32.0)
Pre-injury Employment		
In paid Employed	142	(84.0)
Not in paid employment	27	(16.0)

Clinical Characteristics	Clinic intake	Frequency (%)
Mechanism of injury		
Fall	68	(40.2)
Other	68	(40.2)
Transport	19	(11.3)
Assault	14	(8.3)
Other injuries sustained		
Yes	97	(57.4)
No	72	(42.6)
Medical history		
No	107	(63.3)
Yes	52	(30.8)
Missing	10	(5.9)
Mental health history		
No	86	(50.9)
Yes	83	(49.1)
Concussion history		
No	96	(56.8)
Yes	73	(43.2)
Time since injury		
Less than 8 weeks	115	(68.0)
8 weeks and greater	54	(32.0)

4.1 The Impact of Demographic and Clinical Characteristics

4.1.1 Post-Concussion Symptoms (RPQ) at Clinic Intake

Welch's independent sample *t*-tests were conducted to explore the impact of demographic and clinical characteristics on post-concussion symptoms (RPQ) at clinic intake. Education was significantly associated with RPQ scores ($t(167) = 2.17$, $p = .03$, two tailed). Individuals who had a high school education or less produced significantly higher scores on the RPQ with mean 31.92 ($SD = 14.70$) than those with a university or tertiary education with mean 26.91 ($SD = 14.23$). Sustaining other injuries was also significantly associated with RPQ scores ($t(167) = 2.97$, $p = .003$, two tailed). Individuals who had other injuries scored significantly higher on the RPQ with mean 31.52 ($SD = 14.80$) than those with no other injuries mean 24.94 ($SD = 13.42$). A medical history was significantly associated with RPQ scores ($t(167) = 2.05$, $p = .04$, two tailed). Individuals with a medical history scored significantly higher scores on the RPQ with mean 31.62 ($SD = 12.96$) than those with no medical history mean 26.69 ($SD = 14.74$). Also, a history of mental health was significantly associated with RPQ scores ($t(167) = 2.70$, $p = .008$, two tailed). Individuals with a mental health history scored significantly higher scores on the RPQ with mean 31.73 ($SD = 13.26$) than those with no mental health history with mean 25.80 ($SD = 15.22$).

One-way between group analyses were conducted to explore the impact of mechanisms of injury and ethnicities on the RPQ at clinic intake. Mechanism of injury was significantly associated with the RPQ $F(3, 165) = 4.51$, $p = .005$. Post hoc comparisons using Tukey HSD test indicated individuals who sustained the injury through assault had significantly higher RPQ scores with mean 41.71 ($SD = 13.30$) than fall mean 27.54 ($SD = 15.00$) and other mean 26.93 ($SD = 13.99$). Transport mean 29.7 ($SD = 11.63$) was approaching significance with assault ($p = 0.08$). In addition, the

association between RPQ and ethnicity was approaching significance $F(4, 164) = 2.95$, $p = .06$. Post hoc comparisons using Tukey HSD test indicated Māori individuals had higher scores on the RPQ with mean 34.67 (*SD* = 16.67) when compared to Aotearoa/NZ European mean 26.91 (*SD* = 14.23). Other ethnicity mean 30.48 (*SD* = 13.56) did not differ significantly from either Māori or Aotearoa/NZ European.

4.1.2 Functional Disability (WHODAS 2.0) at Clinic Intake

Welch's independent sample *t*-tests were conducted to explore the impact of demographic and clinical characteristics on functional disability (WHODAS 2.0) at clinic intake. Gender was significantly associated with WHODAS 2.0 scores ($t(167) = -2.23$, $p = .03$, two tailed). Females scored significantly higher scores on the WHODAS 2.0 with mean 19.19 (*SD* = 4.62) than males mean 17.47 (*SD* = 4.62). Education was significantly associated with WHODAS 2.0 scores ($t(167) = 3.82$, $p < .001$, two tailed). Individuals who had a high school education or less scored significantly higher scores on the WHODAS 2.0. mean 20.40 (*SD* = 4.61) than those with a university or tertiary education with mean 17.58 (*SD* = 4.62). Sustaining other injuries was significantly associated with WHODAS 2.0 scores ($t(167) = 2.57$, $p = .01$, two tailed). Individuals who had other injuries scored significantly higher scores on the WHODAS 2.0 with mean 19.40 (*SD* = 5.16) than those with no other injuries with mean 15.51 (*SD* = 4.04). A history of mental health was significantly associated with WHODAS 2.0 scores ($t(167) = 2.73$, $p = .008$, two tailed). Individuals with a mental health history scored significantly higher scores on the WHODAS 2.0 with mean 19.61 (*SD* = 4.83) than those with no mental health history mean 17.62 (*SD* = 4.59).

One-way between group analyses were conducted to explore the impact of ethnicities and mechanisms of injury on the WHODAS 2.0 at clinic intake. Ethnicity was significantly associated with WHODAS 2.0 scores $F(2, 166) = 7.40$, $p = <.001$.

Post hoc comparisons using Tukey HSD test indicated Māori with mean 20.85 (*SD* = 4.48) and other ethnicity mean 20.16 (*SD* = 14.71) had higher scores on the WHODAS 2.0 when compared to Aotearoa/NZ European mean 17.58 (*SD* = 4.62). Mechanism of injury was significantly associated with WHODAS 2.0 scores $F(3,165) = 5.04$, $p = .002$. Post hoc comparisons using Tukey HSD test indicated individuals who sustained the injury through assault had significantly higher WHODAS 2.0 scores mean 22.54 (*SD* = 4.18) than fall mean 17.89 (*SD* = 5.16) and approaching significance with other mean 18.04 (*SD* = 4.39). Transport mean 20.25 (*SD* = 3.63) was not significantly different from all the other groups.

4.1.3 Fear Avoidance (FAB-TBI) at Clinic Intake

Welch's independent sample *t*-tests were conducted to explore the impact of demographic and clinical characteristics on fear avoidance (FAB-TBI) at clinic intake. Education was significantly associated with FAB-TBI scores ($t(167)=1.97$, $p =.05$). Individuals who had a high school education or less had significantly higher scores on the FAB-TBI with mean 23.62 (*SD* = 5.71) than those with a university or tertiary level education with mean 22.99 (*SD* = 6.09). In addition, the association between FAB-TBI and prior mental health history was approaching significance ($t(167)=1.75$, $p =.08$). Individuals with a prior mental history had a higher score on the FAB-TBI with mean 24.60 (*SD* = 6.45) when compared to those without a prior mental health history with mean 22.87 (*SD* = 6.35).

One-way between group analyses were conducted to explore the impact of mechanisms of injury and ethnicities on FAB-TBI at clinic intake. Mechanism of injury was divided into five groups: transport, fall, assault, hit by an object and other. Mechanism of injury was significantly associated with (FAB-TBI) scores $F(4, 164) = 2.86$, $p = .03$. Post hoc comparisons using Tukey HSD test indicated individuals who sustained the injury through assault had

significantly higher scores with mean 28.22 (*SD* = 7.72) than fall mean 22.82 (*SD* = 6.50), hit by an object mean 23.50 (*SD* = 5.19). Transport mean 25.64 (*SD* = 7.06) and other mean 22.18 (*SD* = 6.36) was not significantly different from all groups. Ethnicity was divided into three groups: Māori, Aotearoa/NZ European and other ethnicities. In addition, the association between FAB-TBI and ethnicity was approaching significance $F(4, 164) = 2.36$, $p = .09$. Post hoc comparisons using Tukey HSD test indicated Māori individuals had higher scores on the FAB-TBI with mean 26.03 (*SD* = 6.82) when compared to Aotearoa/NZ European mean 23.00 (*SD* = 6.09). Other ethnicities mean 24.46 (*SD* = 6.93) did not differ significantly from either Māori or Aotearoa/NZ European.

4.2 Fear Avoidance and mTBI Outcomes at Clinic Intake

4.2.1 Predictor and Outcome Variables at Clinic Intake

The predictor and outcome measurement mean scores all show a reduction from clinic intake to follow-up indicating an overall reduction in fear avoidance, post-concussion symptoms, depression, anxiety and stress, and functional disability. However, interestingly the range and maximum and minimum values remained stable from clinic intake to follow-up indicating some individuals still experienced high levels on each measure. At clinic intake the RPQ sample mean was 28.72 (*SD* = 14.56) indicating individuals experienced some post-concussive symptoms. Mean scores at clinic intake for depression 6.58 (*SD* = 6.08) and anxiety 5.66 (*SD* = 4.80) indicate mild to moderate levels in the sample. The stress mean score 8.85 (*SD* = 5.11) indicates mild levels in the clinic intake sample (Crawford, & Henry, 2003). At follow-up the RPQ mean 16.91 (*SD* = 13.63) indicated individuals had a reduction but continued to experience some post-concussive symptoms. Mean scores at follow-up for depression were 4.25 (*SD* = 4.91) and anxiety 3.55 (*SD* = 4.05) indicating mild to moderate levels in the sample. The stress mean score 5.97 (*SD* = 4.49) indicates mild levels in the

follow-up sample (Crawford, & Henry, 2003). The sample mean for the WHODAS 2.0 at clinic intake was 18.5 (*SD* = 4.80) with follow-up mean 13.17 (*SD* = 8.57) indicating there was some reduction in functional disability at follow-up. Further data is outlined in Table 3.

Table 3

Summary of the predictor and outcome variable data for the mTBI sample at clinic intake (n = 169) and at follow-up (n = 146).

	Clinic intake (*n* = 169)				Follow-up (*n* = 146)			
Questionnaire	Mean	(SD)	Range	(minimum-maximum)	Mean	(SD)	Range	(minimum-maximum)
FAB-TBI	23.54	(6.31)	48	(0-48)	16.78	(8.57)	48	(0-48)
RPQ	30.97	(12.71)	63	(1-64)	16.91	(13.63)	63	(0-63)
RPQ-3	5.49	(2.79)	12	(0-12)	2.91	(2.85)	12	(0-12)
RPQ-13	25.49	(10.58)	51	(1-52)	14	(11.45)	51	(1-52)
Depression (DASS-21)	6.20	(5.87)	24	(0-24)	4.25	(4.91)	21	(0-21)
Anxiety (DASS-21)	5.11	(4.52)	19	(0-19)	3.55	(4.05)	21	(0-21)
Stress (DASS-21)	8.34	(4.90)	21	(0-21)	5.97	(4.49)	18	(0-18)
WHODAS 2.0	18.39	(4.94)	37	(0-37)	13.17	(6.89)	37	(0-37)

Note: FAB-TBI = Fear Avoidance after Traumatic Brain Injury; RPQ = Rivermead Post-Concussion Symptoms Questionnaire; RPQ-3/RPQ-13 = Rivermead Post-Concussion Symptoms; DASS-21 = Depression Anxiety Stress Scale-21; WHODAS 2.0 = WHO Disability Assessment Schedule 2.0

4.2.2 Fear Avoidance (FAB-TBI) and Outcome Variable Correlations at Clinic Intake

The relationships between FAB-TBI (fear avoidance) and outcome variables at clinic intake were explored. FAB-TBI was found to be significantly (p = <.001) associated with all outcome variables. Specifically, significantly large positive correlations were found between FAB-TBI and WHODAS 2.0, r = .68, p <.001 and depression r = .53, p <.001. All other relationships were found to have significantly medium effects (Cohen, 1988). Refer to Table 4 for further data.

Table 4

Pearson's product correlations for predictor and outcome variables at clinic intake.

	FAB-TBI	RPQ	Stress (DASS-21)	Anxiety (DASS-21)	Depression (DASS-21)
RPQ	.486**				
Stress (DASS-21)	.484**	.678**			
Anxiety (DASS-21)	.454**	.570**	.719**		
Depression (DASS-21)	.526**	.516**	.699**	.622**	
WHODAS 2.0	.682**	.636**	.574**	.586**	.578**

Note: FAB-TBI = Fear Avoidance after Traumatic Brain Injury; RPQ = Rivermead Post-Concussion Symptoms Questionnaire; DASS-21 = Depression Anxiety Stress Scale; WHODAS = WHO Disability Assessment Schedule.

**Correlation is significant at the 0.01 level (2 tailed)

4.3 Multiple Linear Regression Models at Clinic Intake

4.3.1 Post-Concussion Symptoms (RPQ) at Clinic Intake

To further explore the relationships between FAB-TBI and post-concussion symptoms at clinic intake (M = 8.74 weeks since injury) a hierarchical multiple linear regression model was conducted. The model, with fear avoidance, psychological distress, age, gender, medical history, concussion history, mental health history and other injuries sustained, was significantly associated with post-concussion symptoms at clinic intake ($F(10,148) = 15.65$, $p < .01$, $R^2 = .51$). Fear avoidance was found to make a significant and unique contribution to post-concussion symptoms ($\beta = 0.42$, $p = .01$). In addition, stress and medical history also made a significant and unique contribution to post-concussion symptoms ($\beta = -4.77$, $p = <.01$; $\beta = 1.41$, $p < .01$ respectively). Refer to Table 5 for β coefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 5

Coefficients[a] of participants for multiple linear regression for predictor variables and post-concussion symptoms at clinic intake (T1).

Variable	*β*	SE	*p*
Age	-0.02	0.07	0.78
Gender	1.31	1.78	0.46
Other injury	-2.25	1.81	0.22
Concussion history	0.76	1.79	0.67
Medical history	-4.78	1.87	0.01*
Mental health history	0.99	1.77	0.58
DASS-21 Stress (T1)	1.41	0.27	<.001*
DASS-21 Anxiety (T1)	0.37	0.26	0.16
DASS-21 Depression (T1)	-0.06	0.21	0.79
FAB-TBI (T1)	0.42	0.16	0.008*

Note: a Dependent Variable: RPQ (T1)

*Significance p = <.05

Post-Concussion Symptoms - RPQ-3 and RPQ-13 at Clinic Intake

To further examine the unique and significant contributions of fear avoidance, specifically to RPQ-3 (early symptom cluster) and RPQ-13 (enduring symptom cluster) post-concussion symptoms at follow-up, additional multiple linear regression analyses were run.

RPQ-3 (early symptom cluster) at Clinic Intake

A hierarchical multiple linear regression model with fear avoidance, psychological distress, age, gender, medical history, concussion history, mental health history and other injuries sustained, was significantly associated with RPQ-3 at clinic intake ($F(10,148) = 5.83$, p <.01, $R^2 = .28$). Specifically, fear avoidance made a

significant and unique contribution to RPQ-3 symptoms (β = 0.09, p = .02). In addition stress and anxiety were approaching significance (β = .12, p = <.06; β =.11, p <.07 respectively). Refer to Table 6 for β coefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 6

Coefficients[a] of participants for multiple linear regression for predictor variables and RPQ-3 at clinic intake (T1).

Variable	β	SE	p
Age	-0.006	0.02	0.73
Gender	0.69	0.43	0.11
Other injury	-0.39	0.43	0.38
Medical history	-0.71	0.45	0.12
Concussion history	-0.71	0.43	0.69
Mental health history	0.1	0.42	0.81
DASS-21 Stress (T1)	0.12	0.064	0.06
DASS-21 Anxiety (T1)	0.11	0.06	0.07
DASS-21 Depression (T1)	-0.02	0.05	0.65
FAB-TBI (T1)	0.09	0.04	0.02*

Note: a Dependent Variable: RPQ-3 (T1).

*Significance p = <.05

RPQ-13 (enduring symptom cluster) at Clinic Intake

A hierarchical multiple linear regression model with fear avoidance, psychological distress, age, gender, medical history, concussion history, mental health history and other injuries sustained, was significantly associated with RPQ-13 at clinic intake (F(10,148) = 16.25, p <.01, R^2 = .52). Specifically, fear avoidance made a significant and unique contribution to RPQ-13 (β = 2.78, p = .02). In addition, stress and

medical history also made significant and unique contributions to RPQ-13 symptoms (*β* = 1.20, *p* = <.001; *β* = -3.28, *p* = .02 respectively). Refer to Table 7 for *β* coefficient (*β)*, standard error of measurement (SE) and significance (*p*) of the regression model.

Table 7

Coefficients[a] of participants for multiple linear regression for predictor variables and RPQ-13 at clinic intake (T1).

Variable	*β*	SE	*p*
Age	-0.01	0.05	0.84
Gender	0.68	1.32	0.61
Other injury	-1.66	1.34	0.22
Medical history	-3.28	1.39	0.02*
Concussion history	-0.06	1.33	0.97
Mental health history	0.49	1.31	0.71
DASS-21 Stress (T1)	1.2	0.2	<.001*
DASS-21 Anxiety (T1)	0.1	0.19	0.6
DASS-21 Depression (T1)	0.002	0.16	0.99
FAB-TBI (T1)	0.28	0.12	0.02*

Note: a Dependent Variable: RPQ-13 (T1)

*Significance *p* = <.05

4.3.2 Functional Disability (WHODAS 2.0) at Clinic Intake

To explore the relationships between FAB-TBI (fear avoidance) and outcome variables with functional disability at clinic intake a hierarchical multiple linear regression model was conducted. The model, with fear avoidance, psychological distress, age, gender, medical history, concussion history, mental health history and other injuries sustained, was significantly associated with WHODAS 2.0 at clinic intake (*F*(10,148) = 21.78, *p* <.001, R^2 = .60). Specifically, fear avoidance made a significant

and unique contribution to WHODAS 2.0 (β = 0.32, p <.001). In addition gender, anxiety and depression also made unique and significant contributions to functional disability (β = 1.16, p = <.03; β = 0.21, p = .01; and β = 0.13, p = <.04 respectively). Refer to Table 8 for βcoefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 8

Coefficients[a] of participants for multiple linear regression for predictor variables and WHODAS 2.0 at clinic intake (T1).

Variable	β	SE	p
Age	0.02	0.02	0.35
Gender	1.16	0.54	0.03*
Other injury	-0.48	0.55	0.39
Medical history	-0.41	0.57	0.48
Concussion history	0.22	0.55	0.69
Mental health history	-0.24	0.54	0.66
DASS-21 Stress (T1)	0.09	0.08	0.27
DASS-21 Anxiety (T1)	0.21	0.08	0.01*
DASS-21 Depression (T1)	0.13	0.07	0.04*
FAB-TBI (T1)	0.32	0.05	<.001*

Note: a Dependent Variable: WHODAS 2.0 (T1)

*Significance p = <.05

In addition, a further hierarchical multiple regression was computed to examine if fear avoidance continued to impact functional disability whilst factoring in the impact of post-concussion symptom severity. This model was found to be significantly associated with WHODAS 2.0 at clinic intake (F(10,147) = 23.54, p <.001, R^2 = .64). This model found that even whilst factoring in post-concussion symptom severity, fear

avoidance continued to make a significant and unique contribution to functional disability (β = 0.28, p <.001). In addition gender, anxiety, depression and post-concussion symptoms also made unique and significant contributions to functional disability (β = 1.03, p = <.05; β = 0.17, p = .03; β = 0.14, p = <.03; and β = 0.10, p = <.001 respectively). Refer to Table 9 for β coefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 9

Coefficients[a] of participants for multiple linear regression for predictor variables, RPQ and WHODAS 2.0 at clinic intake (T1).

Variable	β	SE	p
Age	0.02	0.02	0.28
Gender	1.03	0.52	0.05*
Other injury	-0.26	0.053	0.63
Medical history	0.07	0.56	0.91
Concussion history	0.14	0.52	0.79
Mental health history	-0.34	0.51	0.51
DASS-21 Stress (T1)	-0.05	0.08	0.57
DASS-21 Anxiety (T1)	0.17	0.08	0.03*
DASS-21 Depression (T1)	0.14	0.06	0.03*
FAB-TBI (T1)	0.28	0.05	<.001*
RPQ (T1)	0.1	0.02	<.001*

Note: a Dependent Variable: WHODAS 2.0 (T1)

*Significance p = <.05

Summary

Multiple linear regression modelling found that fear avoidance made a significant and unique contribution to post-concussion symptoms (RPQ and its

subscales: RPQ-3 and RPQ-13) at clinic intake. These findings were also found with functioning disability (WHODAS 2.0) at clinic intake, even when post-concussion symptoms were factored in the regression model. Other significant contributors to post-concussion symptoms at clinic intake: stress (higher RPQ and RPQ-13 scores) and medical history (high RPQ). Other significant contributors to functional disability were gender and psychological functioning (anxiety and depression).

4.4 Fear Avoidance at Clinic Intake and mTBI Outcomes at Follow-up

Follow-up questionnaires were administered at approximately three-months (*M* = 22.91 weeks since injury) post clinic intake. There was no significant difference in the demographic and clinical characteristics of participants at clinic intake versus those at follow-up, except for the number of weeks post-injury ($p > .05$)

4.4.1 Predictor and Outcome Variables at Clinic Intake and Follow-up

A total of 169 participants completed the questionnaires at clinic intake and 146 participants at follow-up. All mean scores were reduced at follow-up, however the range, and maximum and minimum of all scores remained relatively unchanged. Refer to Table 3 for full data.

4.4.2 Fear Avoidance (FAB-TBI) at Clinic Intake and Outcome Variables at Follow-up Correlations

Pearson's product correlations were conducted to investigate if FAB-TBI (fear avoidance) at clinic intake and changes over time (FAB-TBI Change Score) are associated with mTBI outcomes at follow-up. Correlations of fear avoidance at clinic intake with stress, anxiety, depression, post-concussion symptoms and functional disability at follow-up were examined. A significant negative relationship between FAB-TBI at clinic intake and change scores in FAB-TBI (r = -.28, p = <.001) was found. This illustrates that higher FAB-TBI scores at clinic intake were associated with lower FAB-TBI change scores. Fear avoidance change scores were significantly positively associated with post-concussion symptoms (RPQ) (r = .41, p = <.001), psychological distress (anxiety r = .18, p = <.001, depression r = .23, p = <.001 and stress r = .24, p = <.001) and functional disability (r = .48, p = <.001) at follow-up. That is, individuals with a decrease in fear avoidance over time were more likely to have lower levels of post-concussion symptoms, psychological distress and functional disability at follow-up. FAB-TBI at clinic intake was found to be significantly associated with all outcome variables at follow-up. Specifically, significant medium positive correlations were found between FAB-TBI and functional disability (WHODAS 2.0) r = .48, p = <.001, (anxiety r = .40, p = <.00, depression r = .37, p = <.001 and stress r = .32, p = <.001). All other relationships were found to have significantly small effects (Cohen, 1988). Refer to Table 10 for further data.

Table 10

Pearson's product correlations for predictor measure (FAB-TBI) at clinic intake (T1) and outcome variables at follow-up (T2).

					Stress (T2)	Anxiety (T2)	Depression (T2)	
	FAB-TBI (T1)	RPQ (T2)	RPQ-3 (T2)	RPQ-13 (T2)	DASS-21	DASS-21	DASS-21	WHODAS (T2)
RPQ (T2)	.292**							
RPQ-3 (T2)	.262**	.808**						
RPQ-13 (T2)	.282**	.989**	.713**					
Stress (DASS-21) (T2)	.315**	.627**	.473**	.629**				
Anxiety (DASS-21) (T2)	.398**	.637**	.544**	.623**	.754**			
Depression (DASS-21) (T2)	.367**	.579**	.498**	.566**	.673**	.724**		
WHODAS 2.0 (T2)	.480**	.711**	.582**	.702**	.614**	.617**	.618**	
FAB-TBI Change Score	-.280**	.407**	.315**	.406**	.240**	.178*	.225**	.477**

Note: FAB-TBI = Fear Avoidance after Traumatic Brain Injury; RPQ/RPQ-3/RPQ-13 = Rivermead Post-Concussion Symptoms Questionnaire; DASS-21 = Depression Anxiety Stress Scale-21; WHODAS 2.0 = World Health Organisation Disability Assessment Schedule 2.0; FAB-TBI Change Score = change in FAB-TBI score from clinic intake to follow-up.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

4.5 Multiple Linear Regression Models at Follow-Up

4.5.1 Post-Concussion Symptoms (RPQ) at Follow-Up

A multiple linear regression model was computed to identify the variables associated with RPQ (post-concussion symptoms) at follow-up. As shown in Table 11, the variables entered into this model were age, gender, other injury, medical, concussion and mental health history, fear avoidance, anxiety, stress, and depression at clinic intake and fear avoidance change scores. This model was found to have a significant association with RPQ at follow-up ($F(12,124) = 11.65$, $p < .01$, $R^2 = .53$).

Specifically, fear avoidance at clinic intake made a significant and unique contribution to post-concussion symptoms at follow-up ($\beta = 0.74$, $p = .009$). Fear avoidance change scores also made a significant and unique contribution to post-concussion symptoms ($\beta = 0.74$, $p = <.001$). That is, individuals with a decrease in fear avoidance over time were more likely to have lower levels of post-concussion symptoms at follow-up. In addition age and gender also made unique and significant contributions to post-concussion symptoms at follow-up ($\beta = 0.19$, $p = <.007$ and $\beta = 4.41$, $p = .01$ respectively), as did RPQ symtoms at intake. Refer to Table 11 for βcoefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 11

Coefficients[a] of participants for multiple linear regression for predictor and outcome variables at clinic intake (T1) and RPQ at follow-up (T2).

Variable	*β*	SE	*p*
Age	0.19	0.07	0.007*
Gender	4.41	1.76	.01*
Other injury	-3.29	1.79	0.07
Medical history	2.56	1.8	0.16
Concussion history	-1.06	1.78	0.55
Mental health history	2.85	1.72	0.1
DASS-21 Stress (T1)	-0.22	0.29	0.45
DASS-21 Anxiety (T1)	0.13	0.26	0.63
DASS-21 Depression (T1)	0.16	0.21	0.46
FAB-TBI (T1)	0.74	0.18	0.009*
FAB-TBI change score	0.74	0.12	<.001*
RPQ (T1)	0.34	0.1	<.001*

Note: a Dependent Variable: RPQ (T2)

*Significance p = <.05

RPQ-3 (early symptom cluster) at Follow-Up

A multiple linear regression model was computed to identify the variables associated with RPQ-3 at follow-up. As shown in Table 12, the variables entered into this model were age, gender, other injury, medical, concussion and mental health history, fear avoidance, anxiety, stress, depression, post-concussion symptom severity (RPQ-13) at clinic intake and fear avoidance change scores. This model was found to have a significant association with RPQ-3 ($F(12,124) = 8.22$, p <.01, R^2 = .44). Fear avoidance at clinic intake made a significant contribution to RPQ-3 symptoms (β =

0.97, p = .002) at follow-up. Fear avoidance change scores also made a significant contribution to RPQ-3 (β = 0.30, p = <.001). That is, individuals with a decrease in fear avoidance over time were more likely to have lower levels of RPQ-3 at follow-up. In addition gender and mental health history and initial RPQ-3 scores also made significant contributions to RPQ-3 at follow-up (β = 1.17, p = .005; β = .84, p = .03 respectively). A significant negative relationship between other injury and RPQ-3 (β = -.88, p = .03) was found. This negative relationship illustrates that with other injuries RPQ-3 scores at follow-up are likely to increase by .88 standard deviation units. Refer to Table 12 for β coefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 12

Coefficients[a] of all participants for multiple linear regression for predictor and outcome variables at clinic intake (T1) and RPQ-3 at follow-up (T2).

Variable	*β*	SE	*p*
Age	-0.01	0.02	0.54
Gender	1.17	0.4	0.005*
Other injury	-0.88	0.41	0.03*
Medical history	0.21	0.41	0.6
Concussion history	0.61	0.4	0.14
Mental health history	0.84	0.4	0.03*
DASS-21 Stress (T1)	-0.11	0.06	0.07
DASS-21 Anxiety (T1)	0.14	0.61	0.81
DASS-21 Depression (T1)	0.61	0.05	0.21
FAB-TBI (T1)	0.97	0.4	0.02*
FAB-TBI change score	0.15	0.26	<.001*
RPQ-3 (T1)	0.3	0.08	<.001*

Note: a Dependent Variable: RPQ-3 (T2)

*Significance p = <.05

RPQ-13 (enduring symptom cluster) at Follow-Up

A multiple linear regression model was computed to identify the variables associated with RPQ-13 at follow-up. As with the previous regression model the same variables were entered except RPQ was changed for RPQ-3 at clinic intake. This model was found to have a significant association with RPQ-13 at follow-up (F(12,124) = 11.16, p <.01, R^2 = .52). Fear avoidance at clinic intake made a significant contribution to RPQ-13 symptoms (β = 0.37, p = .02). Fear avoidance change scores also made a significant contribution to RPQ-13 (β = 0.59, p = <.001). That is, individuals with a

decrease in fear avoidance over time were more likely to have lower levels of RPQ-13 symptoms at follow-up. In addition, age and gender also made significant contributions to RPQ-13 at follow-up (β = .20, p = .0001; β = 3.27, p = .03 respectively). Refer to Table 13 for βcoefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 13

Coefficients[a] of participants for multiple linear regression for predictor and outcome variables at clinic intake (T1) and RPQ-13 at follow-up (T2).

Variable	β	SE	p
Age	0.2	0.06	0.001*
Gender	3.27	1.5	0.03*
Other injury	-2.43	1.53	0.12
Medical history	2.34	1.54	0.12
Concussion history	-1.68	1.52	0.27
Mental health history	2.02	1.47	0.17
DASS-21 Stress (T1)	-0.11	0.25	0.67
DASS-21 Anxiety (T1)	0.12	0.22	0.6
DASS-21 Depression (T1)	0.1	0.18	0.59
FAB-TBI (T1)	0.37	0.15	0.20*
FAB-TBI change score	0.59	0.1	<.001*
RPQ-13 (T1)	0.34	0.1	0.001*

Note: a Dependent Variable: RPQ-13 (T2)

*Significance p = <.05

4.5.2 Functional Disability (WHODAS 2.0) at Follow-Up

A multiple linear regression model was computed to identify the variables that are associated with WHODAS 2.0 at follow-up. The variables selected were identical to

the previous regression model. This model was found to be significantly associated with WHODAS 2.0 at follow-up ($F(12,124) = 33.70$, $p < .01$, $R^2 = .77$). Fear avoidance at clinic intake made a significant contribution to WHODAS 2.0 at follow-up ($\beta = 0.44$, $p = <.001$). Fear avoidance change scores also made a significant contribution to WHODAS 2.0 ($\beta = 0.47$, $p = <.001$). That is, individuals with a decrease in fear avoidance over time were more likely to have less functional disability at follow-up. In addition, age and depression also made significant contributions to WHODAS 2.0 at follow-up ($\beta = .07$, $p = .0007$; and $\beta = .24$, $p = .004$ respectively). Other injury had a significant negative relationship with WHODAS 2.0 at follow-up ($\beta = -1.42$, $p = .04$). This negative relationship illustrates that WHODAS 2.0 scores at follow-up are likely to increase by 1.42 standard deviation units if the individual has other injuries. Refer to Table 14 for β coefficient (β), standard error of measurement (SE) and significance (p) of the regression model.

Table 14

Coefficients[a] of participants for multiple linear regression for predictor and outcome variables at clinic intake (T1) and WHODAS 2.0 at follow-up (T2).

Variable	*β*	SE	*p*
Age	0.07	0.03	0.007*
Gender	0.39	0.68	0.57
Other injury	-1.42	0.69	0.04*
Medical history	0.47	0.69	0.5
Concussion history	-0.62	0.68	0.37
Mental health history	-0.47	0.66	0.48
DASS-21 Stress (T1)	-0.1	0.11	0.37
DASS-21 Anxiety (T1)	0.08	0.1	0.46
DASS-21 Depression (T1)	0.24	0.08	0.004*
FAB-TBI (T1)	0.44	0.05	<.001*
FAB-TBI change score	0.47	0.05	<.001*
RPQ-13 (T1)	0.16	0.04	<.001*

*Note***:** a Dependent Variable: WHODAS 2.0 (T2)

*Significance $p = <.05$

Summary

Multiple linear regression modelling found that fear avoidance at clinic intake made a significant and unique contribution to post-concussion symptoms (RPQ and its subscales, RPQ-3 and RPQ-13) at follow-up. Fear avoidance change scores also made a significant contribution, whereby individuals with a decrease in fear avoidance over time were more likely to have lower scores on measures of post-concussion symptoms and functioning disability at follow-up. Other significant contributors to post-concussion symptoms at follow-up: age (higher RPQ and RPQ-13 scores); gender

(higher RPQ, RPQ-13 and RPQ-13 scores), mental health history (higher RPQ-3 scores) and a negative relationship with other injury (higher RPQ-3) at clinic intake. Furthermore, fear avoidance at clinic intake made a significant and unique contribution to functioning disability at follow-up. Other significant contributors to functional disability at follow-up: age, psychological functioning (depression) and other injury at clinic intake.

Chapter 5 Discussion

Fear avoidance behaviour has been shown to be associated with negative physical, cognitive and psychosocial outcomes and is a well-established phenomenon in musculoskeletal pain (Hasenbring et al., 2011; Kindermans et al., 2011; Van Damme & Kindermans; 2015; Fletcher et al., 2016; Vlaeyen & Linton, 2000). Research on fear avoidance behaviour within mTBI populations, although limited, has also found it contributes to poor functional outcomes (Silverberg et al., 2018; Cassetta et al., 2021; Silverberg et al., 2017). The aim of the current study was to expand on the present literature by exploring fear avoidance behaviour and its impact on symptom and functional outcomes in mTBI. More specifically, this study sought to identify the variables associated with an individual developing fear avoidance behaviour following a mTBI. Moreover, to examine the influence and the impact of fear avoidance behaviour on post-concussion symptoms and functional disability over a three-month time period. Specifically the current study controlled for variables (i.e., psychological functioning, and demographic and injury characteristics) known to impact mTBI outcomes.

Data was obtained from a sample of 169 individuals at clinic intake (M = 8.74 weeks since injury) and 146 of the same individuals at three-months follow-up (M = 22.91 weeks since injury) with mTBI, recruited through concussion services. The findings from this study revealed that demographic and injury characteristics were associated with fear avoidance behaviour. That is, individuals with a lower level of education and traumatic circumstances of injury (assault) were more likely to develop fear avoidance behaviour following a mTBI. Additionally, fear avoidance behaviour was found to be significantly associated with post-concussion symptoms and functional disability at clinic intake and follow-up. Specifically, a reduction in fear avoidance scores, between time-points (clinic intake and three-months follow-up), was found to

significantly contribute to a decrease in post-concussion symptoms and functional disability at follow-up.

5.1 Predictors of Fear Avoidance Behaviour in mTBI.

The current study found that education and mechanism of injury were associated with fear avoidance behaviour. This was consistent with our hypothesis.

Individuals with university or tertiary level education scored significantly less on the FAB-TBI measure compared with individuals with a high school or less education. A potential explanation for the association of education attainment and the development of fear avoidance behaviour is that, individuals with higher levels of education have been shown to have higher socioeconomic status and greater financial support with increased accessibility to health resources, than those with lower education (McMaughan, Oloruntoba & Smith, 2020; American Psychological Association, 2021). In mTBI, lower socioeconomic status has been found to be associated with increased reporting of post-concussion symptoms, poor functional outcomes and increased healthcare usage (Galili et al., 2017; Chu et al., 2019; McCauley et al., 2015; Rabinowitz et al., 2015), which may potentially increase their risk of developing fear avoidance behaviour. In chronic pain, a lower socioeconomic status has been found to be associated with fear avoidance behaviour and increased disability (Valencia et al., 2010; Khan, Morrison & Marshall, 2020).

A further explanation may be the theory of Cognitive Reserve (CR). This refers to the individual's ability to optimise brain performance in response to increased demand, by recruiting available cognitive resources to process tasks flexibly and efficiently (Stern, 2002). According to Stern (2002) any damage to the brain increases cognitive demand, and the greater the individual's CR, the greater the ability to maintain effective brain function under cognitive load. Higher levels of CR have been

found to be positively associated with educational attainment and greater occupational cognitive demands (Kunzi et al., 2021; Levi, Rassovsky, Agranov, Sela-Kaufman & Vakil, 2013). CR plays a fundamental role in resilience, which refers to maintaining psychological and physical functioning in adverse conditions (Bonanno, 2004) and in the individual's response to stressors (Garcia-Moreno,Canadas-Perez, Garcia-Garcia & Roldan-Tapia, 2021). It has been shown to act as a buffer or protective factor to mitigate the impact of TBI (Oldenburg, Lundin, Edman, Nygren-de Boussard & Bartfai, 2016; Sumowski, Chiaravalloti, Krch, Paxton & DeLuca, 2013; Luis, Vanderploeg & Curtiss, 2003; Levi, Rassovsky, Agranov, Sela-Kaufman & Vakil, 2013). In mTBI, lower CR has been associated with increased reporting of post-concussion symptoms (Luis et al., 2003; Oldenburg et al., 2016). However, there appears to be a paucity of information of CR and its association with fear avoidance behaviour. Wijenberg et al., (2020) suggests the use of assessing the CR construct may be helpful to measure cognitive activity when assessing fear avoidance in TBI. Nonetheless, CR presents a viable explanation for the findings of fear avoidance and education in the current study, but requires further investigation.

Several studies have found lower educational achievement is associated with greater fear avoidance beliefs and fear avoidance behaviour in individuals with low back pain (Valencia, Robinson & George, 2010; Macias-Toronjo, Rojas-Ocana, Sanchez-Ramos & Garcia-Navarro, 2020). Within the mTBI literature, Silverberg and colleagues (2018) found fear avoidance behaviour was associated with a lower level of education and poor functional outcomes. The authors proposed a lower education may result in poor health knowledge which may foster maladaptive illness beliefs and coping strategies in mTBI. Snell and colleagues (2011) found a higher level of education was associated with approach (adaptive) coping in mTBI. However, in contrast to the current findings, avoidance coping was not found to significantly contribute to outcomes.

Conversely, approach coping was associated with poorer outcomes (increased emotional distress and post-concussion symptoms, and social and functional limitations). A potential explanation for the contrast in results may be due to avoidance coping and fear avoidance behaviour being different constructs. The tool used to assess avoidance coping in Snell's study is a generalised behavioural response measure incorporating emotional support, help-seeking behaviours, acceptance and learning to live with an event, and active planning (Snell et al., 2011). Whereas, the tool utilised by the current study specifically assesses avoidance behaviour and catastrophising driven by the fear of eliciting or exacerbating symptoms in the mTBI population (Silverberg et al., 2018). Nonetheless, Snell et al., (2011) posited individuals with a higher education may have an increased awareness of problems and consequences following a mTBI, and a higher expectation of recovery. This may result in the individual becoming increasingly distressed concerning symptom manifestation, which thereby impedes their recovery.

Similar to the findings in Snell's study, van der Naalt et al., (2017) also found a higher level of education to be a significant predictor for the individual's ability to adopt an adaptive coping strategy following a mTBI. They reported as many as 48% of individuals adopted an avoidant coping style two-weeks post-mTBI, but this was associated with improved functional outcomes. Interestingly, the authors suggested avoidant behaviour reduced emotional distress by acting as a protective buffer to cognitive overload in mentally challenging scenarios. They found passive, rather than avoidant coping strategies were significantly correlated with post-traumatic stress.

Similar to the coping assessments utilised in Snell and colleagues' (2011) study, van der Naalt and colleagues' (2017) study assessed generalised habitual responses to stressful situations, with the inclusion of an avoidance coping component, which may have captured other factors that FAB-TBI did not capture. In contrast, the FAB-TBI used in the current study is a measure of avoidance determined by the fear of symptom

manifestation in mTBI. It provides a more nuanced assessment of avoidance behaviour in the mTBI population (Snell et al., 2020). Conceivably, the avoidance coping and fear avoidance behaviour assessments may be measuring different constructs, which thereby accounts for the disparate results. Interestingly, Gregorio and colleagues (2014) comment that They recommended cautious use in acquired brain injury (ABI), of both the coping assessments utilised in Snell and Van der Naalt's studies. Their recommendation was for their use in more severe ABI, rather than mild TBI. Thus, this recommendation may further account for the contrasting results found compared with the current study.

In addition to education status, the nature of the injury (traumatic) was also related to fear avoidance behaviour. Individuals who sustained a mTBI as a result of an assault scored significantly higher on the FAB-TBI than other mechanisms of injury. Studies have shown that individuals who sustain a mTBI in traumatic circumstances, such as assault, have been found to be at an increased risk of PTSD (Stein et al., 2019; Kennedy et al., 2007; Vasterling, Jacob & Rasmusson, 2018). PTSD is associated with psychological and behavioural avoidance (Iribarren, Prolo, Neagos & Chiappelli, 2005) and has been found to be associated with fear avoidance behaviour in chronic pain (Devlin, Casey, Williams & Giummarra, 2020) and whiplash injury (Anderson, Karstoft, Brink & Elklit, 2016). Stein and colleagues (2019) found individuals with a mTBI sustained through assault were at an increased risk of developing PTSD compared with a control sample. Interestingly, they found assault, combined with a pre-injury mental health history further increased the risk of PTSD. This current study cannot infer causation between assault, PTSD and fear avoidance behaviour. However, PTSD precipitated by an injury of a traumatic nature (i.e. assault), with or without a pre-injury mental health history, may be a potential mechanism for development of fear

avoidance behaviour or fear avoidance may increase the risk of the development of PTSD.

A pre-injury mental health history was hypothesised to be a factor leading to the development of fear avoidance behaviour. However, in the current study it only approached significance. This was unexpected given its association with fear avoidance behaviour in musculoskeletal pain (Dersh, Polantin, & Gatchel, 2002; Arnow et al., 2006; Zale & Ditre, 2015) and to adverse outcomes in mTBI (Silverberg et al., 2015; Veldhoven et al., 2011; Ponsford et la., 2019; Bertisch et al., 2018; Karr et al., 2020). Interestingly, individuals with a pre-injury mental health history scored significantly higher on the RPQ (post-concussion symptoms) and the WHODAS 2.0 (functional disability) compared with individuals without such a history. There is much evidence to support the association of a pre-injury mental health history with post-concussion symptoms and functional disability in mTBI (Silverberg et al., 2015; Sandel et al., 2017; McCauley et al., 2013; Karr et al., 2020; Bertisch et al., 2018; Scheenen et al., 2017; van der Naalt et al., 2017). However, the author found a lack of inclusion of the pre-injury mental health history as a variable in previous research of fear avoidance behaviour in mTBI (Cassetta et al., 2021; Wijenberg et al., 2020; Silverberg et al., 2017). Snell et al., (2011) included pre-injury psychiatric history and co-morbid psychiatric diagnosis when investigating coping styles (including avoidance, but not specifically fear avoidance) and neither met significance. Notwithstanding, the current study assessed pre-injury mental health utilising a closed (yes or no) question of, “Do you have a mental health history?” This lacked the subtlety to establish the details of the mental health history (e.g., was it still a relevant factor pre-injury?). This is a pertinent fact as some individuals with a mental health history may have previously engaged in psychological therapy, whereby, they have learned and developed skills to manage stressful situations. These skills may potentially act as a buffer against the development

of fear avoidance behaviour following a mTBI. Therefore, for future research it may be valuable to capture a more detailed account of an individual's mental health history. This would enable stronger scrutiny of the impact of their mental health on their recent pre-injury life.

Consistent with prior research, in the current study post-injury depression, anxiety and stress was shown to be significantly correlated with fear avoidance. That is, increasing scores on fear avoidance were associated with increasing scores on depression, anxiety and stress. Zale and Ditre (2015) found a mental health history of anxiety and depression was significantly associated with fear avoidance behaviour in chronic pain. Consequently, it may be of value for future studies to analyse specific pre-injury mental health history details (e.g., depression, anxiety, stress and PTSD) and their association with fear avoidance behaviour to glean a more accurate analysis of this relationship.

The ability to predict who may develop fear avoidance behaviour offers the potential to provide early intervention, and thereby improve functional outcomes post-mTBI. This current research found a lower level of education and/or traumatic circumstances of injury as significant predictors, and a pre-injury mental health history approaching significance for an individual developing fear avoidance behaviour following a mTBI. However, the author recommends further research includes a detailed account of pre-injury mental health history to enable accurate analyses of its relationship with fear avoidance behaviour in mTBI.

5.2 Fear Avoidance Behaviour and Post-Concussion Symptoms at Clinic Intake

Concordant to our hypothesis, fear avoidance behaviour was found to have a significant positive association with post-concussion symptoms, at clinic intake (*M* =

8.74 weeks since injury). Specifically, increased fear avoidance was associated with increased reporting of post-concussion symptoms (inclusive of RPQ-3 and RPQ-13 symptom clusters). The RPQ-3 symptoms are described as an early symptom cluster and consist of headache, dizziness and nausea. The RPQ-13 symptoms are described as an enduring symptom cluster and include mood, emotional, cognitive, noise, visual and sleep disturbances and fatigue symptoms (Eyres et al., 2005; McMahon et al., 2014). However, these symptom clusters have been shown to present simultaneously. For example, Silverberg et al., (2019) found sleep disturbance triggered headaches in individuals at approximately six and 17-weeks post-mTBI. Silverberg et al., (21019) and Ponsford et al., (2019) found individuals reported RPQ-3 and RPQ-13 symptoms at two-months and seven-months respectively post-mtBI.

Some studies offer potential explanations for the association of fear avoidance behaviour, and perpetuation of both symptom clusters post-mTBI. Silverberg et al., (2017) found individuals avoided mental and physical exertion for fear of triggering a headache at two to three-months post-mTBI. Further research by Silverberg and colleagues (2019) found pervasive fear avoidance behaviour developed due to perceived headache triggers at approximately nine-weeks post-mTBI. Post-concussion symptoms of fatigue, sleep disturbances, and noise and light sensitivity were associated with avoidance for fear of triggering a headache. Noise sensitivity is reported as a relatively common symptom post-mTBI (Shepherd, Landon, Kalloor & Theadom, 2019) and has been found to be associated with fear avoidance behaviour (Faulkner, Snell, Shepherd & Theadom, 2021). Fatigue (cognitive and physical) is one of the most commonly reported symptoms following a mTBI (Wijenberg et al., 2017). Penacoba et al., (2021) found individuals with fibromyalgia developed fear avoidance behaviour to avoid fatigue.

These studies appear to support the idea that fear avoidance develops in mTBI (and other conditions) due to the individual's fear of eliciting or exacerbating symptoms. However, it is important to note the reporting of post-concussion symptoms should be interpreted cautiously as they are not unique to mTBI, and are common in the general population and other conditions (Balalla et al., 2020; Fow & Franzen, 2003; Iverson, 2006; Theadom et al., 2018). Nevertheless, the current study found a significant association of fear avoidance behaviour at clinic intake (*M* = 8.74 weeks since injury) with increased reporting of post-concussion symptoms. This finding may aid prediction of individuals on a trajectory for developing persistent post-concussion symptoms (three-months and greater post-injury) and the associated risks for poor functioning outcomes. However, concerningly, at approximately nine-weeks for initial assessment, some individuals may already be well on the pathway of persistent symptomatology. Hence, it may be of value to research and implement assessment tools, for use in the primary healthcare setting, to aid earlier prediction of those individuals at risk of developing fear avoidance behaviour and persistent post-concussion symptoms.

5.3 Fear Avoidance Behaviour and Functional Disability at Clinic Intake

This current study found that fear avoidance behaviour was associated with increased levels of functional disability at clinic intake (*M* = 8.74 weeks since injury), irrespective of post-concussion symptom severity. Several studies have demonstrated consistent findings, showing fear avoidance is associated with increased levels of functional disability (sleep disturbances, reduced social interactions and participation, difficulties with personal cares and physical functioning) (Wertli et al., 2014; Kindermans et al., 2011; Andrews, Strong and Meredith, 2015; Vlaeyen & Linton,

2000; Hasenbring et al. 2011; Demmelmaier et al., 2018). However, the aforementioned studies have predominantly focused on chronic musculoskeletal conditions, therefore, individuals have been assessed many months post-initial presentation of symptoms. Research within mTBI has also generally focused on longer (greater than three-months) timeframes post-injury (Wijenberg et al., 2020; Cassetta et al., 2021).

Silverberg et al., (2018) found an association of fear avoidance with functional disability (diminished cognitions, mobility, activities of daily living, interpersonal functioning and participation) at approximately three-weeks (M = 2.7 weeks) post-mTBI. Of note, Silverberg's study found fear avoidance behaviour increased the risk of developing depression following a mTBI. Fear avoidance has been found to be associated with depression in other conditions, however, functioning status was not assessed (Leventhal, 2008; Brockmeyer et al., 2014). This is of importance, as prior research has shown that depression has been found to contribute to functional disability in acquired brain injury (Astuti et al., 2020). Therefore, depression has the potential to be a confounding factor between fear avoidance behaviour and level of functional disability. Interestingly, in the current study exploratory analysis found fear avoidance was significantly correlated with depression. The current study factored psychological functioning (depression, anxiety and stress) into the regression model. Although anxiety and depression were found to make significant contributions, fear avoidance behaviour remained a highly significant contributor to functional disability at approximately nine-weeks following a mTBI. Taking this into consideration functional disability, fear avoidance and depression may have a complex bi-directional relationship.

Similar to the current study's findings of fear avoidance and post-concussion symptoms at clinic intake, it is of concern, at approximately nine-weeks, some individuals are exhibiting increased functional disability associated with fear avoidance behaviour. According to Vlaeyen and Linton (2000) fear avoidance leads to disuse and

thereby, physical deconditioning. Therefore, it is imperative fear avoidance behaviour is addressed before the cycle of fear avoidance and disuse becomes entrenched. The contribution of depression to functional disability and its possible bi-directional relationship with fear avoidance may also be a possible target for intervention.

5.4 Fear Avoidance Behaviour at Clinic Intake and Post-Concussion Symptoms at Follow-Up

The study also examined fear avoidance behaviour at clinic intake (*M* = 8.74 weeks since injury) and changes (from clinic intake to follow-up) in fear avoidance, and its contribution to post-concussion symptoms at follow-up (*M* = 22.91 weeks since injury), whilst accounting for psychological functioning (stress, depression and anxiety). The current study found fear avoidance behaviour at clinic intake was a significant contributor to post-concussion symptoms (RPQ-3 and RPQ-13) at three-months follow-up.

These findings are consistent with Silverberg et al., (2018), where initial avoidance (at approximately three-weeks) was found to be predictive of post-concussion symptom severity at four to five-months follow-up. Slightly different to the current study, which controlled for psychological functioning, Silverberg's study accounted for psychiatric complications where individuals met criteria for diagnosis of disorders incorporating major depressive, generalised anxiety, panic, social and obsessive-compulsive and PTSD. According to Wiseman et al., (2015) over half (54%) of individuals reported above normal scores for depression, anxiety and stress, on the DASS-21, at three to six-months following a traumatic injury. The DASS-21 is designed as a useful self-rating tool which indicates the presence and severity of symptoms related to depression, anxiety and stress. These scores do not provide a diagnosis for clinical depression or anxiety, rather they provide an indication of the

presence of such symptoms (Crawford & Henry, 2003). Therefore, Silverberg et al's., (2018) study may not have truly accounted for psychological functioning, given the number of individuals who report psychological symptoms but do not meet criteria for a major disorder. For example, Aotearoa/NZers were found to report higher levels of depression and anxiety compared with population norms. However, this research was conducted during the Covid-19 which presents a potential confounding factor (Gasteiger et al., 2021). Also, the only demographic factor accounted for in the Silverberg et al., (2018) study was education, whereas the current study accounted for factors exploratory analyses found influenced post-concussion symptoms (age, gender, other injuries, medical, concussion and mental health history). Accounting for these factors enables the establishment of a causal link (Skelly et al., 2012).

Greenberg and colleagues (2020) found avoiding activities and pain catastrophising were significantly associated with post-concussion symptoms (time since injury was undocumented). Significantly, anxiety was found to contribute to pain catastrophising, avoidance behaviour and post-concussion symptoms. However, unlike the current study depression and stress were not accounted for. Nevertheless, the finding of catastrophising is of interest, as the FAM (refer Figure 1) indicates catastrophising leads to fear-related avoidance and hypervigilance. Therefore, this may be a potential mechanism by which an individual's avoidance develops and is perpetuated. Hence, interventions specifically targeting catastrophising may have potential in preventing the ongoing cycle of avoidance, disuse and disability. Greenberg et al., (2020) noted, directly targeting these areas may be of value in decreasing symptom load and severity in mTBI. These findings are consistent with Wijenberg et al., (2017), where avoidance, catastrophising, post-concussion symptoms and depressive symptoms were significantly associated with each other.

At six to twelve-weeks post mTBI, Anderson and Fitzgerald (2020) found an avoidant help-seeking coping-style was associated with the enduring symptom cluster of RPQ-13. In contrast an approach (adaptive) coping-style was associated with the early symptom cluster of RPQ-3. Similar to the current study psychological functioning was accounted for. However, it is difficult to make direct comparisons as an avoidant help-seeking coping style potentially measures a different construct from the fear avoidance behaviour the current study is investigating. That aside, there are common themes whereby Anderson and Fitzgerald (2020) found an individuals' beliefs about their injury, similar to the FAM, influenced the development of avoidance behaviour (Vlaeyen & Linton, 2000) and predicted the severity of post-concussion symptoms (Anderson & Fitzgerald, 2020). Therefore, interventions targeting an individual's injury beliefs may be of potential value with all maladaptive coping styles.

Of note, in the current study, individuals with decreasing fear avoidance, from clinic intake (M = 8.74 weeks since injury) to follow-up (M = 22.91 weeks since injury), were more likely to report fewer post-concussion symptoms on the RPQ. The author was unable to find other studies to support this. In a similar study, Cassetta et al., (2021) computed fear avoidance change scores, however, post-concussion symptoms were only incorporated at the first time point. Nonetheless, the significant association of reducing fear avoidance and post-concussion symptoms may indicate that avoidance strategies, deemed to be protective and adaptive within the first 48 hours post-mTBI (Silverberg et al., 2013; Grool et al., 2016; Schneider et al., 2017), may potentially continue to protect some individuals for a longer period. This association may also potentially indicate for those individuals who have static or increased fear avoidance and associated increased symptom reporting, targeted fear avoidance interventions hold promise for reducing post-concussion symptoms. However, further research is needed to support this hypothesis.

The key findings for the current study were initial fear avoidance and increasing fear avoidance was associated with increased symptom reporting at three-months follow up. The association between initial fear avoidance and follow-up post-concussion symptoms is highly relevant as it has the potential to predict who may develop persistent symptomatology. As reported previously, persisting post-concussion symptoms beyond three-months is of major concern given its association with poor psychosocial, physical and cognitive functioning outcomes (Silverberg et al., 2015; van der Naalt et al., 2017; Losoi et al., 2016; Cancelliere et al., 2016; Barker-Collo et al., 2015; Cancelliere et al., 2016) and its economic burdens (ACC, 2017; Gupta & Summerville, 2019; Kara, 2017; Fallesen & Campos, 2020). This finding presents the opportunity to assess individuals who may be at risk of persistent symptomatology and initiate targeted interventions at addressing fear avoidant behaviour.

5.5 Fear Avoidance Behaviour at Clinic Intake and Functional Disability at Follow-Up

Consistent with our hypothesis, initial (M = 8.74 weeks since injury) fear avoidance and fear avoidance change, from clinic intake to follow-up (M = 22.91 weeks since injury), was associated with functional disability at three-months follow-up, even after controlling for psychological functioning (depression, anxiety and stress) and post-concussion symptoms. Individuals with decreasing (from clinic intake to follow-up) fear avoidance were more likely to have lower functional disability. Depression was also found to be a significant contributor to functional disability.

These findings are comparable to Cassetta and colleagues' (2021) study. Similar to the current study post-concussion symptoms were accounted for, but unlike the current study no demographic or psychological functioning variables were factored. Exploratory analyses found these variables have the potential to also contribute to

functional disability. Hence, the benefit of incorporating these variables in the regression model is, it reduces the risk of falsely demonstrating an association (Skelly, 2012; Crosby et al., 2016). Despite this, Cassetta's study found fear avoidance to significantly contribute to functional disability at four to five-months post-mTBI. Notably, Cassetta et al., (2021) computed fear avoidance change over a three-month time frame. Similar to the current study, reductions in fear avoidance behaviour were significantly associated with reduced functional disability. This association offers potential for individuals who have static or increasing fear avoidance behaviour to engage in targeted interventions to address such behaviour, and conceivably improve functional outcomes for individuals following a mTBI.

Other studies in the mTBI population support these findings (Silverberg et al., 2018; Maestas et al., 2014). Silverberg et al., (2018) found avoidance at approximately three-weeks post-mTBI was predictive of functional disability (cognitions, mobility, interpersonal functioning and participation, self-care and general day-to-day functioning) at four to five-months post-mTBI. Fear avoidance was also found to increase the risk of developing anxiety disorders. Maestas et al., (2014) investigated coping strategies (avoidance and problem-solving coping) and associations with quality of life outcomes (functioning, well-being, disability and perceived general health) in mTBI. Similar to the current study they accounted for psychological functioning (depression and anxiety). They found an avoidant coping strategy was significantly associated with poor psychological functioning and a reduced quality of life at three-months post-mTBI. Conversely, they found low avoidance was significantly associated with improved psychological functioning and perceived quality of life. However, although these findings are consistent with the current study, Maestas et al., (2014) utilised a general measure of coping style with an avoidant component, which may be

measuring a different construct from the current study's use of a specific measure of fear avoidance behaviour validated for use in mTBI (Silverberg et al., 2018).

Of note in the current study, depression at clinic intake was found to significantly contribute to functional disability at follow-up (it also contributed to functional disability at clinic intake). This is of importance, as depression and fear avoidance may potentially have a complex bi-directional relationship where each variable contributes to the other. As previously discussed, exploratory analysis found fear avoidance was significantly correlated with depression.

The key findings for outcomes at follow-up (M = 22.91 weeks since injury) were that the psychological process of fear avoidance behaviour at clinic intake significantly contributed to physical, psychological, cognitive and social functional disability. Notably, reductions in fear avoidance over a three-month time frame were significantly associated with decreasing functional disability at three-months post-clinic intake. Psychological processes explain recurring patterns of cognitive, emotional and behavioural interactions of humans within their internal and external environments (Tamayo, 2011). Although described as recurring, these patterns are dynamic and accordingly, potentially modifiable (Raeff, 2020; Kilic, 2015). Therefore, early targeted intervention of fear avoidance behaviour may have the potential to alter the individual's maladaptive patterned response to the stressful situation incurred following a mTBI. Modifying maladaptive behavioural responses, post-mTBI, thereby has the potential to improve physical, psychological, cognitive and socioeconomic functional outcomes and quality of life post-mTBI. Therapeutic interventions may also have the additional advantage of managing depressive symptoms which have been found to contribute to functional disability.

5.6 Implications

The current study's findings of a significant association between fear avoidance, and fear avoidance changes, with post-concussion symptoms and functional disability, and the potential predictors of individuals who may be at risk of developing fear avoidance behaviour following a mTBI have implications for clinical application. Specifically the significant association of fear avoidance behaviour with increased reporting of post-concussion symptoms has the potential to contribute to persistent symptomatology. Persistent symptoms have been found to contribute to poor physical, cognitive, psychological and socioeconomic functional outcomes (Silverberg et al., 2015; van der Naalt et al., 2017; King & Kirkwilliam, 2011; Cancelliere et al., 2016). In the current study fear avoidance was also found to significantly contribute to functional disability. Significant factors associated with develop fear avoidance behaviour post-injury were found to be a lower level of education and traumatic injury circumstances (assault) with a pre-injury mental health history approaching significance.

From a clinical perspective this knowledge will firstly, 'red flag' individuals who are at risk (education and traumatic injury circumstances) of developing fear avoidance behaviour, and who might therefore potentially be on a trajectory for persistent symptomatology and poor functioning outcomes. Secondly, the clinician may assess fear avoidance behaviour, post-concussion symptoms, functional disability and psychological functioning at baseline and continue to monitor changes over time, especially if the individual's recovery is poor. Thirdly, identification of individuals at risk of developing or having developed fear avoidance behaviours enables the implementation of targeted interventions. Interventions such as, Cognitive Behavioural Therapy (CBT) which assume that unhelpful or distorted cognitions influence negative emotions and behaviour. CBT advocates modification of the underlying core beliefs that contribute to unhelpful cognitions (Dobson & Dobson, (2017). Thus, by modifying

cognitive, emotional and behavioural responses it has the potential to improve functioning outcomes. There is strong evidence to support the successful use of CBT in the management of fear avoidance in chronic pain (Gatchel et al., 2016; Zale & Ditre, 2015; Nagarajan & Nair, 2010; Wertli et al., 2014; Jay et al., 2018; Schutze et al., 2010). A potential modality of CBT that may have promising results in fear avoidance behaviour, in mTBI, is Acceptance and Commitment Therapy (ACT) (Faulkner et al., 2020; Terpstra et al., 2021). The core component of ACT is psychological flexibility which describes the ability of an individual to engage and adapt cognitively, emotionally, physically and psychologically in the present moment within the present context in the pursuit of value-based goals. Psychological flexibility is a well-documented psychological construct which incorporates key processes (cognitive defusion, awareness of self, acceptance, mindfulness, values and committed action) to address the experiential avoidance of emotions, cognitions and behaviour (Hayes et al, 2006; Tyndall et al., 2020; Hayes, Strosahl & Wilson, 2016). It has the potential to influence an individual's outcome post-injury by aiding the individual to readjust maladaptive behaviours (e.g., fear avoidance) to adaptive (Ravn et al., 2018; Schutze et al., 2010). Terpstra et al., (2021) found the severity of post-concussion symptom reporting was associated with catastrophised thinking and fear avoidance behaviour. The authors postulated that targeted intervention of catastrophic cognitions and the resultant fear avoidance behaviour may have the potential to improve outcomes. ACT has also been found to improve anxiety and depressive symptoms in mTBI (Rauwenhoff et al., 2019; Kangas & McDonald, 2011). Given that anxiety and depression are commonly reported post-mTBI (Barker-Collo et al., 2015) this provides an additional benefit.

In summary, the capacity to identify individuals who may develop fear avoidance behaviour following mTBI offers the ability to offer early intervention with

CBT. Specifically, ACT psychotherapy, to potentially prevent the development, or modify existing fear avoidance behaviour following a mTBI. This may also have the potential of improving psychological functioning, and reduce the development of persistent symptomatology and its associated personal and socioeconomic burdens for the individual, their whānau/family and society. Ideally, these interventions should be initiated early post-mTBI before the cycle of catastrophising, fear, avoidance and hypervigilance leads to disuse, disability and emotional dysregulation becomes entrenched.

5.7 Strengths and Limitations

There were several strengths for the current study. Firstly, the inclusion of two time points with the administration of all measures. This allowed for direct comparisons and to assess changes in fear avoidance behaviour. Secondly, this study accounted for factors known to impact outcomes (potential confounders) with the inclusion of psychological functioning (anxiety, depression and stress) measures, and demographic and injury characteristics in the multiple linear regression. This is important as confounding variables may distort findings by masking potential associations or more commonly demonstrate a relationship when in fact no relationship exists (Skelly, Dettori & Brodt, 2012). For example, in the current study the finding of the association of fear avoidance behaviour with post-concussion symptoms may be erroneous if psychological functioning (e.g., depression, anxiety and/or stress) was not factored. Potentially, psychological functioning may be the cause of an increased reporting of post-concussion symptoms, rather than fear avoidance. Accounting for confounders enables the ability to establish causal links (Cozby et al., 2016, Skelly et al., 2012). Thirdly, the sample size was adequately large enough to permit up to 11 variables to be included in the regression analyses (Faul et al., 2009). This accounts for multiple

potential factors in the one regression model allowing for a more detailed analysis (Marill, 2004). Lastly, recruitment occurred at multiple sites throughout the North Island of NZ offering improved sample diversity and representation of the NZ population.

However, limitations of the study are, individuals were only assessed at two time points. Longitudinal assessments at more time points would capture a more accurate assessment of the trajectory of fear avoidance behaviour following mTBI. Although the study factored variables known to impact recovery the study cannot show causality. Some associations may be bi-directional, such as the association of fear avoidance and depression. Measures of avoidance (FAB-TBI) showed strong reliability, however, the reliability of FAB-TBI change scores has not been validated and therefore, reliability may be lower (Cassetta et al., 2021). The measures utilised for the current study were all subjective and can only be elicited from self-reporting and therefore, are difficult to verify (Rosenman, Tennekoon, & Hill, 2011). There is also a risk of over-reporting with self-report questionnaires and reporting bias could not be excluded (Iverson, Brooks, Ashton & Lange, 2010).

The current study sample may also not be representative of the NZ population. The majority (63.8%) of individuals were Aotearoa/NZ European with 12.4% of Māori, and other populations (Pasifika, Chinese, Indian, other Asian and European) accounting for 23.8%. Therefore, it cannot speak to generalisability due to its disproportionate representation of ethnicities which may not be a true reflection of the mTBI population (Feigin et al., 2013; Lagolago et al., 2015). Recruitment was solely through specialist concussion clinics, at approximately nine-weeks, indicating referred individuals may be experiencing a complicated mTBI recovery and as we know approximately 36% of people do not seek medical assistance post mTBI n the Aotearoa/NZ population (Feigin et al., 2013). Concerningly, symptoms are classified as persistent at 12-weeks and

greater, therefore, individuals may already be on a trajectory for established fear avoidance behaviour with resultant persisting post-concussion symptoms and functional disability. Recruitment of individuals via emergency departments or general practitioners or in the wider community (e.g., through sports clubs) may address this limitation in future research of fear avoidance.

5.8 Future Research

This research has expanded the knowledge on the factors which influence fear avoidance behaviour within mTBI populations. It has also further elucidated the impact of fear avoidance on outcomes (functional disability and post-concussion symptoms) following a mTBI. In particular it has shown a reduction in fear avoidance behaviour is associated with reduced reporting of post-concussion symptoms and improved functional outcomes. However, further research is needed to expand on the current research in mTBI.

Firstly, to further explore fear avoidance behaviour and its relationship with outcomes over a longer time period (greater than six-months), particularly in indigenous populations, given their higher incidence of mTBI compared with European populations (Feigin et al., 2013; Lagolago et al., 2015; Langlois et al., 2003; Pozzato et al., 2019). This will consolidate the findings of the current study and extensively describe the trajectory of fear avoidance behaviour and its impact on outcomes in mTBI. Secondly, to investigate potential modifiable interventions that directly target the components of fear avoidance behaviour, such as ACT. ACT has been found to have potential in the management of maladaptive behaviours (e.g., fear avoidance) in mTBI (Whiting, Deane, Simpson, McLeod & Ciarrochi, 2017). ACT has also been found to mediate fear avoidance in chronic pain (Ravn et al., 2018) and therefore, holds promise as a potential

intervention in the prevention or the modification of fear avoidance behaviour following a mTBI. However, further research is needed (Terstra et al., 2021).

Thirdly, to investigate the effects of pre-injury mental health on the development of fear avoidance behaviour. A mental health history has been found to influence the development of fear avoidance behaviour in musculoskeletal pain (Dersh, Polantin, & Gatchel, 2002; Arnow et al., 2006; Zale & Ditre, 2015) and shown to adversely impact outcomes in mTBI (Silverberg et al., 2015; Veldhoven et al., 2011; Ponsford et la., 2019; Bertisch et al., 2018; Karr et al., 2020). Including the impact of cognitive reserve on fear avoidance behaviour. Given these findings and the current study's findings of approaching significance it is worthy of further investigation. Fifthly, to further examine the varying relationships of post-concussion symptoms with fear avoidance. Post-concussion symptoms, as scored on the RPQ, may not elucidate the true picture. An individual may score the same at various time points, but information on specific symptoms is lacking (Dean & Sterr, 2013). Therefore, it is crucial to explore the lived experiences and perspectives from individuals with mTBI to understand post-concussion symptom presentation and its relationship with fear avoidance behaviour. This has the potential to positively affect the development of persistent symptomatology. Sixthly, to investigate the relationship of fear avoidance and depression. Both have been found to impact post-concussion symptoms and functional disability (Delmonico, Theodore, Sandel, Armstrong & Camicia, 2021; Haagsma et al., 2015; van der Naalt et al., 2017) and may possibly have a complex bi-directional relationship. Also, depression is reported as commonly occurring in mTBI (Delmonico et al., 2021; Haagsma et al., 2015; Mathias & Coats, 1999; Barker-Collo et al., 2015) and is a risk factor for persistent symptomatology (Iverson et al., 2017; Quinn et al., 2018; Scott et al., 2016). Therefore, the author believes it warrants further evaluation.

Lastly, to investigate the relationship between trauma-related mTBI, particularly PTSD, and fear avoidance behaviour. Traumatic life events and PTSD have been found to be associated with increased depression and anxiety, and a reduction in reported quality of health at three-months post-mTBI (Veldhoven et al., 2011). Haagsma et al., (2015) also found PTSD to be associated with a marked decrease in functional ability and quality of life. Given the relationship of PTSD with negative outcomes and the current study's findings of traumatic injury circumstances the author recommends further investigation.

5.9 Conclusion

Mild TBI has the potential to negatively impact an individual's physical, cognitive and psychosocial functioning through persistent post-concussion symptoms and functional disability. Prospectively, this may financially and socially burden the individual, their whānau/family and society. The key contributions to knowledge reflected in this thesis are, that fear avoidance behaviour, following a mTBI, has the potential to significantly contribute to persistent post-concussion symptoms and functional disability, whilst accounting for demographic and psychological factors. Specifically, a reduction in fear avoidance, over a three-month time span, was associated with reduced reporting of post-concussion symptoms and less functional disability. Further, psychological functioning (depression and anxiety) was also found to contribute to post-concussion symptoms and functional disability. Furthermore, this thesis found a lower level of education and traumatic circumstances of injury (assault) aided identification of those individuals at an increased risk of developing fear avoidance behaviour following a mTBI.

While there is continued research into the relationship between mTBI and fear avoidance behaviour, the findings from this research have important implications for

management of mTBI. Behavioural interventions which target fear avoidance behaviour may lessen the development of persistent post-concussion symptoms and functional disability following a mTBI. Conceivably, these interventions also have the potential to manage depression and anxiety, which the current study found contributed to persistent symptomatology and poor functioning outcomes. Assessment of demographic and injury characteristics offer the ability to predict who may be at risk of developing fear avoidance behaviour, presenting the opportunity to provide early intervention, and thereby improve functional outcomes post-mTBI.

Early intervention may reduce the impacts of physical, cognitive and psychosocial impairment, and improve functional outcomes, and quality of life following a mTBI. This has the possibility to substantially reduce the social and economic burdens for the individual, their whānau/family and society

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Appendices

Appendix A: Exploring fear avoidance behaviour in individuals who sustain a mild traumatic brain injury and the impact on outcomes.

Ethics Approval

9 March 2020

Josh Faulkner

Faculty of Health and Environmental Sciences

Dear Josh

Re: Ethics Application: **20/32 The role of psychological flexibility in recovery following concussion**

Thank you for your request for approval of amendments to your ethics application.

The amendments to the study protocol relating to the changes in the cogitative measures and the substitution of FAQ for the CIA questionnaire is approved.

The addition of an additional co researcher is noted.

I remind you of the **Standard Conditions of Approval**.

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard.

AUTEC grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted. When the research is undertaken outside New Zealand, you need to meet all ethical, legal, and locality obligations or requirements for those jurisdictions.

Please quote the application number and title on all future correspondence related to this project.

For any enquiries please contact ethics@aut.ac.nz. The forms mentioned above are available online through http://www.aut.ac.nz/research/researchethics

(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat

Auckland University of Technology Ethics Committee

Appendix B: Exploring fear avoidance behaviour in individuals who sustain a mild traumatic brain injury and the impact on outcomes.

Consent Form

Consent Form

Project title: The Role of Psychological Flexibility in Recovery Following Concussion *Project Supervisor:* Professor Alice Theadom
Researcher: Dr Josh Faulkner

- ϒ I have read and understood the information provided about this research project in the Information Sheet dated _____
- ϒ I have had an opportunity to ask questions and to have them answered.
- ϒ I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- ϒ I agree for the researcher to advise me of any concerns they may have.
- ϒ I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- ϒ I consent to the research staff collecting and processing my information, including information about my health.
- ϒ I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.
- ϒ I agree to take part in this research.
- ϒ I wish to receive a summary of the research findings (please tick one): Yesϒ Noϒ

Participant's signature.....

Participant's name: .....

Phone : .....

Email : .....

Date: .....

Approved by the Auckland University of Technology Ethics Committee on 19 February 2020 AUTEC Reference number 20/32

Note: The Participant should retain a copy of this form.

Study Number.....

Appendix C: Exploring fear avoidance behaviour in individuals who sustain a mild traumatic brain injury and the impact on outcomes.

Participant Information Sheet

Participant Information Sheet

Study title: **The Role of Psychological Flexibility in Recovery Following Concussion**

Locality: **Wellington**

Lead investigators: **Alice Theadom and Josh Faulkner**

Ethics committee ref.: **20/32**

Contact phone number: **0212460728**

You are invited to take part in a study looking at what impacts recovery following a concussion. Whether or not you take part is your choice. If you don't want to take part, you don't have to give a reason, and it won't affect the care you receive. If you do want to take part now, but change your mind later, you can pull out of the study at any time.

This Participant Information Sheet will help you decide if you'd like to take part. It sets out why we are doing the study, what your involvement would look like, what the benefits and risks to you might be, and what would happen after the study ends. We will go through this with you and answer any questions you may have. You do not have to decide today whether or not you will take part in this study. Before you decide you may want to talk about the study with other people, such as family, whānau, friends, or healthcare providers. Feel free to do this.

We will contact you within 30 days of receiving this information to discuss if you want to be involved.

If you agree to take part in this study, you will be asked to sign the Consent Form on the last page of this document. You will be given a copy of both this Information Sheet and the Consent Form to keep.

This document is 6 pages long, including the Consent Form. Please make sure you have read and understood all the pages.

WHAT IS THE PURPOSE OF THE STUDY?

Our overall aim is to better understand what impacts recovery following a concussion. By understanding this, we hope to improve the care and treatment for people who are recovering from a concussion.

This study is funded by the Health Research Council of New Zealand.

WHAT WILL MY PARTICIPATION IN THE STUDY INVOLVE?

You have been invited to partake in this study because you have had a concussion and have been referred to Proactive4Health Concussion Services covered by ACC.

If you would like to take part in this study, we would like to arrange a time to come and meet you either at a Proactive clinic or, if you would prefer, at your home. You will be asked to complete questionnaires and tasks to measure certain thinking skills. You will be asked questions about your post-concussion symptoms, how you have been feeling, as well as your ability to take part in everyday activities. You will also be asked to complete some cognitive tasks which will take place on a computer. At three and six months after this meeting, we will also ask you to complete these questions again. This will occur either via email, by telephone or in person depending on what you would like.

You can ask any questions you may have about the study. If you are happy to take part, you will be invited to sign the consent form.

WHAT ARE THE POSSIBLE BENEFITS AND RISKS OF THIS STUDY?

Taking part in this study will take some of your time and we estimate that on the first occasion this will take between 60 to 90 minutes. On the second and third occasion this will take approximately 30 minutes. There are no known risks caused by this study, however you may feel uncomfortable or embarrassed by some questions. You do not have to answer any questions you do not wish to. All our researchers have received training in administering these assessments.

If any concerns about your well-being occur during the study, then these will be discussed with you. We can also give you the contact numbers for support services and will make a referral to your family GP for you. If there are concerns that you or others are in immediate danger of harm, we will support your/their safety by phoning the emergency services (111) or the Crisis Assessment Team. As long as it is safe to do so, this phone call will be made while we are with you.

Your usual care under concussion services will not be affected in any way by being involved in the study or withdrawing from the study at any stage. Your involvement in this study will be stopped should there be any harmful effects or if the doctor or other medical professionals, feel it is not in your best interests to continue.

WHO PAYS FOR THE STUDY?

There should be no direct costs to you in taking part in this study. If you need to travel to meet the researcher, we will cover your travel costs.

WHAT IF SOMETHING GOES WRONG?

It is unlikely that you will be at risk of harm from taking part in this study. If something goes wrong, please contact the principal investigator as soon as possible 09 921 9999

WHAT ARE MY RIGHTS?

The study files and all other information that you provide will remain strictly confidential, unless there is information that indicates you, your child or someone else is at risk.

No material that could personally identify you will be used in any reports or discussions about this study.

Your participation is entirely your choice, and you will be able to withdraw from the study at any time without experiencing any disadvantage.

You will be able to access your information collected as part of the study if you wish to do so. If any information that may be of benefit to you is found during the study, we will contact you to let you know

WHAT HAPPENS AFTER THE STUDY OR IF I CHANGE MY MIND?

When the study is finished, your records will be stored on a computer by the lead investigator Professor Theadom). All computer records will be password protected. No information will be shared outside of the research team without seeking your permission.

After 10 years all electronic information will be deleted, and paper forms will be shredded and destroyed with the university confidential waste.

After we have looked at all the data, we will send you a summary of results if you would like to receive them.

WHO DO I CONTACT FOR MORE INFORMATION OR IF I HAVE CONCERNS?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Alice Theadom

Telephone number: 09 921 9999 x7805 Email: alice.theadom@aut.ac.nz

If you concerns regarding the conduct of the research then notify Dr Carina Meares, Executive Secretary of AUTEC, *ethics@aut.ac.nz* , (+649) 921 9999 ext 6038.

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone : 0800 555 050

Fax : 0800 2 SUPPORT (0800 2787 7678)

Email : advocacy@hdc.org.nz

You can also contact the health and disability ethics committee (HDEC) that approved this study on:

Phone: 0800 4 ETHICS

Email: hdecs@moh.govt.nz

Support Services available:

The Brain Injury Association

Phone: (04) 473 5004
Address: Federation House, Level 2/9599, Molesworth St, Thorndon

Maori Community Health Team:

Phone: (04) 237 9608
Address: 213/217 Bedford St Cannons Creek Porirua 5024

Te Haika: Crisis Assessment Team

Phone: 0800 745 477

Please keep this for your information. Thank you for interest in this study

Appendix D: Exploring fear avoidance behaviour in individuals who sustain a mild traumatic brain injury and the impact on outcomes.

Study Demographics Questionnaire

Study Number Initials

The Role of Psychological Flexibility in Recovery Following Concussion

Participant Details

CONFIDENTIAL

1. Gender: Male=1 Female=2 (Please enter appropriate number)

2. Date of birth: dd/mm/yy

3. What ethnic group or groups, do you most identify with (choose as many as apply) [Yes=1; No=2]

Māori

NZ European Pacific Island Chinese

Indian

Other Asian

European

Other *please specify:* _____

4. What is the highest level of education you have attained?

None [1]

Primary Education [2]

High School Education [3] College of Education [4] University [5]

Private training establishment [6]

Other [7] (please specify)

5. Employment status prior to injury

Full time paid work [1]

Part time paid work [2]

Self-employed [3]

Not in paid employment due to disability/illness [4]

Unemployed [5]

Student [6]

Homemaker [7]

Other [8]

If other, please explain: .....

6. If in paid employment what is/was your occupation?

Coding options:
1 = managers
2 = professionals
3 = technicians and trades workers
4 = community and personal service workers
5 = clerical and administrative workers
6 = sales workers
7 = machinery operators and driver 8 = labourers

7. Current employment status

Full time paid work [1]

Part time paid work [2]

Self-employed [3]

Not in paid employment due to disability/illness [4]

Unemployed [5]

Student [6]

Homemaker [7]

Other [8]

If other, please explain:.....

8. What is your current intimate/romantic relationship status?

Married [1]

Civil Union [2]

Living with Partner [3]

Separated [4]

Divorced [5]

Widowed [6]

Single/Never Married [7]

9. When did you experience your concussion?

Date of injury dd/mm/yy

10. How did you sustain your concussion?

Transport Accident [1]

Assault [2]

Fall [3]

Accidentally hit by object [4]

Other [5]

if other please specify.....

11. What activity were you doing when you sustained your concussion?

Sports or recreation
Activity of daily living
Other
In a conflict situation
Work
Other
If other please specify.....

12. Did you sustain any other injuries when you sustained your concussion? [Yes=1; No=2]

If yes, please specify.....

13. Did you seek medical attention following your injury? [Yes=1; No=2]

If yes where did you go?

Hospital
GP
Accident and Medical Clinic
Physiotherapist, Occupation Therapist or other

14. Have you previously experienced a concussion? [Yes=1; No=2]

If yes, how many.....

15. Do you have any other medical conditions? [Yes=1; No=2]

If yes, please specify:

16. Do you have any history of mental health conditions? [Yes=1; No=2]

Please specify

Depression [1]
Anxiety [2]
OCD [3]
PTSD [4]
Eating Disorder [5]
Substance Addiction [6]
If other please specify [7].....

Thank you for taking the time to answer these questions

Appendix E: Exploring fear avoidance behaviour in individuals who sustain a mild traumatic brain injury and the impact on outcomes.

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