Impact of Concussion on Youth: Pediatric Perspectives of Recovery Related to Learning, Emotional Health, Social Life, and School

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IMPACT OF CONCUSSION ON YOUTH: PEDIATRIC PERSPECTIVES
OF RECOVERY RELATED TO LEARNING, EMOTIONAL HEALTH,
SOCIAL LIFE, AND SCHOOL

By Ruta Clair
Submitted in Partial Fulfillment of the Requirements for the Degree of
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Dissertation Approval

This is to certify that the thesis presented to us by _______________________________ on the _____ day of __________________, 20___, in partial fulfillment of the requirements for the degree of Doctor of Psychology, has been examined and is acceptable in both scholarship and literary quality.

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Abstract

Pediatric concussion is a significant health concern for parents, medical providers, and schools. There is little research about how children and adolescents view their recovery and the challenges that they face while their brains gradually restore metabolic function. This study was designed to gain insight into the perspectives of children and adolescents recovering from concussion. Further, exploration of factors, such as type and intensity of symptoms, time since injury, gender, and age of patient, were examined to provide an understanding of the interaction between these factors and the impact on the individual’s perception of his or her recovery. The Pediatric Life After Concussion Evaluation Scale and the Post Concussion Symptom Scale were completed by individuals ages 7-22. Concussion is an experience that can impact quality of life across cognition, emotion expression, and social interactions. Almost half of individuals reported that the concussion disrupted their life to a significant degree. There were no statistically significant differences related to age between the children and adolescents concerning symptoms or quality of life. The study showed that girls reported more physical and somatic symptoms, worse quality of life during recovery, difficulty with cognition, and elevated emotional symptoms than boys. Time since injury was also a significant factor with those children and adolescents who experienced prolonged recovery, reporting more symptoms across all domains. Further, physical symptoms and quality of life were found to be closely associated. Overall, this study showed that children and adolescents can provide information about their recovery experience, that recovery from concussion is multifaceted, and that concussion has significant impact on quality of life for children and adolescents.
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Concussion is a significant medical issue in the United States that impacts up to 5% of the population each year (Fife & Kalra, 2015). Of these individuals, almost 500,000 children seek treatment in emergency rooms for pediatric traumatic brain injury (Langlois, Rutland-Brown, & Thomas, 2006). Despite this number, many individuals never go to the emergency room after a concussion, Therefore, it is probable that prevalence rates underestimate the true occurrence of mild traumatic brain injury (TBI; Arbogast et al., 2016; Marar, McIlvain, Fields, & Comstock 2012; Trenchard, Rust, & Bunton, 2013).

Determining the incidence and outcomes from concussion, or mild TBI, is difficult because of the nature of the condition. TBIs are often considered a “silent epidemic” because, despite their high incidence and prevalence, the thinking and memory problems resulting from TBI are invisible, and the public has a limited understanding of the condition (Langlois, et al., 2006). Nevertheless, the numbers suggest that schools, pediatricians, and other community members who work with children and adolescents are likely to interact with those suffering from mild TBI regularly.

**Symptom Expression**

Concussion is a complex pathophysiological process that causes physical symptoms, cognitive changes, and emotional concerns (Ellis, Leddy, & Willer, 2016; Sady, Vaughn, & Gioia, 2011). When the injury occurs, a pathophysiological cascade is
initiated, which triggers both immediate and delayed symptoms (Ellis et al., 2016; Harmon et al., 2013; Langlois et al., 2006). Physical symptoms associated with concussion include headache, nausea, vomiting, dizziness, balance and gait problems, tinnitus, photophobia, phonophobia, and fatigue (Eisenberg, Meehan, & Mannix, 2014; Khurana & Kaye, 2012; McNally et al., 2013). Most children and adolescents with concussion recover within 30 days (Crowe et al., 2016); however, symptoms can persist for months in up to 20% of concussion patients (McCrorry et al., 2009; National Center for Injury Prevention and Control, 2007; Zemek, Farion, Sampson, & McGahern, 2013). The experience of persistent physical symptoms, such as headaches or dizziness, can be debilitating and can affect multiple areas of functioning (Blume, 2015; Kontos et al., 2013 Mihalik et al, 2013).

The experience of concussion goes beyond the physical symptoms and recovery progression (Limond, Dorris, & McMillan, 2009; Novak et al., 2016; Scherwath et al., 2011; Zemek et al., 2013). Cognitive and emotional symptoms are often a significant aspect of mild TBI (Ellis et al., 2016; Limond et al., 2009; Scherwath et al., 2011). Memory problems and difficulty concentrating and sustaining focus often emerge during the recovery process (Grubenhoff et al., 2014; Scherwath et al., 2011). Managing complex tasks and learning can be overwhelming and symptoms can be exacerbated by cognitive activity (Halstead et al., 2013). In pediatric patients, school can become difficult and stressful in the face of prolonged recovery (Novak et al., 2016).

The impact of a concussion on daily functioning can last well beyond recovery from the physical symptoms (Limond et al., 2009). The complex nature of head injury and recovery leads to diverse profiles that include varying levels of physical, cognitive,
and emotional symptoms (Limond et al., 2009; Novak et al., 2016; Sady et al., 2011). For example, anxiety and depression may emerge during the recovery process and can linger long after physical symptoms subside (Eisenberg et al., 2014; Ellis et al., 2016; Ellis et al., 2015; Luis & Mittenberg, 2002). Recovery is a process that has multiple dimensions, including type of injury, physical symptom profile, and tolerance for exertion and symptoms (Sady et al., 2011). It remains unclear which symptoms or premorbid conditions are specific precursors for a delayed recovery progression (Zemek et al., 2013).

**Risk and Recovery**

The trajectory of the recovery from concussion is influenced by factors such as gender, age, and time since injury. Gender, for example, may be a risk factor for concussion (Baker et al., 2016; Covassin & Elbin, 2011; Dick, 2009; Marar et al., 2012; Novak et al., 2016). Females have a higher risk for injury due to concussion and, once injured, tend to have longer recovery periods than males (Baker et al., 2016; Blume & Hawash, 2012; Covassin & Elbin, 2011; Dick, 2009; Heyer et al., 2016). In addition, females tend to experience increased number and intensity of symptoms across physical, cognitive, and emotional domains (Blume et al., 2012; Covassin, Elbin, Harris, Parker, & Kontos, 2012; Kontos et al., 2012; Ono et al., 2016). Although gender as a risk factor is emerging in the literature, the mechanism for the risk is not yet understood (Blume & Hawash, 2012; Covassin & Elbin, 2011; Dick, 2009). Theories concerning the increased risk for females consider both biological and cultural factors (Baker et al., 2016; Covassin & Elbin, 2011; Dick, 2009).
In addition to gender, age at time of injury is also a risk factor for concussion, with adolescence as the most vulnerable age period (Howell, Osternig, & Chou, 2014). Theories suggest that significant development in the regions of cervical musculature, central nervous system, and hormonal/chemical systems during adolescence results in greater risk (Field, Collins, Lovell, & Maroon, 2003; Makdissi et al., 2013). Further, symptoms progress and change over time, with some symptoms emerging early and others at later points, in part because of the metabolic load and pathophysiology (Harmon et al., 2013). The intersection between pre-injury variables and post-injury deficits, coupled with the complex pathophysiology that occurs in the brain, result in recovery processes that vary widely.

Beyond the metabolic cascade and functional changes, the experience of concussion can affect the individual’s quality of life (QOL; Moran et al., 2011; Novak et al., 2016). Health related QOL involves multiple dimensions of function that include physical symptoms, physical functioning, emotional functioning, and social variables (DiBattista, Soo, Catroppa, & Anderson, 2012; Fineblit, Selci, Loewen, Ellis, & Russell, 2016; McLeod, Houston, & Welch, 2015; Novak et al., 2016). Limited research has explored the impact of concussion on the subjective experience of head injury (Moran et al., 2011; Novak et al., 2016). Measurement has focused primarily on the symptoms related to recovery, but not on the perspectives of how the concussion affects life across domains for children and adolescents with concussion.

Pediatric measures used to explore physical symptoms have been developed from measures of symptoms established for adult athletes. The purpose of measures such as the Post Concussion Symptom Survey (PCSS), for example, is to capture the state of
symptoms at the time of completion of the measure (Lovell et al., 2006). The range of the PCSS has been extended to pediatric patients and has been found reliable (Joyce, Labella, Carl, Lai, & Zelko, 2015; Kontos et al., 2012; Lovell et al., 2006). Although these tools can be used reliably with pediatric patients, there may be a need to develop tools that use language that is better understood by youth (McLeod et al., 2015). Current measures do not capture the broad experience of concussion for children and adolescents (Moran et al., 2011).

Concussion is a disruptive experience for the majority of children and adolescents who sustain head injuries (Sady et al., 2011). Although much of the field has focused on return to play protocols, it is increasingly evident that return to learn is a greater area of need for most children and adolescents with concussion (Burke, Fralick, Nejatbakhsh, Tartaglia, & Tator, 2014; Purcell, Harvey, & Seabrook, 2016; Sady et al., 2011). There is limited understanding concerning ideal medical management of concussion, much less the ideal protocol for accommodating learning and recovery (Corwin et al., 2014; Sady et al., 2011). The field is only beginning to understand how symptoms emerge and impact the functioning of children and adolescents during recovery from concussion (Karr, Areshenkoff, & Garcia-Barrera, 2014; Sady et al., 2011).

Most pediatric concussion patients recover physically within a month (Blume & Hawash, 2012; Crowe et al., 2016; Zemek et al., 2013), but up to 50% of children and adolescents will continue to experience cognitive or emotional symptoms after the physical symptoms have resolved (Crowe et al., 2016). For a portion of injured children and adolescents, symptoms will linger beyond 30 days (Field et al., 2003; Harmon et al.,
2013; Heyer et al., 2016; Makdissi et al., 2003; Novak et al., 2016; Purcell et al., 2016; Raikes & Smart, 2015). In turn, lingering symptoms affect QOL of children and adolescents with concussion (McLeod et al., 2015; Novak et al., 2016). Health related QOL describes the interaction of domains of function that include physical symptoms, physical functioning, emotional functioning, and social variables to form the overall picture of health and recovery (DiBattista et al., 2012; McLeod et al., 2015). The field has only begun to examine the impact of concussion on broad health related QOL for children and adolescents (Moran et al., 2011; Novak et al., 2016; Yeates et al., 2012). Although it is evident that there are subjective health outcomes as a result of the experience concussion symptoms, research capturing the subjective experience of pediatric concussion is limited (Fineblit et al., 2016; Moran et al., 2011; Novak et al., 2016).

**Purpose of the Study**

The purpose of this study was to explore QOL factors for pediatric patients with concussions in order to gain a better understanding of the issues facing children and adolescents during recovery. It is important to understand the impact of concussion on the lives of children and adolescents, as the field is only beginning to understand the complex interaction of pre-injury and post-injury variables that result in lingering problems for injured youth. Many of the obstacles that individuals experience may be subtle and can interact in a cascade of problems that affect multiple neurological and neuropsychological systems. Further, symptoms progress and change over time, with some symptoms emerging early and others at later points, in part because of the biological process related to metabolic load.
In addition to identifying symptoms, it is important to understand how symptoms impact the individual’s day-to-day functioning during recovery. Concussion often disrupts learning and functioning in school, even when recovery is rapid. Some pediatric patients continue to experience somatic symptoms several months post-injury. The tasks and activities that students are exposed to in school deplete cognitive reserves, which has consequences for learning, emotional functioning, and general QOL. School can become very stressful as students balance their recovery needs with school demands. Emotional regulation, anxiety, and mood problems may develop during recovery and further complicate the recovery process.

Although current research demonstrates that there are subjective health outcomes that result from lingering concussion symptoms, research capturing the subjective experience of pediatric concussion is limited. Self-report symptom assessment tools were developed originally for adult concussion patients and primarily focus on physical symptoms. There are currently few tools to examine the QOL issues that pediatric patients face, such as impact on school, activities, and social experiences. As a result, the field lacks information about how children and adolescents view their recovery and the challenges that they face while their brains gradually restore metabolic function.

It is proposed that pediatric patients can provide essential information about their recovery experience and the impact on their QOL as related to cognition, emotional health, social experiences, and school. Further, exploration of factors such as type and intensity of symptoms, time since injury, gender, and age of patient can provide an understanding of the interaction between these factors and the impact on the individual’s perception of his or her recovery. Expanding the knowledge of the field to include the
unique perspectives of the children and adolescents recovering from concussion will inform treatment and accommodation plans developed by medical and school teams.
Chapter 2: Literature Review

Definition and Incidence

A concussion is a form of a mild TBI, an acquired neurological condition resulting from injury. In other words, a “concussion is a biomechanically induced alteration in the function of the brain” (Rivera, Roberson, Whelan, & Rohan, 2015). The blow may be to the head or other body part that causes the brain to move or rotate in the skull, causing injury (Borse et al., 2008; Raikes & Smart, 2015). This may occur in various ways, including falls, impact during sports, and car accidents (Borse et al., 2008). The injury triggers metabolic and functional pathology in the brain (Raikes & Smart, 2015; Rivera et al., 2015).

Concussion triggers a complex neurometabolic cascade that is qualitatively different from the structural damage of the brain caused by more severe TBI (Ellis et al., 2016; Kontos et al., 2013; Sady et al., 2011). Much about the pathophysiology of concussion is not well understood at this time (Adamson et al., 2013; Kontos et al., 2013; Wang et al., 2015). Nevertheless, it is clear that when the brain sustains significant shaking as a result of a direct or indirect blow, there are changes in brain glucose metabolism, brain protein release, neurotransmitters, and cerebral blood flow (Ellis et al., 2016; Kontos et al., 2013; Sady et al., 2011; Wang et al., 2015). The biological process of recovery causes a metabolic energy crisis that stresses the brain and exacerbates symptoms (Ellis et al., 2016; Sady et al., 2011). Engaging in both cognitive and physical activity deplete brain resources which, in turn, exacerbates symptoms, making recovery more difficult (Halstead et al., 2013; Kontos et al., 2013; Master, Goia, Leddy, & Grady, 2012; Sady et al., 2011). Further, current research suggests that some changes that occur...
during this period, such as neuroelectric efficiency, can show changes even two years after concussion (Moore et al., 2016).

According to the Center for Disease Control (CDC), there has been a dramatic increase in emergency room visits for head injury (Borse et al., 2008). In 2010, there were approximately 2.5 million brain injuries in the United States (Faul, Xu, Wald, & Coronado, 2010). Approximately 75% of the TBIs that occur are concussions (Borse et al., 2008; Faul et al., 2010). The rate of emergency visits for concussions resulting from sports injuries have increased by at least 57% among children (Faul et al., 2010).

**Physical Symptoms and Sequelae**

In the immediate aftermath of the injury, the individual may experience nausea, dizziness, and delayed motor responses. Loss of consciousness occurs in approximately 10% of concussions (Rivera et al., 2015). One does not, therefore, have to lose consciousness to sustain a concussion. Physical symptoms associated with concussion include headache, nausea, vomiting, dizziness, balance and gait problems, tinnitus, photophobia, phonophobia, and fatigue (Eisenberg et al., 2014; Khurana & Kaye, 2012; McNally et al., 2013). The emergence of specific symptoms is related to the complex relationship between the characteristics of the injury and the injured individual (Eisenberg et al., 2014; McNally et al., 2013).

The trajectory of recovery from concussion is different from other types of pediatric injuries (Barlow et al., 2010; Crowe et al., 2016; Limond et al., 2009). Although the majority of those who experience a concussion return to typical functioning within 2 to 4 weeks after injury (Barlow et al., 2010; Purcell et al., 2016), symptoms can linger for approximately 10% of children with concussion (Barlow et
al., 2010; Purcell et al., 2016). The mechanisms for prolonged recovery are only beginning to be understood (Barlow et al., 2010; McNally et al., 2013). For example, high rates of total symptom burden in the early days after concussion is predictive of persistent impairment and slow recovery (Heyer et al., 2016; Howell, O’Brien, Beasley, Mannix, & Meehan, 2016; Meehan, Mannix, Monuteaux, Stein, & Bachur, 2014). Further, initial elevated rate of somatic symptoms may be a good predictor of prolonged recovery in adolescents (Heyer et al., 2016; Howell et al., 2016). In addition, the type and characteristics of the injury causing the concussion can predict the intensity of symptoms within the first month post injury, and premorbid emotional symptoms and demographic factors have been shown to predict persisting post-concussion symptoms (Barlow et al., 2010; McNally et al., 2013). Currently, it is believed that the recovery process is an interaction between pre-injury and post-injury characteristics (Barlow et al., 2010; McNally et al., 2013; Meehan et al., 2014; Purcell et al., 2016).

In addition to physical symptoms, an individual with a concussion may also have speech difficulties, confusion, and memory deficits in the initial injury period (Scherwath et al., 2011). The most severe of these symptoms typically resolve within hours; however, somatic and cognitive symptoms persist for many children who have suffered from concussion (Yeates et al., 2012). The nature of the physical symptoms can have a significant effect on functioning across domains (Eisenberg et al., 2014; Scherwath et al., 2011; Yeates et al., 2012).

**Headache.** Headache, dizziness, and fatigue tend to emerge in the early stages of the injury recovery process (Eisenberg et al., 2014; Marar et al., 2012). Although the relative ratio of concussion patients suffering from headache varies across studies, it is
evident that headache is one of the most common symptoms (Barlow et al., 2010; Blume, 2015; Blume et al., 2012; Castile, Collins, McIlvain, & Comstock, 2012; Eisenberg et al., 2014; Howell et al., 2016; Marar et al., 2012; McNally et al., 2013). In addition, the presence of headache immediately after the injury is associated with increased risk for prolonged recovery (Howell et al., 2016). The literature indicates that up to 45% of pediatric patients with concussion continue to experience headache 3 months after injury (Blume, 2015).

As a central symptom of concussion, headache emerges early in the recovery process and there is no single type of headache associated with concussion (Blume, 2015; Eisenberg et al., 2014; Marar et al., 2012). Moreover, the experience of headache symptoms during the recovery period can be disabling and impact multiple domains of function (Blume, 2015; Blume et al., 2012; Kontos et al., 2012; Mihalik et al, 2013). Physicians and clinicians should pay careful attention to presence of initial headache as this may be a good predictor of prolonged recovery (Howell et al., 2016).

Chronic headache pain may also contribute to elevated post-concussion symptoms that persist over longer periods of time than for those children who experience minimal pain (Blume, 2015; Mahalik et al., 2013; McNally et al., 2013). In addition, migraine symptoms in the early recovery period may indicate a risk for longer recovery (Blume, 2015; Ellis et al., 2016; Kontos et al., 2013 Mihalik et al., 2013). Adolescents with post-injury migraine have been seven times more likely to experience a prolonged recovery period than concussion patients with little or no headache (Kontos et al., 2013). Additionally, adolescents with post-traumatic migraine symptoms experience more severe physical symptoms than patients with no headache or headache without migraine.
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(Blume, 2015; Ellis et al., 2016; Mihalik et al., 2013). Further, the presence of migraine after a concussion is associated with more severe symptoms across physical, cognitive, and neurobehavioral domains (Mihalik et al., 2013). Chronic pain and migraine symptoms can linger and impair pediatric patients with concussion.

Headache is also often associated with sleep deprivation and cognitive impairment, making management of pain and concussion symptoms more difficult (Blume, 2015; Blume et al., 2012). Task demands impact and are impacted by headache pain during recovery. For example, when children are in school, the cognitive tasks required during learning can trigger or exacerbate headache pain (Blume, 2015). The complex interaction of pain, migraine symptoms, and cognitive load can be disabling for some pediatric patients for months after their injury (Blume, 2015; Blume et al., 2012; Eisenberg, Andreas, Meehan, & Mannix, 2013; Eisenberg et al., 2014).

**Fatigue and sleep.** Sleep disturbances may also emerge during recovery from concussion and are associated with slow recovery from physical symptoms (Blume, 2015; Chaput, Giguere, Chauny, Denis, & Lavigne, 2009; Halstead et al, 2013). Having trouble falling or staying asleep can interfere with the recovering child’s learning, mood, and general functioning (Blume, Lucas, & Bell, 2011; Tkachenko, Singh, Hasanaj, Serrano, & Kothare, 2015).

Fatigue is a symptom that emerges after the initial physical symptoms begin to wane (Blume et al., 2011; Eisenberg et al., 2014). Approximately 50-60% of children develop fatigue during recovery (Eisenberg et al., 2014; Tkachenko et al., 2015). Being tired can interfere with cognitive function and learning (Blume et al., 2011; Halstead et al., 2013; Tkachenko et al., 2015). For example, fatigue is related to cognitive
impairments such as memory and attention deficits following injury (Blume et al., 2011; Halstead et al., 2013). Further, fatigue and sleep disturbances may have an emotional component and should be monitored carefully by physicians treating pediatric patients (Eisenberg et al., 2014).

The interaction between symptoms and fatigue has profound consequences for recovery from concussion (Blume et al., 2011; Eisenberg et al., 2014; Halstead et al., 2013; Tkachenko et al., 2015). There may be a progression of somatic symptoms, cognitive deficits, and sleep deficits which then interact with emotional disturbances that impact the recovery process negatively (Eisenberg et al., 2014). For example, poor sleep patterns after concussion contribute to increased symptom load, which can then prolong recovery (Blume et al., 2011; Eisenberg et al., 2014; Halstead et al., 2013; Tkachenko et al., 2015).

Somatic symptoms. Somatic symptoms, such as light or sound sensitivity, are hallmark symptoms of concussion that can interfere with recovery across functional domains. Sensory sensitivities may can interfere with the patient’s ability to engage with tasks (Rivera et al., 2015). Another common physical symptom that has far reaching implications for individuals suffering from concussion is vertigo, or dizziness, which occurs in up to 55% of individuals with concussion (Alsalaheen et al., 2010; Fife & Kalra, 2015). Children experience vertigo at a similar rate as adults with concussion (Alsalaheen et al., 2010). Vertigo may fluctuate or may be a continuous chronic experience during recovery (Fife & Kalra, 2015). Just as with other somatic symptoms, vertigo often resolves within several weeks of injury (Alsalaheen et al., 2010; Fife & Kalra, 2015). Although vertigo usually resolves within a relatively short time, the
experience of dizziness contributes to difficult recovery and interferes with daily living (Alsalaheen et al., 2010; Fife & Kalra, 2015). Vestibular dysfunction is often accompanied by symptoms such as blurred vision, motion sensitivity, and poor balance which can interfere with QOL (Ellis et al., 2016). Further, secondary symptoms such as anxiety may emerge as a result of the persistence of symptoms such as dizziness, further complicating recovery (Fife & Kalra, 2015).

The presence of acute symptoms immediately after a head injury by itself does not predict the persistence of somatic symptoms in pediatric patients (Grubenhoff et al., 2014; Kontos et al., 2012). Kontos et al. (2012) suggest that a combination of headache, nausea, and photo-or phonosensitivity may be a better predictor of lengthened recovery than any of the symptoms alone. At this time, there is no diagnostic sensitivity that can predict which patients will experience more intensive somatic symptoms and longer recovery periods from concussion (Grubenhoff et al., 2014).

Cognitive Impact and Learning

**Effects on cognition.** The biological effect of a concussion has consequences for the child’s functioning across cognitive, emotional, and behavioral realms. Post-injury changes are evident in cognitive domains related to memory, processing speed, executive function, and attention (Blume et al., 2011; Grubenhoff et al., 2014; Moore et al., 2016; Scherwath et al., 2011). The physical symptoms of concussion, such as headache and fatigue, may have a pronounced effect on the child’s ability to learn (Blume et al., 2011; Sady et al., 2011). For example, pediatric patients with post-traumatic migraine after injury tend to function more poorly on measures of verbal and visual memory, as well as reaction time (Kontos et al., 2013. Memory concerns, difficulty concentrating, and
sustaining focus are common in children with concussion (Blume et al., 2011; Grubenhoff et al., 2014; Scherwath et al., 2011).

In children with long recovery periods, cognitive problems may be more impairing and result in a vicious cycle (Grubenhoff et al., 2014). The cognitive exertion required during the school day may overtax the brain and exacerbate cognitive and physical symptom clusters (Sady et al., 2011). As a result, the tasks and activities to which students are exposed in school deplete the already limited energy reserves of the brain, which, in turn, has wide ranging impact on learning, emotional functioning, and QOL (Grubenhoff et al., 2014; Halstead et al, 2013; Sady et al., 2011).

Recovery of cognition is not monolithic, as the rates of recovery differ for different skills and functions (Karr et al., 2014). For example, executive function is particularly sensitive to the metabolic crisis related to concussion, which leads to a slower recovery trajectory for this domain (Karr et al., 2014; Raikes & Smart, 2015; Sady et al., 2011). Similarly, deficits in sustained attention are often evident in individuals after concussion, as well as impaired awareness of errors (Raikes & Smart, 2015). Further, behaviors consistent with hyperactivity and attention difficulties are common problems that occur after concussion and may linger after physical symptoms have dissipated (Blume et al., 2011; Massagli et al., 2004; Moore et al., 2016). Current research suggests that children and adolescents may continue to have difficulty modulating attention and coordinating working memory (Moore et al., 2016).

In addition, multiple concussions are a significant risk factor for lingering executive function deficit (Karr et al., 2014). For example, a history of two or more concussions can have a long-term negative effect on the electrophysiological functioning
of the brain, which, in turn, has a negative effect on self-monitoring for errors and executive function (De Beaumont, Beauchemin, Beaulieu, & Jolicoeur, 2013). Further, if the concussion occurs during a developmentally sensitive period, deficits in executive functions, such as shifting and response inhibition, can continue and alter the developmental trajectory of these brain functions (Moore et al., 2016).

**Effects on learning.** Learning problems are also often evident during recovery from concussion (Grubenhoff et al., 2014; Sady et al., 2011; Scherwath et al., 2011). Moreover, unlike with other physical injuries, the recovery period is not necessarily linear. Scherwath et al. (2011) found that cognitive impairment may emerge after a delay. A few days after injury, 12% of children with concussion showed deficits in learning and memory for new material, whereas 30% of the sample demonstrated impairment 2 months after injury (Scherwath et al., 2011). In addition, children’s subjective experience of learning problems may be different from what is present on objective testing. In other words, although deficits related to cognition, attention, and executive function may linger, the child or adolescent may not be fully aware of ongoing problems, believing that impaired skills have returned to baseline (Blume et al., 2011).

Further, academic tasks such as math problem solving become difficult for many children with mild TBI during the recovery phase (Halstead et al., 2013; Van Beek, Ghesquiere, Smedt, & Lagae, 2015). Cognitive deficits may interfere with performance of tasks requiring detail and multiple steps (Halstead et al., 2013; Van Beek et al., 2015). As a result, a one-size-fits-all approach to accommodations is problematic, as recovery rates vary widely (Halstead et al., 2013; Popoli, Burns, Meehan, & Reisner, 2014). Current research regarding return to school following a brain injury suggests the need for
accommodations in a number of areas of learning, including but not limited to changes in schedule, reduced exposure to screens and text, limitations to classroom expectations for tasks such as reading and note-taking, and modified testing (Halstead et al, 2013).

**Emotional Symptoms**

Although physical symptoms are the most apparent in the short term after concussion, symptoms related to cognition and mood emerge more gradually (Eisenberg et al., 2014; Heyer et al., 2016). Many patients with concussion experience negative emotions during the recovery period (Chaput et al., 2009; Eisenberg et al., 2014; Luis & Mittenberg, 2002). In addition, secondary symptoms related to frustration, emotional response, and regulation may also occur (Chaput et al., 2009; Eisenberg et al., 2014). Ellis et al. (2015) found that 49% of adolescent concussion patients experience at least one emotional symptom and 11.5% of the participants in their study were diagnosed with a psychiatric disorder after a concussion. Moreover, elevated emotional symptoms in the early period after injury predicts prolonged recovery (Heyer et al., 2016). This highlights the need to further explore the emotional symptoms of concussion.

**Emotional symptoms and risk factors.** Head injury is a risk factor for developing an internalizing disorder (Ellis et al., 2016; Ellis et al., 2015; Luis & Mittenberg, 2002). Children and adolescents are at greater risk for developing anxiety after injury than adults (Max et al., 2011). Further, experiencing post-injury stress increases the risk for developing persistent internalizing symptoms during recovery (Luis & Mittenberg, 2002; Max et al., 2011). Even mild forms of head injury increase the risk of developing an internalizing disorder, such as anxiety or depression (Ellis et al., 2015; Luis & Mittenberg, 2002). In addition, the development of an anxiety disorder after
concussion is often associated with simultaneous symptoms of depression (Ellis et al., 2015; Max et al. 2011). One theory of the mechanism for emotional concerns after injury is that damage to the neurometabolic system in the superior frontal gyrus is implicated in difficulties with emotional regulation after injury (Max et al, 2011).

Once triggered, emotional symptoms tend to persist, even after physical symptoms have abated (Eisenberg et al., 2014; Luis & Mittenberg, 2002). Behavior symptoms, attention problems, and emotional concerns can persist months, or even several years, after a head injury, even when the injury is mild (Limond et al., 2009; Massagli et al., 2004). Persistent symptoms impact coping skills and lead to changes in behavior (Massagli et al., 2004). Children are at risk for developing psychiatric symptoms that can emerge months after the injury (Massagli et al., 2004). Prompt diagnosis and careful management are essential for supporting pediatric patients during recovery (Ellis et al., 2015; Luis & Mittenberg, 2002)

**Anxiety.** Individuals who demonstrate anxiety sensitivity tend to worry about symptoms and experience more distress from their injury (Wood, McCabe, & Dawkins, 2011). In addition, individuals with a predisposition to anxiety are more likely to have a worse recovery (Ponsford et al., 2012; Wood et al., 2011). For example, elevated levels of anxiety 1 week post injury are associated with the persistence of symptoms 3 months after injury (Ponsford et al., 2012). One explanation for this is that emotional distress may be connected to attitudes and attributions about the symptoms, which, in turn, may act as an exacerbating factor (Ponsford et al., 2012; Wood et al., 2011).

**Depression.** A similar process to anxiety development occurs for depression symptoms. Individuals who have some symptoms of depression prior to a concussion are
more likely to suffer from depression and anxiety symptoms after concussion (Yang, Peek-Asa, Covassin, & Torner, 2015). The exacerbated depression and anxiety symptoms have a negative impact on recovery and coping with the stress of injury (Massagli et al., 2004; Silver, McAllister, & Arciniegas, 2009; Yang et al., 2015). For example, depression after a mild head injury is related to more persistent and intense physical symptoms, such as headache and vision problems (Silver et al., 2009). Multidisciplinary treatment that includes symptom management, education about recovery from brain injury, and support is associated with better recovery (Silver et al., 2009).

**Risk Factors for Extended Recovery**

Most symptoms resolve within a month, but some children may suffer from symptoms for extended periods (Blume & Hawash, 2012; Crowe et al., 2016; Zemek et al., 2013). Prediction about which children will suffer from extended recovery versus typical recovery is not yet possible (Blume & Hawash, 2012; Zemek et al., 2013). Recovery is impacted by injury characteristics that interact with pre-existing factors present in the injured child or adolescent (Figure 1; Blume & Hawash, 2012; Zemek et al., 2013). As symptoms related to concussion can also be related to premorbid conditions, it can be difficult to tease out what is a direct result from the injury and what is a pre-existing concern (Blume & Hawash, 2012). For example, prior comorbid conditions such as attention deficit hyperactivity disorder, learning disabilities, and emotional concerns may be implicated in a more difficult and longer recovery period (Popoli et al., 2014). In addition, previous concussion is a significant risk factor for both subsequent concussion as well as slower recovery with worse outcomes (Brooks et al.,
2013; Corwin et al., 2014). The literature shows that history of previous head injury is a risk factor for increased somatic symptoms (Brooks et al., 2013).

Figure 1. Risk Factors for Prolonged Recovery from Concussion

**Age at time of injury.** Age at time of injury is also a risk factor for concussion, with children and adolescents at greater risk for injury than adults (Blume, 2015; Blume et al., 2012; Howell et al., 2014; Makdissi et al., 2013). When injured, adults recover faster from concussion than do adolescents and children (Blume, 2015; Makdissi et al., 2013; Purcell et al., 2016). Deficits with attention, working memory, and executive function can linger for several years after injury in children (Moore et al., 2016).

Adolescents with concussion have greater number and intensity of symptoms compared to younger children and adults (Field et al., 2003; Purcell et al., 2016). In addition, individuals who are injured during adolescence are at greater risk for suffering from headache and prolonged recovery from concussion (Blume, 2015; Blume et al.,
2012; Eisenberg et al., 2013; Eisenberg et al., 2014). Particularly, adolescent girls are at greatest risk for chronic headache after concussion, and the pain can last up to one year after the injury (Blume & Hawash, 2012; Blume et al., 2012). Theories concerning the increased risk for children and adolescents include the impact of the developing cervical musculature in injury recovery, factors related to brain development, and hormonal/biochemical differences between adults versus children and adolescents (Field et al., 2003; Makdissi et al., 2013).

Slower recovery and increased symptoms impact the child’s ability to function across settings. Recovery in adolescence often lasts longer than a month, unlike adults who usually recover within a week (Field et al., 2003; Makdissi et al., 2003; Purcell et al., 2016). Similarly, high school athletes recover neuropsychological function at a slower rate than do college athletes (Field et al., 2003; Makdissi et al., 2013, Purcell et al., 2016). Field et al. (2003) even found that memory function in college athletes returns to baseline in approximately a day, whereas high school athletes continue to have memory impairment 7 days after their injuries. Further, the protracted recovery is often more complex and impacts more domains of function for pediatric patients with concussion (Blume, 2015; Blume et al., 2012; Howell et al., 2014; Makdissi et al., 2013; Purcell et al., 2016). In addition, longer and more complex recovery periods impact the adolescent student’s ability to return to learning (Field et al., 2003; Purcell et al., 2016). For example, three quarters of students are able to return to school within a week, but 40% require accommodations, such as a modified schedule (Purcell et al., 2016).

Professionals who work with children and adolescents must consider age when reviewing the impact of concussion on the individual’s functioning.
Gender. Gender and sex also appear to play a role in symptom severity and duration, with females experiencing a higher risk for injury and longer recovery periods than males (Covassin & Elbin, 2011; Makdissi et al., 2013; Marar et al., 2012; Novak et al., 2016). In addition, girls are more likely to suffer a concussion than boys in gender-matched sports (Baker et al., 2016; Marar et al., 2012). The mechanism for concussion may be different, however, as males are injured more often through player contact, whereas females are more often injured by contact with the ball or playing surface (Castile et al., 2012; Dick, 2009). Furthermore, recovery may take twice as long for females as it does for males (Baker et al., 2016). This may result from greater intensity of symptoms rather than a different rate of recovery (Ono et al., 2016).

Further, the quality of the recovery experience appears to be different for males and females (Baker et al., 2016). Early after injury, being female is a risk factor for quantity and intensity of physical symptoms (Baker et al., 2016; Blume & Hawash, 2012; Joyce et al., 2015; Mahalik et al., 2013; Ono et al., 2016; Ponsford et al., 2012). For example, headache is more likely to linger in adolescent girls as compared to boys (Blume & Hawash, 2012; Blume et al., 2012). Adolescent girls are also two times more likely to suffer from migraine symptoms after concussion than adolescent males (Mihalik et al., 2013). The presence of migraine symptoms is indicative of increased risk of functional impairment and slower recovery (Mihalik et al., 2013).

In addition to increased physical symptoms, females with concussion also experience more symptoms in the cognitive and emotional domains than do males (Blume et al., 2012; Kontos et al., 2012). Female gender is associated with reduced health related QOL for children after concussion (Novak et al., 2016). For example,
gender differences during recovery from concussion are evident in memory, reaction time, and concentration, with females having more difficulty with these cognitive domains (Covassin & Elbin, 2011; Covassin et al., 2012; Dick, 2009). In addition, symptoms related to anxiety and sadness are also elevated in females with concussion as compared to males (Baker et al., 2016; Covassin & Elbin, 2011; Dick, 2009; Ono et al., 2016). Explanations for sex and gender differences continue to require exploration. Theories concerning the increased risk for females include biomechanical factors related to head and neck musculature differences between sexes, hormonal differences between the sexes, and cultural factors that may lead to male reluctance for reporting symptoms (Dick, 2009). Nevertheless, there is not yet consensus in the field on the mechanisms and recovery process related to gender.

Impact on School and Return to Learning

**Cognitive rest.** Cognitive rest is the most common form of initial treatment prescribed by physicians (Master et al., 2012). In the aftermath of a concussion, glucose in the brain is reduced during the initial recovery phase and it is important to conserve glucose to aid recovery (Master et al., 2012). Physicians prescribe cognitive rest in the initial recovery phase to reduce neurometabolic demand on the brain (Corwin et al., 2014). Reducing the cognitive demands on the brain allows the brain to heal (Corwin et al., 2014). As such, school attendance is often affected when a student attains a concussion (Corwin et al., 2014; DeMatteo et al., 2015; Sady et al., 2011).

Although the intuitive benefit of rest is clear, the most beneficial length of time for cognitive rest remains unclear (Corwin et al., 2014; DeMatteo et al., 2015; Sady et al., 2011). There continues to be a paucity of studies examining medical protocols related to
return to learn and return to play specifically (Burke et al., 2014). The timing and length of rest may be the crucial factors for maximal benefit (Corwin et al., 2014; Sady et al., 2011). Typically, the range of recommended rest varies from one or two days to several weeks, and the child is banned from screens (telephones, computers, televisions, etc.), physical activity, and cognitive exertion (Corwin et al., 2014; Popoli et al., 2014; Sady et al., 2011). As a result, students typically miss school (Popoli et al., 2014). On average, pediatric patients with persistent systems are absent twice as long as those patients who recover within the typical timeframe (Grubenhoff, Deakyne, Comstock, Kirkwood, & Bajaj, 2015).

**Planning for return to learn.** Many parents are concerned about their injured children’s education during recovery, but only 24% report that their children’s schools provide written plans for managing learning during concussion recovery (Sady et al., 2011). A study by Grubenhoff et al. (2015) found that of pediatric patients with persistent post-concussion symptoms, only 53% received any type of school accommodations. Further, patients who received follow-up care from their physicians were more likely to receive accommodations from their schools (Grubenhoff et al., 2015). Communication between the school and physician concerning recovery profile and needed accommodations would allow for more coordinated support for the student returning to school (Halstead et al., 2013; Master et al., 2012; Raikes & Smart, 2015). Further, an integrated and collaborative process between the child’s medical and school teams is essential for the student’s recovery (Kirkwood, Yeates, & Wilson, 2006; Raikes & Smart, 2015).
Once the initial symptoms begin to wane, the student gradually increases cognitive demands. Overall, the approach to recovery needs to be more conservative for children than for adults (Kirkwood et al., 2006). Often, a schedule of partial days is used to gradually increase time in school to a full day (Blume et al., 2011; Halstead et al., 2013). Similarly, return to play also follows a graduated process from rest to mild physical activity and eventual return to full practices and games (Blume et al., 2011; Kirkwood et al., 2006; Popoli et al., 2014). Nevertheless, the return to learn protocol should precede return to play, so that students only return to sports after they have been able to return to learning in school successfully (Kirkwood et al., 2006; Makdissi et al., 2013; Master et al., 2012).

Learning is the primary job of children, and academic tasks require significant neurometabolic load (Corwin et al., 2014; Master et al., 2012; Sady et al., 2011). As a result, the neurodevelopmental demands are greater than those of adults making recovery from concussion more complex for pediatric patients (Kirkwood et al., 2006). A systematic program of school accommodations is necessary to support recovery from concussion (Halstead et al., 2013; Master et al., 2012; Popoli et al., 2014).

**Managing symptoms in school.** During recovery, the pattern of symptoms should be used to guide the student’s learning (Kirkwood et al., 2006; Sady et al., 2011), as attempting to learn new skills while concussed can worsen physical symptoms (Halstead et al, 2013; Master et al., 2012). As a result, the students, their families, and school staff need to understand the concept of the subsymptom threshold, which is the goal of keeping cognitive activity just below the level that would trigger physical symptoms (DeMatteo et al., 2015; Master et al, 2012). The metabolic system of the brain
is unable to manage significant cognitive demands easily, especially in the early phases of recovery (Master et al., 2012).

In terms of symptoms management and recovery, a balance of cognitive demand and rest is important to aid recovery. This balance is maintained by pushing students to higher rates of cognitive demands while ensuring that they stay below the symptom threshold (Baker et al., 2014; Blume et al., 2011; DeMatteo et al., 2015; Halstead et al., 2013; Master et al., 2012; Sady et al., 2011). Students suffering from concussion require close monitoring to measure progress, minimize symptoms, and reduce stress from learning (Halstead et al, 2013; Popoli et al., 2014). Further, the pace and complexity of recovery profiles indicates that each child and adolescent requires an individualized approach (Makdissi et al., 2013; Sady et al., 2011). Some pediatric patients will be able to quickly increase school demands while others will require a slower controlled process (Master et al., 2012). Insight into how an individual with concussion perceives his or her recovery and symptom expression may help caregivers, school staff, and medical providers make decisions about the pace of increasing demands in school.

The process of minimizing cognitive load for children and adolescents recovering from concussion requires removal from activities and friends during the most acute symptom period (DeMatteo et al., 2015; Master et al., 2012). As a result, it is important to keep social isolation to a minimum, as this can increase anxiety and depression symptoms that interfere with recovery (DeMatteo et al., 2015). For example, controlled social activities, even in the earliest stages of recovery, can benefit the child by reducing a sense of isolation (DeMatteo et al., 2015; Master et al., 2012). Further, focusing on return to school without academic task demands, even prior to returning to learn, can
reduce social isolation and, thus, reduce negative emotional consequences (DeMatteo et al., 2015).

Identifying the pattern of symptoms and their impact on the individual’s functioning in school is essential for supporting recovery. The physical symptoms often have a profound impact on the child’s ability to learn and manage school demands (Blume et al., 2011; Sady et al., 2011). When physical symptoms are more intense and persistent, the child’s daily functioning is impacted negatively, and there is increased likelihood that a formal intervention plan will need to be enacted by the school (Halstead et al., 2013; Yeates et al., 2012). A school multidisciplinary team approach to management of school demands is ideal in supporting the complex nature of recovery in the school setting (Halstead et al., 2013). A balance must be struck between the necessity and benefit of attending school during recovery and the modifications to academic demands that are necessary to maximize recovery (Halstead et al., 2013; Kirkwood et al., 2006).

During recovery, the school team must monitor the student with head injury carefully to strike a balance between learning and symptom management. Most students will be symptomatic when they return to school after their concussion (Baker et al., 2014; Halstead et al., 2013; Karr et al., 2014). Further, the symptoms and recovery period will vary widely across students (Baker et al., 2014; Karr et al., 2014). As students progress through their individual recovery trajectories, the medical and school teams must expect to make adjustments to plans for returning to learning and increasing the academic and task demands, while simultaneously being mindful of the individual’s symptom threshold (Baker et al., 2014; Halstead et al., 2013). In addition, physical, cognitive, and emotional
symptoms emerge and change at different rates and vary across individuals (Karr et al., 2014; Sady et al., 2011). The variability of symptom expression across individuals and domains (Baker et al., 2014) makes school planning challenging.

**Health Related Quality of Life**

The impact of a head injury on wide ranging domains of function lead to a greater likelihood for QOL issues for the injured child (DiBattista et al., 2012). Although physical symptoms resolve within 30 days for 90% of children and adolescents with concussion, factors related to QOL, such as behavior, cognition, and emotions, may linger and affect up to 50% of individuals (Crowe et al., 2016). Nevertheless, even children who report full recovery from symptoms report lower QOL related to school functioning for 12 weeks after injury (Novak et al., 2016). Since concussion impacts many aspects of function for individuals, overall QOL can be reduced (Moran, 2011; Novak et al., 2016).

Health related QOL involves the interaction of multiple dimensions of function that include physical symptoms, physical functioning, emotional functioning, and social variables to form the overall picture of health (DiBattista et al., 2012; Fineblit et al., 2016; McLeod et al., 2015). The construct of health related QOL differs from QOL because there is a focus on health status as part of the evaluation of QOL (McLeod et al., 2015). For example, children with persistent symptoms after concussion report lower health related QOL across physical, emotional, social, and school domains (Novak et al., 2016).

A complicating factor when considering health related QOL issues is that QOL after concussion is not stable (DiBattista et al., 2012; Fineblit et al., 2016; Novak et al.,
Perceptions and concerns by parents and physicians may change as some symptoms linger and others abate (DiBattista et al., 2012). In addition, ratings of the domains that are measured as part of QOL often change depending on the stage and pace of recovery (DiBattista et al., 2012). For example, school functioning is the last domain to improve for children after concussion (Novak et al., 2016).

Further, Yeates et al. (2009) suggest that there are four different trajectories for recovery from concussion: no post-concussive symptoms, moderate persistent post-concussive symptoms, high acute/resolved post-concussive symptoms, and high acute/persistent post-concussive symptoms. The interaction between injury and non-injury factors leads to these different patterns of recovery and symptom profiles (Yeates et al., 2009); however, the pattern of factors that might predict the trajectory of an individual child with concussion is not yet known (Baker et al., 2014; Karr et al., 2014; Sady et al., 2011; Yeates et al., 2009). Further, the complexity of factors impacted by concussion suggest the need for a whole-person approach to evaluation and a multidisciplinary approach to treatment (McLeod et al., 2015; Yeates et al., 2009).

**Interaction of physical and psychosocial factors.** There is an interaction of the physical and psychosocial elements in recovery from any significant injury or illness. For example, chronic pain has a significant effect on both physical and psychosocial domains (Barakat, Patterson, Daniel, & Dampier, 2008; Blume, 2015; Mahalik et al., 2013; McNally et al., 2013). Persistent pain also impacts QOL across domains and interferes with recovery (Barakat et al., 2008; Blume, 2015; Mahalik et al., 2013; McNally et al., 2013). Although the focus is often on the physical (i.e., external) symptoms, it is essential to address the emotional (i.e., internal) symptoms and stress that
individuals with chronic illness face (Barakat et al., 2008; Fineblit et al., 2016; McLeod et al., 2015). The interaction between internal and external factors affects the pediatric patient’s functioning across settings (Barakat et al., 2008; McLeod et al., 2015).

Although it is evident that there are subjective health outcomes that result from lingering concussion symptoms, research capturing the subjective experience of pediatric concussion is limited (Fineblit et al., 2016; Moran et al., 2011). Many of the problems and deficits that linger are subtle and may not be obvious without careful investigation (Raikes & Smart, 2015). As a result, assessment of the pediatric patient with concussion needs to evaluate multiple modalities, such as vestibular function, cognition, and the patient’s perception of his or her QOL as related to the head injury (McLeod et al., 2015). Understanding the child or adolescent’s perspectives on his or her recovery is important for treatment planning (Fineblit et al., 2016; McLeod et al., 2015).

**Predicting recovery across domains.** Recovery issues related to QOL after concussion vary widely across pediatric patients (Pieper & Garvan, 2014; Yeates et al., 2012). For most children, broadly defined QOL does not appear to be impacted long term by concussion (Pieper & Garvan, 2014); however, when QOL is diminished over longer periods, such as several months after the concussion injury, careful evaluation and intervention is necessary (Pieper & Garvan, 2014; Yeates et al., 2012). At times, pediatric head injury such as concussion can have long lasting effects that impact domains related to QOL into adulthood (McLeod et al., 2015). Nevertheless, the field is only beginning to understand the underlying pathophysiology and effects of metabolic load during recovery, and there is relatively limited ability to make accurate predictions about any individual’s recovery process (Harmon et al., 2013).
The quality and severity of injury and immediate symptoms at the time of the concussion usually impact recovery and QOL during the recovery phase (Limond et al., 2009; Meehan et al., 2014; Moran et al., 2011). For example, the severity of reported physical symptoms at the time of the injury has a significant effect on prognosis and lingering impact across functional domains from the injury (Limond et al., 2009; Meehan et al., 2014). Additionally, those pediatric patients who require hospital treatment of any kind are more likely to experience maladaptive changes to behavior, executive function, and emotional coping (Limond et al., 2009).

Even without a hospital stay, more severe physical and cognitive symptom burden in the early period after injury predicts slow recovery and lower QOL (Meehan et al., 2014; Moran et al., 2011). Specifically, high ratings of symptoms immediately post-concussion predict lower psychosocial health related QOL (Moran et al., 2011; Yeates et al., 2012). Further, elevated somatic symptoms that linger several months post-injury can have an effect across many functional aspects of the child’s life (Limond et al., 2009; Moran et al., 2011). For example, some children continue to sustain lower QOL across domains at 3 to 12 months post-injury (Moran et al, 2011). Persistent physical symptoms are a risk factor for poor QOL in children with concussion (Joyce et al., 2015; Moran et al., 2011; Yeates et al., 2012). In addition, the presence of both somatic and cognitive symptoms in the early recovery period predict psychosocial QOL issues after injury. The pattern of symptoms and their progression predicts the functional impact (Yeates et al., 2009). Understanding the perspectives on recovery domains of the individual with concussion would likely contribute to better predictions of which children and adolescents are at risk for prolonged recovery.
Another risk factor for poor QOL post-injury is the presence of premorbid symptoms, or symptoms prior to the injury (Moran et al., 2011). Understanding the interaction of premorbid factors, life demands, injury characteristics, and domains impacted during recovery is essential for supporting recovery from concussion (McLeod et al., 2015; Moran et al., 2011; Novak et al., 2016). As a result, a shift in focus from physical symptoms to a whole patient perspective is important in managing recovery effectively (McLeod et al., 2015; Polster, Giza, & Babikian, 2016). There is an interaction between physical symptoms and psychosocial factors that must be addressed during recovery to best avoid longstanding negative impact on function (Barakat et al., 2008; Yeates et al., 2009).

**Post-Concussion Symptom Instruments**

The PCSS is one of the most commonly used instruments for pediatric concussion research. This measure, which is used frequently in pediatric clinical practice and research, was developed as part of the Pittsburgh Steelers concussion program (Lovell et al., 2006). The purpose of this measure is to capture the state of symptoms at the time of its completion (Kontos et al., 2012; Lovell et al., 2006). Because the person completing the scale focuses on his or her symptoms that day, it is important to consider the measure as a snapshot in time. The advantage of this type of measure is that the scale can be repeated at frequent intervals to track recovery (Kontos et al., 2012; Lovell et al., 2006).

The instrument has been validated using both neuropsychological measures and scans, such as functional magnetic resonance imaging (fMRI; Chen, Johnston, Collie, McCrory, & Ptito, 2007). Symptom level on the PCSS is related to accuracy and pace on neuropsychological measures (Chen et al., 2007; Kontos et al., 2012). For example,
moderately impaired individuals (22 or more points) demonstrate reduced signal in the
dorsolateral prefrontal cortex and atypical activation in the left temporal lobe when
engaged in verbal learning tasks (Chen et al., 2007).

Factor analyses of the PCSS have produced different factorial structures
depending on variables such as time since injury. Kontos et al. (2012) found four factors
when evaluating high school and college athletes at baseline and then within one week of
injury. These factors included a cognitive-fatigue-migraine, affective, somatic, and sleep
factors. A general concussion factor that consists of cognitive, migraine, and fatigue
variables was found to best represent the experience of injury in the first week after
injury (Kontos et al., 2012).

Despite the initial finding of four factors, Joyce et al. (2015) found that the PCSS
consisted of three factors: somatic symptoms, neurocognitive function, and emotional
symptoms. They argued that the previous study’s small sample size and predominantly
male participants may explain the different factor structures (Joyce et al., 2015). The
somatic and emotional factors can be summed to produce a continuous index in these
areas; however, they suggest that the neurocognitive factor is best interpreted as based
upon a symptom count rather than a continuous index. As such, Joyce et al. (2015)
suggested that a total score approach may not best capture the symptoms experienced by
pediatric concussion patients.

The PCSS has expanded to use with pediatric populations. This scale is reliable
when used with adolescent athletes to assess severity of concussion symptoms (Joyce et
al., 2015; Kontos et al., 2012; Lovell et al., 2006). In addition, this is an effective tool for
quantifying symptoms (Lovell et al., 2006); however, there are few guidelines on which symptoms are necessary for effective diagnosis or treatment (Zemek et al., 2013).

There are a number of instruments that have been designed to measure post-concussion symptoms, including measures such as the Graded Symptom Checklist, Rivermead Post-Concussion Symptoms Questionnaire, and the Acute Concussion Evaluation Tool. These self-report symptom assessment tools were developed originally for adult concussion patients (Makdissi et al., 2013). Although these tools can be used reliably with pediatric patients, there may be a need to develop tools that use language that is better understood by youths (McLeod et al., 2015). Assessment must proceed in a developmentally appropriate manner and the tools must be child friendly (Makdissi et al., 2013; McLeod et al., 2015). Further, measures used for children must account for normal development as a baseline to determine impact of injury (Makdissi et al., 2013).

In addition to self-report, parents have been used commonly as proxies for pediatric patients when evaluating QOL issues for their children; however, the level of agreement between the parent rating and child self-report rating is poor for domains related to emotional and social function (Varni, Limbers, & Burwinkle, 2007). Nevertheless, there is no standard or ideal method for data gathering concerning symptoms in pediatric populations (Zemek et al., 2013).

Finally, although the PCSS is used commonly in the field, there are numerous scales for concussion symptoms that evolved from clinical need rather than systematic scale development (Alla, Sullivan, Hale, & McCrory, 2009). Many of these instruments use the term “scale” even though the instrument has not emerged from a process of systematic validation (Alla et al., 2009). Although tools developed for clinical use
provide clinicians with potentially useful information, systematic validation provides essential information about the accuracy of the conclusions drawn from patient responses.

Quality of Life Surveys

QOL and pediatric patient perspectives about concussion recovery have received little attention in the literature (Makdissi et al., 2013; McLeod et al., 2015; Moran, 2011). QOL research has focused primarily on chronic illness such as cancer and diabetes. Children with chronic conditions demonstrate problems with function across life domains, including emotional, social, and school domains (Varni et al., 2007). Many of the measures have utilized parent proxies as described above; however, children are reliable reporters and their perspectives on their illnesses are important (Varni et al., 2007). Understanding the pediatric patient’s perspective is important for developing effective treatment plans (Moran et al., 2011; Varni et al., 2007).

One of the pediatric QOL measures used most commonly in the literature is the Pediatric Quality of Life Inventory (PedsQL). This instrument examines the physical, emotional, social, and school domains (Varni, Seid, & Kurtin, 2001). Generally, the PedsQL has shown good validity and reliability, but the school functioning domain has not demonstrated consistent validity and reliability across ages (Varni et al., 2001). This may be a result of the different demands that schools place on students at the various levels of education. Although reliable generally, the PedsQL does not address concerns that pediatric patients may have related to the specific impact of a concussion on QOL domains.
Preliminary Study

A preliminary study was completed to examine the perspectives of children and adolescents with concussion, as well as to determine whether their perspectives could inform the field in a meaningful way. Participants were 118 patients with concussion receiving treatment at a regional sports medicine concussion clinic. Of the entire sample, aged 10-18, 50.4% were between the ages of 15 and 17. There were 67 female and 51 male participants. The time since injury ranged from 1 week to 204 weeks, with 85.4% of participants falling within 12 weeks of injury. Participants were divided into three groups based on the length of time since injury. Individuals within four weeks of their injuries comprised 52.9% of the participants. Another 32.5% of participants were within 5 to 12 weeks of injury. The final group included participants who had sustained their concussions more than 12 weeks prior (14.2%).

The preliminary study showed that greater than half of the pediatric patients reported that the concussion had disrupted their lives to a fairly significant degree (Table 1). This is consistent with prior research suggesting that concussion is a disruptive experience for the majority of children and adolescents who sustain head injuries (Sady et al., 2011). Concerns about thinking and emotional symptoms are present for many children and adolescents with concussion (McLeod et al., 2015; Purcell et al., 2016; Raikes & Smart, 2015).
Table 1

*Preliminary Study: Percent of Participant Likert Responses by Recovery Profile Item*

<table>
<thead>
<tr>
<th>Profile Item</th>
<th>Not True</th>
<th>A Little True</th>
<th>Somewhat True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>The concussion has disrupted my life</td>
<td>15.0</td>
<td>26.7</td>
<td>24.2</td>
<td>34.2</td>
</tr>
<tr>
<td>I feel frustrated by my symptoms</td>
<td>25.8</td>
<td>32.5</td>
<td>16.7</td>
<td>25</td>
</tr>
<tr>
<td>I feel overwhelmed</td>
<td>46.7</td>
<td>17.5</td>
<td>18.3</td>
<td>17.5</td>
</tr>
<tr>
<td>I don’t hang out w/friends as much</td>
<td>59.2</td>
<td>13.3</td>
<td>14.2</td>
<td>13.3</td>
</tr>
<tr>
<td>I don’t like activities as much</td>
<td>72.5</td>
<td>14.2</td>
<td>8.3</td>
<td>5</td>
</tr>
<tr>
<td>Things are harder for me now</td>
<td>46.7</td>
<td>25</td>
<td>11.7</td>
<td>16.7</td>
</tr>
<tr>
<td>I worry that I might never get better</td>
<td>68.3</td>
<td>19.2</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>My symptoms impair me in school</td>
<td>35.0</td>
<td>27.5</td>
<td>19.2</td>
<td>18.3</td>
</tr>
<tr>
<td>My school is helpful in supporting me</td>
<td>8.4</td>
<td>22.7</td>
<td>29.4</td>
<td>39.5</td>
</tr>
<tr>
<td>My symptoms make it hard to think</td>
<td>36.1</td>
<td>34.5</td>
<td>16</td>
<td>13.4</td>
</tr>
<tr>
<td>My symptoms effect my mood</td>
<td>50.8</td>
<td>17.5</td>
<td>21.7</td>
<td>10</td>
</tr>
<tr>
<td>Symptoms effect interactions w/ friends</td>
<td>66.7</td>
<td>15.8</td>
<td>12.5</td>
<td>5</td>
</tr>
</tbody>
</table>

In the preliminary study, time since injury predicted overall perception of recovery. The longer the child’s recovery time, the greater impairment he or she perceived. Further, impairment was experienced across domains. Concerns were evident in the areas of mood, thinking, frustration with symptoms, and social relationships (Clair, Henigan, et al., 2016). Children and adolescents with longer recovery are more likely to experience diminished QOL during recovery (Pieper & Garvan, 2014; Yeates et al., 2012). Protracted recovery is often more complex and impacts more domains of function for pediatric patients with concussion than other concussion patients (Blume, 2015; Blume et al., 2012; Howell et al., 2014; Makdissi et al., 2013; Purcell et al., 2016).

Pediatric patients with symptoms lasting longer than 12 weeks experienced QOL issues across domains of function (Figure 2). Consistent with the literature, extended recovery impacted cognition, emotions, and the social lives of pediatric concussion
patients (Blume, 2015; Blume et al., 2012; Howell et al., 2014; Makdissi et al., 2013; Novak et al., 2016; Purcell et al., 2016). The correlation between QOL and support from school was not statistically significant, but there was trend for those pediatric patients with longer recoveries feeling less supported. When college students were added to the sample, this factor was significant (Clair, Tresco, et al., 2016).

Figure 2. Factors by Time Since Injury

Preliminary analyses concerning psychometric properties indicated that the instrument developed to examine pediatric patient perspectives demonstrated good reliability for the total scale and the constructed factors. Because of this finding, there was support for modifying the scale to further explore patient perceptions of their QOL during recovery from concussion.

Conclusions

Concussion is a serious health issue that impacts the lives of many children and adolescents (Khurana & Kaye, 2012; Marar et al., 2012; Trenchard et al., 2013). The injury triggers a neurometabolic cascade that results in an energy crisis in the brain.
(Kontos et al., 2013; Sady et al., 2011). In turn, the pathophysiology of the brain causes physical, somatic, cognitive, and emotional symptoms that emerge at different rates and can linger for long periods of time (Halstead et al., 2013; Kontos et al., 2013; Master et al., 2012; Sady et al., 2011). Specifically, symptoms such as headache, vertigo, fatigue, cognitive difficulties, and emotional concerns emerge for most children and adolescents with concussion, but the rates and intensity of the symptoms vary widely (Karr et al., 2014). At this time, there is limited understanding of the processes that occur in the brain during recovery, the connection to symptom expression, and why up to one third of children and adolescents with concussion experience prolonged recovery (Blume & Hawash, 2012; Zemek et al., 2013).

Several risk factors for prolonged recovery appear to include female gender, adolescent age, and worse injury; however, the mechanisms for risk and recovery remain unclear (Sady et al., 2011; Zemek et al., 2013). There is minimal research on how symptoms interact with risk factors and how the child or adolescent with concussion perceives recovery. Although there has been limited research, it seems clear that concussion has a negative impact on health related QOL for many children (DiBattista et al., 2012). Nevertheless, symptoms may be subtle; therefore, understanding the child or adolescent’s perspectives on his or her recovery is important for treatment planning (McLeod et al., 2015).

The literature shows that children are reliable reporters and their perspectives on their illnesses are important (Fineblit et al., 2016; Varni et al., 2007). Understanding the pediatric patient’s perspective is vital for developing effective treatment plans for concussion recovery (Fineblit et al., 2016; Moran et al., 2011; Varni et al., 2007).
Nevertheless, there is limited research about the perspectives of children and adolescents on their recovery and how symptoms impact their QOL (Fineblit et al., 2016; Moran et al., 2011; Novak et al., 2016). Measures examining concussion recovery were developed primarily for adult populations and measures addressing QOL issues tend to do so in the context of chronic illness.

Understanding the perspectives of the individual with concussion on his or her recovery is a key step to better predict which children and adolescents are at risk for prolonged recovery, as well as to develop treatment plans that address the needs of individual children and adolescents (Polster et al., 2016). Although there is much research on pediatric concussion, the voice of the child recovering from concussion is all but absent from the literature.

**Research Questions**

The current study expanded upon the literature and the preliminary study in order to gain better insight into the perspectives of children and adolescents recovering from concussion. The limited QOL research available suggests that pediatric patients can provide essential information about their recovery experiences and the impact on their QOL. The original instrument has been expanded and refined to explore perspectives across four domains: cognition, school, emotional experience, and social life/activities. It was hypothesized that the instrument would capture essential perspectives about the recovery experience. The literature identifies several risk factors for worse symptoms and lingering recovery. This study examined factors such as time since injury, gender, and age of individual to expand on the understanding of the interaction between these characteristics and the impact on the individual’s perception of his or her recovery.
Further, according to the literature, there is an interaction between symptom severity and recovery; however, there is little research that explores patient perceptions of QOL after concussion and the relationship to physical and somatic symptoms. As such, the present study included self-rating of physical symptoms in order to explore the relationship between physical symptoms and perceptions of recovery. The following research questions were investigated:

**Perceptions.** How do children and adolescents perceive their recovery across domains?

1a. Do children and adolescents with concussion perceive themselves as having impairments in cognition?
1b. Do children and adolescents with concussion perceive themselves as having emotional symptoms during recovery?
1c. Do children and adolescents with concussion perceive negative impact to social life as a result of concussion?
1d. Do children and adolescents with concussion perceive their school as supportive of recovery?

**Impact of Gender.** Are there gender differences in perceptions of recovery?

2a. Do males and females with concussion perceive their recovery differently across domains?
2b. Are there gender differences concerning the relationship between physical symptoms experienced during recovery and perceptions of recovery domains?

**Impact of age.** Are there differences regarding concussion experiences between children and adolescents?
3a. Are there differences between how children and adolescents perceive recovery as a whole and across domains?
3b. Do children and adolescents experience physical symptoms differently?
3c. Do younger children perceive school as more supportive of recovery?
3d. Are adolescents more concerned about the social impact during recovery than are younger children?

Impact of time since injury. Are there differences in perceptions of the concussion experience depending on length of time since injury?

4a. Does time since injury predict more difficult recovery as measured by the domains and total recovery profile score?
4b. Is there a relationship between time since injury and amount recovered?
4b. Is there a relationship between time since injury and perceptions of support from school?
4d. Is there a relationship between time since injury and perceptions concerning thinking, emotional concerns, social life, and social support?

Interaction of physical symptoms (PCSS) and perceptions. Is there a relationship between physical symptoms and perceptions of recovery?

5a. Does perception the level of perceived recovery (percent recovered) relate to the level of physical symptoms currently experienced by the individual with concussion?
5b. Is there a relationship between physical symptoms and recovery perception?
5c. Is there a relationship between physical symptoms and perceptions concerning thinking, emotional concerns, social life, and school support?
Chapter 3: Method

The current study explored pediatric patients’ perceptions of their recovery and QOL. This study proposed that there are significant QOL issues that impact children and adolescents during recovery, especially when symptoms linger past several weeks. It was hypothesized that these issues could be captured by patients rating their own functioning across domains.

Participants

Participants were pediatric patients receiving treatment for concussion at a regional concussion clinic. A total of 280 data sets were gathered in October and November 2016. The age of participants ranged from 7 to 21, with a mean age of 14.8 years. The majority of participants fell between ages 13 and 17 (75.3%), with lower percentages of younger children (age 7-12, 16.5%) and older adolescents (age 18-21, 8.2%). There were slightly more male (52.5%) than female participants (47.5%).

Time since injury ranged from 1 week to 250 weeks. The responses were divided into three groups based on time since injury. The early recovery groups responded within the first 4 weeks after injury (52.5%), the middle recovery group responded between 5 and 11 weeks after recovery (30.7%), and the prolonged recovery responded 12 weeks or longer after recovery (16.6%).

The majority of participants attended school for full days (71.8%). Students attending school for partial days accounted for 16.2% of participants. One student received in-home instruction and 10.8% had not returned to school after their injury.
Measures

**Pediatric Life After Concussion Evaluation Scale.** The Pediatric Life after Concussion Evaluation Scale (PLACES), a pencil and paper self-rating instrument, was developed to examine pediatric concussion patients’ self-perceptions of their recovery. The PLACES consists of 20 questions (Appendix B). The instrument takes less than 15 minutes to complete.

The instrument consists of two sections. Section A includes demographic questions regarding participant gender, age, number of weeks since the injury, and perception of recovery status. Recovery status was determined by asking participants to rate how recovered they believed they were by estimating percent recovered. There was no specific identifying information on the instrument. Section B includes the perception questions related to concussion. The scale uses a 4-point Likert rating from 0 (“Not at all”) to 3 (“Very true”).

The use of these questions was intended to tap the subjective experience of the pediatric population with concussion not captured by existing self-ratings. One section of questions related to the patients’ perceptions of their own functioning in school and the level of support that they felt from their school. A second set was related to the impact of concussion on social activities and peer relationships. A third set evaluated emotional experiences that include mood, frustration, feeling overwhelmed, and worry about recovery. A fourth set of questions examined the child’s perceptions of his or her thinking and attention.

**Post-Concussion Symptom Scale.** The PCSS lists 22 symptoms on which the participant rates himself or herself. Symptoms include physical, cognitive, and affective
domains. The PCSS uses a 7-point Likert scale ranging from “Not at All” to “Very True.” The directions ask the individual to rate his or her symptoms on the day of administration.

Procedure

The PLACES and the PCSS were completed by participants as part of the symptoms packet that all patients completed at their medical visits at a regional concussion clinic. When the participants checked in for their appointment, they were provided with a packet and instructed to complete it in the waiting room. The staff at the regional concussion clinic collected the measures from the participants. The deidentified responses were copied and provided to the research team.
Chapter 4: Results

Overview

In order to understand how pediatric patients view their recovery, the initial step included examination of the descriptive analysis of the responses to the items. Correlational analysis was then used to examine the relationship between demographics, QOL, and symptom domains. Analysis of variance (ANOVA) was computed to explore the relationships between variables related to symptom load, time since injury, age, gender, and QOL domains. Finally, regression analyses explored whether variables such as time since injury and recovery domain scores would predict perceptions of recovery experience. The goal of the study was to gain a better understanding of patient perspectives on their recovery from concussion. A secondary goal was to begin to explore whether there was a need for a QOL measure targeted specifically for pediatric concussion patients.

Perceptions of Recovery from Concussion Across Quality of Life Domains

To examine how children and adolescents with concussion perceive QOL and recovery, descriptive statistics were computed. Domain scores for the cognition, emotion, and social domains were calculated by summing the five questions in that domain. Higher ratings were indicative of greater impairment. A total school support score was obtained by summing the four questions related to supports provided by the students’ schools. Higher ratings on this score were indicative of feeling more supported in school. A total PLACES score was calculated by adding each of the five questions in the cognition, emotion, and social domains, plus the one symptom question in the school domain ($M = 17.6$, $SD = 12.32$). The total PCSS score was calculated by adding
responses to all 22 questions ($M = 20.15$, $SD = 22.385$). Higher ratings on this scale were indicative of greater symptoms.

Analysis of participant responses (Table 2) showed that 47.1% of participants reported that their concussions had disrupted their lives (Mostly True to Very True). Emotional symptoms were endorsed in areas such as frustration with symptoms (46% Mostly-Very True) and feeling overwhelmed (32.1% Mostly -Very True). In addition, children and adolescents recovering from concussion report cognitive concerns and general difficulties with thinking (35% Mostly-Very True) and paying attention (37.9% Mostly-Very True). Recovery from injury was also found to impact social concerns such as symptoms preventing participation in activities (74.2% Mostly-Very True) and social isolation from friends (28.4% Mostly-Very True). Regarding perceived support from school, 60.6% of participants responded Very True when asked if they believed that their schools were helpful. Generally, students found their teachers to be supportive of their recovery. When asked about their use of accommodations, 48.4% endorsed Very True, whereas 8.6% of participants did not use prescribed accommodations.
Table 2

Percent of Participant Responses to PLACES Items

<table>
<thead>
<tr>
<th>Questions</th>
<th>Not At All</th>
<th>Somewhat True</th>
<th>Mostly True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>My symptoms make it hard to think</td>
<td>33.9</td>
<td>31.1</td>
<td>20.7</td>
<td>14.3</td>
</tr>
<tr>
<td>Hard to pay attention</td>
<td>33.6</td>
<td>28.6</td>
<td>21.1</td>
<td>16.8</td>
</tr>
<tr>
<td>Trouble learning new information</td>
<td>47.1</td>
<td>29.5</td>
<td>14.7</td>
<td>8.6</td>
</tr>
<tr>
<td>Hard to remember info already learned</td>
<td>57.0</td>
<td>20.4</td>
<td>13.6</td>
<td>9.0</td>
</tr>
<tr>
<td>My symptoms impair me in school</td>
<td>40.5</td>
<td>27.9</td>
<td>17.1</td>
<td>14.5</td>
</tr>
<tr>
<td>My teacher(s) are understanding</td>
<td>5.1</td>
<td>14.1</td>
<td>27.0</td>
<td>53.9</td>
</tr>
<tr>
<td>My school has been helpful</td>
<td>5.5</td>
<td>14.1</td>
<td>21.7</td>
<td>60.6</td>
</tr>
<tr>
<td>My school follows recommendations</td>
<td>6.0</td>
<td>13.1</td>
<td>25.9</td>
<td>55.0</td>
</tr>
<tr>
<td>I use accommodations prescribed</td>
<td>8.6</td>
<td>15.6</td>
<td>27.5</td>
<td>48.4</td>
</tr>
<tr>
<td>School demands make recovery longer</td>
<td>42.1</td>
<td>25.5</td>
<td>20.6</td>
<td>11.7</td>
</tr>
<tr>
<td>Symptoms keep me from friends</td>
<td>46.2</td>
<td>25.5</td>
<td>14.9</td>
<td>13.5</td>
</tr>
<tr>
<td>Symptoms prevent participation</td>
<td>17.8</td>
<td>8.0</td>
<td>14.1</td>
<td>60.1</td>
</tr>
<tr>
<td>I feel left out because of symptoms</td>
<td>51.4</td>
<td>26.4</td>
<td>9.4</td>
<td>12.7</td>
</tr>
<tr>
<td>I feel less social than before injury</td>
<td>56.7</td>
<td>19.6</td>
<td>11.6</td>
<td>12.0</td>
</tr>
<tr>
<td>Symptoms effect how I interact</td>
<td>62.6</td>
<td>22.7</td>
<td>7.0</td>
<td>7.7</td>
</tr>
<tr>
<td>The concussion has disrupted my life</td>
<td>26.6</td>
<td>26.3</td>
<td>20.1</td>
<td>27.0</td>
</tr>
<tr>
<td>I feel frustrated by symptoms</td>
<td>29.7</td>
<td>24.3</td>
<td>20.3</td>
<td>25.7</td>
</tr>
<tr>
<td>The symptoms effect how I feel</td>
<td>48.7</td>
<td>21.8</td>
<td>13.1</td>
<td>16.4</td>
</tr>
<tr>
<td>I feel overwhelmed</td>
<td>44.4</td>
<td>23.5</td>
<td>14.8</td>
<td>17.3</td>
</tr>
<tr>
<td>I worry more than I did before the injury</td>
<td>51.3</td>
<td>22.4</td>
<td>11.6</td>
<td>14.8</td>
</tr>
</tbody>
</table>

Correlations were calculated to examine relationships between perceptions of QOL, post-concussive symptoms, age, and time since injury (Table 3). There was a strong positive relationship \((r = .732, p < .01)\) between total QOL symptom load (PLACES total) and total post-concussion symptoms (PCSS total). Elevated post-concussion symptom load on the PCSS was correlated with worse QOL (total PLACES). Further,
total post-concussion symptoms, as measured by the PCSS, was correlated strongly with the QOL domains related to cognition ($r = .733, p < .01$), emotion ($r = .629, p < .01$), and social experience ($r = .553, p < .01$). There was no significant relationship between perception of school support and post-concussion symptoms ($r = -.04, p < .54$).

Total PLACES had a strong negative correlation with perception of percent recovered ($r = -.552, p < .01$). Similarly, there was a strong negative correlation between rating of percent recovered and total symptoms on the PCSS ($r = -.597, p < .01$). A lower symptom load was correlated with a greater sense of recovery. A strong negative correlation was found between perception of percent recovered and cognition ($r = -.547, p < .01$). Moderate negative correlations were found between percent recovered and emotion ($r = -.404, p < .01$) and social ($r = -.439, p < .01$) domains. The more recovered the individual felt, the lower the symptom scores related to cognition, emotion, and social QOL.

Strong significant positive correlations were found between cognition, and emotion ($r = .714, p < .01$), and between cognition and the social domain ($r = .561, p < .01$). Perception of school support had insignificant correlations with both cognition and emotion. There was a small significant positive correlation between perception of school support and perception of social impairment ($r = .161, p < .05$).
Table 3  
**Correlations Among Quality of Life Symptoms, PCSS, and Injury Demographics**

<table>
<thead>
<tr>
<th></th>
<th>Cognition</th>
<th>Social</th>
<th>Emotion</th>
<th>School</th>
<th>PLACES Total</th>
<th>PCSS Total</th>
<th>% Recovered</th>
<th>Weeks since injury</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognition</td>
<td>1</td>
<td>.561**</td>
<td>.714**</td>
<td>.002</td>
<td>.870**</td>
<td>.733**</td>
<td>-.547**</td>
<td>.223**</td>
<td>.076</td>
</tr>
<tr>
<td>Social</td>
<td>1</td>
<td>.685**</td>
<td>.161*</td>
<td>.029</td>
<td>.837**</td>
<td>.553**</td>
<td>-.439**</td>
<td>.114</td>
<td>-.008</td>
</tr>
<tr>
<td>Emotion</td>
<td>1</td>
<td>.029</td>
<td>.913**</td>
<td>.066</td>
<td>-.040</td>
<td>-.017</td>
<td>.026</td>
<td>.009</td>
<td></td>
</tr>
<tr>
<td>School</td>
<td>1</td>
<td>.870**</td>
<td>.629**</td>
<td>-.040</td>
<td>.118</td>
<td>.057</td>
<td>.189**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>PLACES Total</td>
<td>1</td>
<td>.732**</td>
<td>-.552**</td>
<td>.231**</td>
<td>.060</td>
<td>.069</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCSS Total</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% recovered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weeks since injury</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Age and Recovery**

Analyses were completed to examine whether the experience of concussion was different across the lifespan from childhood to late adolescence. A small positive correlation was found between age and weeks since injury ($r = .189$, $p < .01$). There was also a small positive correlation between age and emotion on the PLACES ($r = .148$, $p < .05$). All other correlations for age were insignificant.

To further explore the age variable, the sample was then divided by age into three groups: group 1 consisted of participants aged 7-12 years (16.5% of sample), group 2 was aged 13-17 (75.3%), and group 3 was aged 18-21 (8.2%). Analyses examined age differences for total PLACES and PCSS scores, the four domains of the PLACES, and
the percent recovered rating. A one-way ANOVA was calculated to determine whether recovery from concussion was different depending on age (Table 4).

Analyses explored whether children and adolescents experienced their recoveries differently. The total PLACES score was lowest for adolescents ($M = 16.44, SD = 11.65$) in comparison to the youngest group ($M = 19.19, SD = 14.27$) and the older adolescent group ($M = 20.33, SD = 14.43$), but the differences between the age groups was insignificant, $F(2, 242) = 1.505, p = .224$. A reverse pattern was evident for total PCSS symptoms, with the score increasing from the youngest group ($M = 18.29, SD = 23.48$) to the adolescent group ($M = 20.69, SD = 22.73$), and then falling for the oldest group ($M = 18.3, SD = 17.79$); the differences between the age groups was insignificant, $F(2, 261) = 0.280, p = .756$. Taken together, these results show no significant differences between the age groups for either total concussion symptoms or total QOL rating.

The ANOVA also showed no significant differences between the age groups for cognition, emotion, social, school, or percent recovered. Perception of school support was not significantly different for younger individuals. Similarly, adolescents did not express more concerns about their social experiences during recovery than participants in other age groups.
**Table 4**

*ANOVA of Differences Between Age Groups and Recovery Domains*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Sum Squares</th>
<th>df</th>
<th>Mean Sq</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLACES Total</td>
<td>456.51</td>
<td>2</td>
<td>228.26</td>
<td>1.505</td>
<td>.224</td>
</tr>
<tr>
<td>PCSS Total</td>
<td>282.49</td>
<td>2</td>
<td>141.25</td>
<td>0.28</td>
<td>.756</td>
</tr>
<tr>
<td>Cognition</td>
<td>2.99</td>
<td>2</td>
<td>1.49</td>
<td>0.07</td>
<td>.933</td>
</tr>
<tr>
<td>Emotion</td>
<td>38.15</td>
<td>2</td>
<td>19.08</td>
<td>2.30</td>
<td>.102</td>
</tr>
<tr>
<td>Social</td>
<td>79.05</td>
<td>2</td>
<td>39.53</td>
<td>2.30</td>
<td>.102</td>
</tr>
<tr>
<td>School Support</td>
<td>8.14</td>
<td>2</td>
<td>4.07</td>
<td>0.41</td>
<td>.668</td>
</tr>
<tr>
<td>Percent Recovered</td>
<td>105.48</td>
<td>2</td>
<td>527.24</td>
<td>0.79</td>
<td>.456</td>
</tr>
</tbody>
</table>

**Gender and Recovery**

The study also sought to examine whether males and females experience recovery differently. Analyses were run to examine gender differences for total PLACES and PCSS scores, the four domains of the PLACES, and the percent recovered rating. A one-way ANOVA was conducted to determine whether recovery from concussion was different depending on gender (Table 5). The total PLACES score was higher for females ($M = 18.94$, $SD = 11.64$) than for males ($M = 15.42$, $SD = 12.79$), and this difference was statistically significant, $F(1, 241) = 4.98$, $p = .027$, indicating worse QOL symptoms for girls when compared to boys. Similarly, females ($M = 24.27$, $SD = 23.96$) reported significantly more symptoms on the PCSS than did males ($M = 16.25$, $SD = 20.33$), $F(1, 261) = 8.62$, $p = .004$. In addition, on both symptom and QOL measures, girls reported higher total symptoms than males. When rating their level of recovery, males ($M = 77.68$, $SD = 25.91$) reported having a higher level of recovery than did females ($M = 71.29$, $SD = 25.69$), $F(1, 247) = 3.83$, $p = .05$. Overall, girls reported more symptoms and a lower percent recovered than boys.
ANOVAs were completed for each of the domains for the PLACES to further examine possible gender differences. Girls ($M = 6.02, SD = 4.46$) reported significantly more cognitive symptoms than boys ($M = 3.99, SD = 4.54$), $F(1, 265) = 13.65, p = .000$. Similarly, girls ($M = 6.39, SD = 4.61$) reported significantly more emotional symptoms than boys ($M = 5.20, SD = 4.80$), $F(1, 269) = 4.34, p = .038$. Finally, females reported more cognitive and emotional symptoms than males. There was no significant difference between males and females for either the social or school domains.

Table 5

*ANOVA of Differences Between Males and Females for Recovery Domains*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Sum Squares</th>
<th>df</th>
<th>Mean Sq</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLACES Total</td>
<td>747.17</td>
<td>1</td>
<td>747.17</td>
<td>4.98</td>
<td>.027</td>
</tr>
<tr>
<td>PCSS Total</td>
<td>4217.03</td>
<td>1</td>
<td>4217.03</td>
<td>8.61</td>
<td>.004</td>
</tr>
<tr>
<td>Cognition</td>
<td>276.56</td>
<td>1</td>
<td>276.56</td>
<td>13.65</td>
<td>.000</td>
</tr>
<tr>
<td>Emotion</td>
<td>96.38</td>
<td>1</td>
<td>96.38</td>
<td>4.34</td>
<td>.038</td>
</tr>
<tr>
<td>Social</td>
<td>3.94</td>
<td>1</td>
<td>3.94</td>
<td>0.26</td>
<td>.635</td>
</tr>
<tr>
<td>School Support</td>
<td>8.89</td>
<td>1</td>
<td>8.89</td>
<td>0.91</td>
<td>.342</td>
</tr>
<tr>
<td>Percent Recovered</td>
<td>2530.83</td>
<td>1</td>
<td>2530.83</td>
<td>3.83</td>
<td>.051</td>
</tr>
</tbody>
</table>
Time Since Injury and Recovery

Analyses were completed to examine the relationship between time since injury and recovery domains. There was a small positive correlation between weeks since injury and the total score on the PLACES \( (r = .231, p < .01) \), suggesting that longer recovery times were related to more negative QOL outcomes. Higher ratings in the cognitive symptoms domain had a small positive correlation with time since injury \( (r = .223, p < .01) \), as did higher ratings on the emotion symptoms domain \( (r = .186, p < .01) \). Correlations between the social domain, school domain, percent recovered rating, and post-concussion symptoms were all insignificant.

Participants were grouped by length of time since injury into three groups based on literature concerning recovery patterns (Crowe et al., 2016; Novak et al., 2016). The early recovery groups responded within the first 4 weeks after injury (62%), the middle recovery group responded between 5 and 11 weeks after injury (21.4%), and the prolonged recovery group responded 12 weeks or longer after injury (16.6%). A one-way ANOVA was conducted to determine whether recovery from concussion was different depending on the number of weeks since injury (Table 6).
Table 6

**ANOVA of Differences Between Time Since Injury Groups for Recovery Domains**

<table>
<thead>
<tr>
<th>Domain</th>
<th>Sum Squares</th>
<th>df</th>
<th>Mean Sq</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLACES Total</td>
<td>2402.04</td>
<td>2</td>
<td>1201.02</td>
<td>8.62</td>
<td>.000</td>
</tr>
<tr>
<td>PCSS Total</td>
<td>4445.07</td>
<td>2</td>
<td>2222.53</td>
<td>4.47</td>
<td>.012</td>
</tr>
<tr>
<td>Cognition</td>
<td>335.89</td>
<td>2</td>
<td>167.95</td>
<td>8.62</td>
<td>.000</td>
</tr>
<tr>
<td>Emotion</td>
<td>264.86</td>
<td>2</td>
<td>132.43</td>
<td>6.23</td>
<td>.002</td>
</tr>
<tr>
<td>Social</td>
<td>139.32</td>
<td>2</td>
<td>69.66</td>
<td>4.15</td>
<td>.017</td>
</tr>
<tr>
<td>School Support</td>
<td>24.94</td>
<td>2</td>
<td>12.47</td>
<td>1.34</td>
<td>.265</td>
</tr>
<tr>
<td>Percent Recovered</td>
<td>10660.65</td>
<td>2</td>
<td>5330.33</td>
<td>9.05</td>
<td>.000</td>
</tr>
</tbody>
</table>

An ANOVA showed that total PLACES scores dropped from the early recovery group \( (M = 17.42, SD = 11.62) \), to middle recovery \( (M = 13.04, SD = 11.31) \), and rose again for the prolonged group \( (M = 22.5, SD = 13.15) \). There was a significant effect of time since injury on total PLACES, \( F(2,222) = 8.62, p < .01 \). Bonferroni post hoc analysis (Figure 3) showed a significant difference between early and middle recovery groups (Mean difference = 4.38, \( p = .041 \)), and between middle and prolonged recovery groups (Mean difference = -9.46, \( p < .01 \)).
A similar statistically significant pattern was evident for an ANOVA calculated to examine effect of time since injury on total PCSS scores; with symptoms elevated initially for the early recovery group ($M = 22.99, SD = 23.62$), dropping in the middle recovery group ($M = 13.9, SD = 19.81$), and rising for the prolonged recovery group ($M = 23.21, SD = 22.53$), $F(2,241) = 4.476, p = .012$. Bonferroni post hoc analysis (Figure 4) showed a significant difference between early and middle recovery groups (Mean difference $= 9.09, p = .015$), but not between any other groups.
A one-way ANOVA was calculated to examine effect of time since injury on cognition. Results showed a significant effect for cognition, $F(2,244) = 8.622, p < .01$. Bonferroni post hoc analysis (Figure 5) showed a significant difference between early and middle recovery groups (Mean difference = 1.97, $p = .006$), and between middle and prolonged groups (Mean difference = -3.25, $p < .01$). Individuals in the middle recovery period indicated the least difficulty with their cognition, in contrast to participants in the earliest and prolonged recovery groups. Chronbach’s alpha was computed, and cognition demonstrated good reliability ($\alpha = .930$).
A one-way ANOVA demonstrated statistically significant differences between the time since injury groups for emotion, $F(2,248) = 6.23, p = .002$. Bonferroni post hoc analysis (Figure 6) revealed that the difference between groups was significant between the early and prolonged recovery groups (Mean difference = 2.27, $p = .018$), as well as middle and prolong groups (Mean difference = 3.09, $p = .002$). Pediatric patients with prolonged recovery experienced significantly more emotion symptoms than children and adolescents in the earlier periods of recovery. Chronbach’s alpha for Emotion demonstrated good reliability ($\alpha = .892$).
A one-way ANOVA demonstrated statistically significant differences between the time since injury groups on the social domain. Results showed a significant effect for social concerns, $F(2,248) = 4.149, p = .017$. Bonferroni post hoc analysis (Figure 7) was significant for a difference between early and middle recovery groups (Mean difference = 1.63). Children and adolescents who were within the early recovery period expressed significant concern about their social interactions. Although those in prolonged recovery also expressed concerns about social interactions, the difference was not statistically significant. Chronbach’s alpha for Social demonstrated good reliability ($\alpha = .855$).
A one-way ANOVA demonstrated statistically significant differences between the time since injury groups on ratings of percent recovered, $F(2,232) = 9.045, p < .01$. Bonferroni post hoc analysis (Figure 8) was significant for a difference between early and middle recovery groups (Mean difference = 15.02). Individuals between 5 and 11 weeks reported that they were more recovered than either early or prolonged groups.

A one-way ANOVA was calculated to examine effect of time since injury on perceptions of school support. Results showed a statistically insignificant effect for school support, $F(2,222) = 1.337, p = .265$. 
Symptoms on PCSS and Recovery

Correlations were calculated to examine the relationships between post-concussion symptoms on the PCSS and QOL domains. Total post-concussion symptoms, as measured with the PCSS, correlated strongly with the QOL domains related to cognition ($r = .733, p < .01$), emotion ($r = .629, p < .01$), and social experience ($r = .553, p < .01$). Total symptoms on the PCSS were also correlated negatively with self-ratings of percent recovered ($r = -.597, p < .01$). Higher total symptom load was correlated with perception of less recovered status.

A multiple regression was computed to predict total symptoms on the PCSS from the total PLACES score, time since injury, ratings of percent recovered, and gender. The results of the regression (Table 7) indicated that total PLACES score explained 54.9% of
the variance ($R^2 = .549, F(1,196) = 238.43, p < .01$) in PCSS total symptoms. Perception of percent recovered added 4.7% to the variance, whereas time since injury (.6%) and gender (.8%) added little to the total model that explained 60.2% of variance. Findings suggest a relationship between symptoms and perceptions of QOL.

Table 7

Summary of Multiple Regression for PCSS

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE$\beta$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>15.21</td>
<td>5.88</td>
<td></td>
</tr>
<tr>
<td>Total PLACES Score</td>
<td>1.06</td>
<td>0.098</td>
<td>.59**</td>
</tr>
<tr>
<td>Time Since Injury</td>
<td>-1.19</td>
<td>1.37</td>
<td>-.02</td>
</tr>
<tr>
<td>% Recovered</td>
<td>-.24</td>
<td>0.05</td>
<td>-.25**</td>
</tr>
<tr>
<td>Gender</td>
<td>4.11</td>
<td>2.03</td>
<td>.09*</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01
Predictors of Quality of Life Domains

Multiple regression analyses were completed to explore the QOL domains and predictors in order to better understand the multifaceted recovery process from concussion. A multiple regression was computed to predict total cognition symptoms from weeks since injury, total PLACES score, and total symptoms from PCSS. The results of the regression (Table 8) indicated that total PCSS score explained 51.8% of the variance ($R^2 = .518, F(2,211) = 144.89, p < .01$). Total PLACES scores added 20% to the variance to the total model, which explained 77.6% of the variance. Post-concussion symptoms explained the most variance for difficulties with cognition, whereas QOL issues added a significant amount to the model.

Table 8

Summary of Multiple Regression for Cognition Domain

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B$</th>
<th>$SE_\beta$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-4.16</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Time Since Injury</td>
<td>0.01</td>
<td>0.01</td>
<td>.05</td>
</tr>
<tr>
<td>Total PCSS</td>
<td>0.05</td>
<td>0.01</td>
<td>.25**</td>
</tr>
<tr>
<td>Total PLACES</td>
<td>0.25</td>
<td>0.02</td>
<td>.67**</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01
A multiple regression was calculated to predict total emotion symptoms from weeks since injury, total PLACES score, and total symptoms from PCSS. The results of the regression (Table 9) indicated that time since injury explained 3.8% of the variance. Total PCSS score added 36% of the variance. The total PLACES score added the most variance (42.8%) to the total model, which explained 83% of the variance ($R^2 = .83$, $F(3,210) = 342.76, p < .01$). Perception of QOL combined with total post-concussion symptoms was most predictive of emotion concerns after concussion.

Table 9

Summary of Multiple Regression for Emotion Domain

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B$</th>
<th>$SE_{\beta}$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.35</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Time Since Injury</td>
<td>-0.003</td>
<td>0.01</td>
<td>.05</td>
</tr>
<tr>
<td>Total PCSS</td>
<td>0.18</td>
<td>0.01</td>
<td>-.09**</td>
</tr>
<tr>
<td>Total PLACES</td>
<td>0.38</td>
<td>0.02</td>
<td>.98**</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01

A multiple regression was computed to predict total social symptoms from weeks since injury, total PLACES score, and total symptoms from the PCSS. The results of the regression (Table 10) indicated that time since injury explained 2.2% of the variance. The total PCSS score added 25.7% to the variance. Total PLACES score added the most variance (45.6%) to the total model, which explained 74% of the variance ($R^2 = .74$, $F(3,210) = 342.76, p < .01$).
Perception of QOL combined with total post-concussion symptoms was found to be most predictive of social concerns after concussion.

Table 10

Summary of Multiple Regression for Social Domain

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE(\beta)</th>
<th>(\beta)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.47</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Time Since Injury</td>
<td>-0.01</td>
<td>0.01</td>
<td>-0.05</td>
</tr>
<tr>
<td>Total PCSS</td>
<td>-0.04</td>
<td>0.01</td>
<td>-0.20**</td>
</tr>
<tr>
<td>Total PLACES</td>
<td>0.33</td>
<td>0.02</td>
<td>1.01**</td>
</tr>
</tbody>
</table>

\(*p<.05, \; **p<.01\)
Chapter 5: Discussion

Summary of Findings

This study sought to explore the perceptions of pediatric patients with concussion concerning their recovery experiences. Results showed that the perspectives of children and adolescents recovering from concussion can be measured and can provide insight into their experiences. Perceptions of recovery are related to symptom load across both measures, in that individuals rating themselves as less recovered correlated to more physical symptoms and worse QOL ratings. Broadly, concussion is a disruptive experience for many children and adolescents that can impact QOL. Further, there is an interplay between individual demographics, physical and somatic symptoms, and QOL variables.

The first research question sought to examine how children perceive their recovery across the QOL domains. The findings in this study are consistent with previous research concerning symptoms that pediatric patients experience after concussion. This study showed that children and adolescents perceive difficulties across QOL domains. In addition, this study found that elevated post-concussion symptom load was correlated with worse QOL, which is consistent with previous research (Meehan et al., 2014; Moran et al., 2011).

*Do children and adolescents with concussion perceive themselves as having impairments in cognition?* Approximately half of the participants perceived some difficulty with cognition. Specifically, more than one third of children and adolescents reported difficulties (Mostly-Very True) with thinking and attention. Previous research showed that difficulties with concentration, memory, and sustaining focus are common in
children with concussion (Blume et al., 2011; Grubenhoff et al., 2014; Scherwath et al., 2011). Similarly, more than half of the respondents in this study reported at least some impairment of thinking or learning. As a result, it appears that children and adolescents with concussion are aware of their cognitive deficits during recovery and many report significant impairment.

_Do children and adolescents with concussion perceive themselves as having emotional symptoms during recovery?_ Emotional symptoms are common during recovery from concussion (Chaput et al., 2009; Eisenberg et al., 2014; Luis & Mittenberg, 2002). Almost half of respondents in this study reported feeling frustrated by symptoms and 32% reported feeling overwhelmed, which is consistent with Ellis et al. (2015) who found that 49% of their sample endorsed at least one emotional symptom. In addition, 48.7% of respondents reported at least some increase in their level of worrying compared to prior to the injury. Evaluating pediatric patients’ perspectives on their emotional responses is important, as a concussion is a risk factor for developing an internalizing disorder (Ellis et al., 2015; Luis & Mittenberg, 2002). Once triggered, the emotional symptoms tend to persist, even after physical symptoms have abated (Eisenberg et al., 2014; Luis & Mittenberg, 2002). Children and adolescents are aware of changes in their emotional functioning after concussion and many report symptoms associated with anxiety.

_Do children and adolescents with concussion perceive negative impact to social life as a result of concussion?_ Social isolation may be a common experience during recovery from concussion (DeMatteo et al., 2015; Master et al., 2012). This study supported that theory, in that 74% of individuals were unable to participate in activities
because of concussion symptoms. Further, 28% reported feeling socially isolated from friends and 22% felt left out because of symptoms interfering with social interaction.

Understanding children’s and adolescents’ perspectives concerning impact of concussion on social function is important because feelings of social isolation may interfere with recovery (DeMatteo et al., 2015; Master et al., 2012). Isolation from peers is a common byproduct of recovery from concussion that should be monitored and addressed.

*Do children and adolescents with concussion perceive their school as supportive of recovery?* Learning is the primary job of children, and academic tasks require significant neurometabolic load (Corwin et al., 2014; Master et al., 2012; Sady et al., 2011). As such, school support is an essential component to recovery from concussion. Regarding perceived support from school, 60.6% of participants in this study responded Very True to a question about helpfulness of their school during recovery. Generally, students found their teachers to be supportive of their recovery. When asked about their use of accommodations, 48.4% endorsed Very True, whereas 8.6% of participants did not use prescribed accommodations at all. In sum, the majority of children and adolescents perceive their school as supportive of their recovery. The findings suggest that schools have improved response to concussion and are supportive of students who have suffered head injury.

The second research question examined whether there were gender differences concerning perspectives of recovery from concussion. Research suggests that females may be at higher risk for injury and for longer recovery periods than males (Covassin & Elbin, 2011; Makdissi et al., 2013; Marar et al., 2012; Novak et al., 2016). Further, the
quality of the recovery experience of concussion may be different for males and females (Baker et al., 2016).

_Do males and females with concussion perceive their recovery differently across domains?_ Females reported significantly worse QOL than boys as measured by the PLACES total symptom score. Further, the girls reported significantly more cognitive and emotional symptoms than did the boys. Research has shown that females with concussion experience more physical symptoms, as well as symptoms in the cognitive and emotional domains, than males (Blume et al., 2012; Kontos et al., 2012). Further, the female gender is associated with reduced health related QOL for children after concussion (Novak et al., 2016).

_Are there gender differences concerning the physical symptom experienced during recovery and how these relate to perceptions of recovery?_ Female participants endorsed higher total PCSS scores than male participants, indicating higher symptom load. Additionally, girls reported significantly lower rating of percent recovered than boys. Further, the strong correlation between total post-concussion symptom load (PCSS) and total QOL score (PLACES) indicates that post-concussion symptoms are tied closely to QOL. Girls reported higher symptom load and worse QOL, and rated themselves as less recovered boys. This supports previous research that reported that girls are more likely than boys to experience greater number and intensity of physical symptoms (Baker et al., 2016; Blume & Hawash, 2012; Joyce et al., 2015; Mahalik et al, 2013; Ono et al., 2016; Ponsford et al., 2012).

The third research question examined age at time of injury, because previous research has suggested that adolescents with concussion have greater number and
intensity of symptoms compared to younger children and adults (Field et al., 2003; Purcell et al., 2016).

*Are there differences between how children and adolescents perceive recovery as a whole and across domains?* Other than one weak correlation between age and the emotion domain, there were no significant differences between the age groups for cognition, emotion, social, or school domains. Similarly, there was no significant difference between age groups on the total PLACES score.

*Do children and adolescents experience physical symptoms differently?* Although total symptoms were higher for the adolescent group than other groups, there was no statistically significant difference. Similarly, ratings of percent recovered did not differ across the groups.

*Do younger children perceive school as more supportive of recovery?* Perception of school support was not found to be significantly different for younger students.

*Are adolescents more concerned about the social impact during recovery?* Adolescents did not express significantly more concern about social function than the older or younger participants. Taken together, there are no significant differences between children and adolescents concerning their perspectives about recovery or symptom ratings.

The fourth research question examined the variable of time since injury and perceptions of recovery. Although adults typically recover from a concussion in 1 week, pediatric patients with concussion have slower recovery rates that typically last a month or more (Field et al., 2003; Makdissi et al., 2003; Purcell et al., 2016). Further, the protracted recovery is often more complex and impacts more domains of function for
pediatric patients with concussion (Blume, 2015; Blume et al., 2012; Howell et al., 2014; Makdissi et al., 2013; Purcell et al., 2016).

*Does time since injury predict more difficult recovery as measured by the domains and total recovery profile score?* The Total PLACES score dropped from the early group (1-3 weeks) to the middle recovery group (4-11 weeks) and then rose significantly for the protracted recovery group (greater than 12 weeks). This pattern was evident across the cognitive, emotion, and social domains. Early and middle groups were significant for all three PLACES domains and prolonged differences were significant for cognition and emotion. Children and adolescents with protracted recovery past 11 weeks were found to be more likely to experience poor QOL across domains. This is consistent with the emerging research that suggests that concussion can cause QOL issues across domains (Moran, 2011; Novak et al., 2016).

*Is there a relationship between time since injury and perception of percent recovered?* There was a significant effect for time since injury on perceptions of percent recovered. Children and adolescents evaluated between 4 and 11 weeks reported a greater sense of recovery than the early or prolonged recovery groups. It is hypothesized that most children and adolescents are recovered within several months of injury (Barlow et al., 2010; Purcell et al., 2016), meaning individuals within this time frame may be more likely to report fewer symptoms and have a greater sense of recovery.

*Is there a relationship between time since injury and perceptions of support from school?* No significant findings were found between time since injury and perceptions of school support. An individual’s perceptions about the support from school concerning his or her recovery was not found to be related to the length of time since injury.
Is there a relationship between time since injury and perceptions concerning thinking, emotional concerns, social life, and social support? Both cognition and emotion domains had a similar significant pattern of elevated symptoms during the early recovery period, lower symptoms during the middle period, and prolonged symptoms for individuals who experienced prolonged recovery. Individuals who experience prolonged recovery were more likely to endorse symptoms in cognitive and emotion domains.

Concussion is a complex pathophysiological process that causes physical symptoms, cognitive changes, and emotional concerns. (Ellis et al., 2016; Sady et al., 2011). Children and adolescents with concussion notice symptoms in these domains and are concerned about their recovery.

Although the field has begun to acknowledge that recovery from concussion can be isolating socially (DeMatteo et al., 2015; Master et al., 2012), there is little research focused on pediatric perspectives about the social experience of recovery. Children have been found to express concerns about the impact of concussion on their social interactions, with those in the earliest stages expressing the most concern. One interpretation of this is that children and adolescents with prolonged recovery patterns may learn to modify their interactions with peers to gain more satisfaction or they may be more focused on the broad impact across domains reducing concerns about their social lives.

The fifth question explored the interaction between post-concussion symptoms and perceptions of QOL after concussion. Understanding the interaction between post-concussive symptoms and perspectives on recovery is important because persistent
physical symptoms are a risk factor for poor QOL in children with concussion (Joyce et al., 2015; Moran et al., 2011; Yeates et al., 2012).

Does perception of the level of perceived recovery (percent recovered) relate to the level of physical symptoms currently experienced by the individual with concussion? Total symptoms on the PCSS were correlated negatively with self-ratings of percent recovered. As a result, higher total symptom load was correlated with perception of less recovered status. The same pattern was evident for perceptions of QOL, in that worse QOL was correlated with lower ratings of percent recovered.

Is there a relationship between physical symptoms and overall recovery perception? There was a strong positive correlation found between total post-concussion symptoms on the PCSS and total QOL symptoms. Endorsement of more symptoms on the PCSS was related to endorsing more symptoms on PLACES. Further, the total PLACES score explained 54.9% of the variance on the total PCSS score. There is a strong relationship between post-concussive symptoms and QOL after concussion. This may be, in part, a reflection that both measures include cognitive and emotion domains. Another interpretation of these results is that the physical symptoms related to concussion have a broad impact on function and QOL, especially when symptoms linger.

Is there a relationship between physical symptoms and perceptions concerning thinking, emotional concerns, social life, and school support? Total post-concussion symptoms (PCSS) had strong positive correlations with the cognition, emotion, and social QOL domains. Post concussive symptoms (total PCSS) explained 57.5% of the variance for cognition, whereas the total PLACES score added an additional 20% of variance. For the emotion, domain there was a reverse pattern. Total post-concussive
symptoms explained 36% of the variance, whereas the total PLACES score added 42.8% of the variance. This finding may be explained by the notion that emotional symptoms are more closely tied to QOL than they are to physical symptoms. This theory may also explain the interaction of variables for the social domain. Total post-concussive symptoms explained 25.7% of variance, whereas the total QOL rating added 45.6%. These findings support an interaction between physical, cognitive, emotional, and social domains during recovery from concussion.

This study showed that children provide important perspectives on their recovery from concussion. The experience of a concussion goes beyond the physical symptoms and impacts QOL for many children and adolescents. Further, there is an interaction between post-concussion symptoms and QOL domains. Higher symptom load is related to worse perception of recovery and to perceptions of more difficulty with cognition, social life, and increased emotional symptoms.

Demographic and recovery characteristics were examined to better understand the recovery process. Surprisingly, there were no significant age differences between participants aged 11 and younger, and adolescent participants aged 12-17, or those aged 18-22. Conversely, gender had a significant effect that was consistent with the literature. Girls endorsed significantly more physical symptoms and worse QOL. In addition, girls reported that they were less recovered than boys. The subjective experience of a concussion seems to be worse for girls than for boys.

The length of time since injury is significant for children and adolescents. The greatest number of symptoms are noted in the first 4 weeks and then for those individuals whose symptoms linger beyond 12 weeks. It is interesting that individuals reporting
symptoms during the 4-to-11-week range reported the least symptoms. This may reflect the notion that most individuals recover during this time period. Children expressed concerns about the impact of concussion on their social interactions, with those in the earliest stages expressing the most concern. This may be because children and adolescents with prolonged recovery patterns learn to modify their interactions with peers to gain more satisfaction, or they may be more focused on the broad impact across domains reducing concerns about their social lives. Overall, the findings of this study supported the idea that concussion is a complex pathophysiologic process impacting multiple domains and that QOL is impacted. It is important for the adults treating and working with children and adolescents with concussion to consider and support QOL to minimize negative effects during recovery.

Limitations

Although this study contributes to the field by providing information about pediatric patient perspectives and the interaction of demographic and injury characteristics, the conclusions may be limited by the characteristics of participants included. This study sampled pediatric patients at a regional concussion clinic. Most of the participants were referred for treatment to the clinic by athletic trainers and primary care physicians. The sample may not be consistent with the broad range of concussion injuries seen by pediatricians and other primary care providers. Further, as a suburban clinic, patients’ socioeconomic status may differ from those seen by urban or rural hospitals and physicians. In addition, the participants were divided into groups by age rather than grade. There may be differences depending on grade level and school structure that were not captured in this study.
In addition, the clinic provided data from all patients seen within a 2-month period. It is estimated that approximately one third of participant responses were from patients who were seen at two different points in their recovery. Although the repeat visits were part of the routine protocol of the clinic, it is possible that there was a unique commonality among these patients. In order to better understand the recovery process, it may have been effective to follow patients across their entire treatment spans to explore differences between rapid and prolonged recovery profiles.

Although the directions indicated that the pediatric patient complete the scale, it was noticed that parents and patients sometimes had conversations while the patient completed the forms. It may be that some children and adolescents were influenced by parent perspectives.

Information on premorbid conditions was not included. The literature has shown that the presence of premorbid conditions, such as emotional or learning concerns, can impact recovery ((Ponsford et al., 2012; Wood et al., 2011; Zemek et al., 2013). It is unknown whether the sample includes children or adolescents with pre-existing learning disabilities, emotional regulation diagnoses, or attention concerns. In addition, the study did not include data on the number of concussions participants had suffered, which has been shown to increase recovery times and symptom load.

**Clinical Implications**

Despite limitations, this study showed that children and adolescents have important perspectives on their recovery from concussion. Previous research has focused generally on symptoms related to recovery, but not on the perspectives of how the concussion affects life across domains for children and adolescents with concussion.
Many children feel that concussion has disrupted their lives. In addition to post-concussion symptoms, pediatric patients with concussion report concerns about their learning, emotions, and social interactions. When developing a plan for recovery accommodations, it is essential to consider factors outside of the physical domain. In addition to accommodations for physical and somatic function, consideration must be made for cognition, emotional symptoms, impact on social interactions, and support by school.

Gender differences were evident across the QOL domains. In confirmation of previous research (Covassin & Elbin, 2011; Makdissi et al., 2013; Marar et al., 2012; Novak et al., 2016), girls endorsed more physical symptoms and concerns with QOL than boys. Female participants viewed their recovery as more impaired than male participants. Further, girls endorsed more cognitive and emotion symptoms than boys. Gender differences were evident in perspectives about recovery. Therefore, clinicians should consider gender when discussing recovery with patients. Normalizing recovery trajectories that differ for boys and girls may reduce anxiety about the presence of symptoms and ultimately improve recovery outcomes.

Time since injury is an important aspect of recovery. Children and adolescents take longer to recover than adults. Most symptoms resolve within a month, but some children may suffer from symptoms for extended periods (Blume & Hawash, 2012; Crowe et al., 2016; Zemek et al., 2013). Further, symptoms progress and change over time, with some symptoms emerging early and others at later points, in part because of the metabolic load and pathophysiology (Harmon et al., 2013). There remains little understanding of the recovery process and why some children and adolescents experience
prolonged recovery. The pattern of symptom expression in this study, with fewer QOL symptoms endorsed for individuals between 4 and 11 weeks, appears unique in the field. Should this finding continue to be supported in the literature, targeted interventions concerning QOL during the 4-to-11-week window may reduce lingering symptoms allowing for better recovery.

This study extends knowledge of recovery from concussion for children and adolescents. Professionals who work with children and adolescents with concussion must be mindful of the significant effect the injury has on the QOL of these patients. A concussion has the potential to impact overall health, wellness, and recovery for extended periods of time. Further, recovery from a brain injury while learning can be a daunting task for many students with concussion. Schools must understand an individual student’s concerns and unique recovery pattern in order to provide the best support for recovery and for learning. Overall, the voice of the child must be heard when developing accommodation plans and recovery protocols.

**Future Directions**

Replication of this study would provide further information about the recovery process and QOL after concussion. In addition, several limitations should be addressed in future research. Including data about how the injury occurred and initial symptoms would likely provide essential information about the recovery process. Moreover, the role that premorbid conditions play in perceptions concerning recovery from concussion should be examined. Further, in order to understand the recovery process, individuals should be followed across their recovery trajectory. This would allow researchers to
explore similarities and differences between individuals who recover quickly and those who experience prolonged recovery.

The PLACES measure shows promise as a tool for research and clinical use. Although the measure showed good reliability, the psychometric properties of the scale should be evaluated. Item analysis and validity should be examined. In addition, the scale should be modified to address demands in school and clarify some of the items. Further research will allow the field to understand the perspectives of children and adolescents and add to research concerning QOL after concussion. In addition, the development of a pediatric QOL measure for concussion would allow school and medical professionals to better tailor accommodations and recovery protocols to address the concerns of children and adolescents.
References


Appendix A

Post Concussion Recovery Profile (Preliminary Study)

Current Date: ____________________

Current Age: ____________________  Gender:  M  F

Time from concussion (e.g. 3 weeks since my concussion) ____________________

**Indicate how true the statement is for you. For example:**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>A little true</th>
<th>Somewhat true</th>
<th>More than a little</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like the color green</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>The concussion has disrupted my life</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I feel frustrated by my symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I feel overwhelmed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I don’t hang out with friends as much as before</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I don’t like activities as much as before the concussion</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Things are harder for me now</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I worry that I might never get better</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>My symptoms impair me in school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>My school has been helpful in supporting my concussion symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>My symptoms make it hard to think</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>My symptoms effect my mood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>My symptoms effect the way I interact with my friends</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix B

Pediatric Life After Concussion Evaluation Scale

Patient Self Report

Current Date: __________________ Current Age: __________________

Gender: M F Weeks since injury (e.g. 3 weeks since my concussion) _______

How far along am I in my recovery (the % recovered that you feel you are today from 0-100%):
I am ___% recovered from my concussion

This describes my school day: ___ Full day ___ Some of the day ___ Home school ___ No school

Indicate how true the statement is for you. For example:

<table>
<thead>
<tr>
<th>I like the color green</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Mostly true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statements about Thinking</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Mostly True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>My symptoms make it hard to think</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My symptoms make it hard to pay attention</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I have trouble learning new information</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My symptoms make it hard to remember Information I already learned</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My symptoms impair me in school</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statements about School</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Mostly</th>
<th>Very</th>
</tr>
</thead>
<tbody>
<tr>
<td>My teacher(s) have been understanding about my recovery needs</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My school has been helpful in supporting my concussion symptoms</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My school provides/follows the accommodations my doctor recommended</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I am using the accommodations in school that were recommended by my doctor</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>School demands seem to make my recovery longer</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
### Statements about Friends/Activities

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Mostly True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>My symptoms keep me from spending time with friends</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My symptoms prevent me from participating in clubs and/or sports like I did before my injury</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel left out because of my symptoms</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel less social than I did before I was injured</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My symptoms effect the way I interact with my friends</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

### Statements about my Feelings

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Mostly</th>
<th>Very</th>
</tr>
</thead>
<tbody>
<tr>
<td>The concussion has disrupted my life</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel frustrated by my symptoms</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>My symptoms effect how I feel</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel overwhelmed</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I find myself worrying more than I did before my injury</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>