Reliability of Child SCAT 3 Component Scores in Non-Concussed Children at Rest and After Exercise

By

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A Thesis Submitted to the Faculty of Graduate Studies of the University of Manitoba

In partial fulfillment of the requirements of the degree of

Master of Science

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Winnipeg

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Acknowledgements

Thank you to the Pan Am Clinic Foundation, the University of Manitoba and the University of Winnipeg for their ongoing support of this project.

Dedication

This thesis is dedicated to my family that has sacrificed many days and nights to allow me to complete this project. To Jennifer, Lauren, Tyler, Mom, Dad and Ian, I appreciate all the help, patience and understanding over the past five years that aided in my completion of this thesis.

Abstract

Title: Reliability of Child SCAT 3 Component Scores in Children at Rest and Following Exercise

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Problem: A lack of research exists regarding the test-retest reliability of the Child Sport Concussion Assessment Tool 3 (Child SCAT 3) in healthy non-concussed adolescent females in both baseline and post-exercise settings.

Method: This study consisted of two testing sessions. Within each session the Child Sport Concussion Assessment Tool 3 (Child SCAT 3) was administered once prior to exercise and once after a bout of exercise.

Results: Individual component scores displayed a wide range of reliability and response stability values. A positive correlation existed within one session, between child symptom scores and slower rates of heart rate recovery after exercise.

Conclusions: Overall, the Child SCAT 3 appears to be a moderately reliable assessment tool when used to evaluate uninjured female children. However, further research is required to clarify the exact sources of method error within individual Child SCAT 3 component scores.

8. Introduction

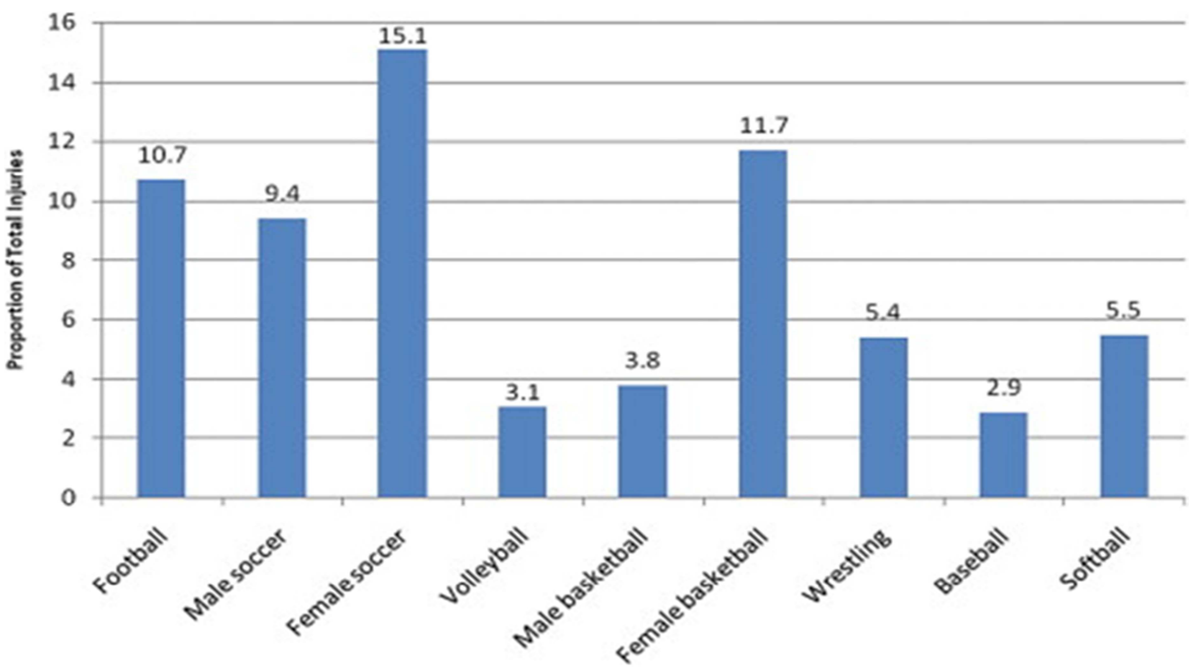
Concussions related to athletic activities and the potential for long-term consequences from concussion have become a prevalent topic in today's sporting community. Although, the majority of research surrounding concussion has focused on high school and university age individuals, the International Consensus Group on Concussion in Sport introduced the Child Sport Concussion Assessment Tool 3 (Child SCAT 3) in 2012. The Child SCAT 3 attempts to address the need for a tool that adequately aids in the assessment of children between the ages of 5 and 12. Since this tool is quite new, it has yet to be validated (Choe & Giza, 2015).

Epidemiological statistics from amateur sports in North America demonstrate the need for appropriate assessment and management of concussions in children. In Canada, concussion was found to be the most common individual injury that occurred within a cohort of 9-16 year old ice hockey players (Emery & Meeuwisse, 2006). According to the Center for Disease Control (CDC) in the United States, the highest rates of any kind of traumatic brain injury (TBI) were among males 10-19 years of age and 65% of all TBI's occurred among children aged 5-18 years old (Gilchrist, Thomas, Wald, & Langlois, 2007), with these concussions occurring in both organized and non-organized sporting or recreational activity settings (Bakhos, Lockhart, Myers, & Linakis, 2010). It has also been reported that 5-15% of all injuries occurring in sporting activities were some form of TBI (Figure 1) (Gessel, Fields, Collins, Dick, & Comstock, 2007).

Concerns with long-term cognitive difficulties, such as chronic traumatic encephalopathy (CTE) have increased worry within individuals as well as parents of children involved in sport. Also, the potential for litigation regarding the mismanagement of concussed athletes has become an issue for health care providers in recent years. This is evidenced by a number of ongoing lawsuits involving former professional athletes. Appropriate assessment and management of concussions has become a widely discussed, debated and researched topic within the last decade, as experts strive to improve care for those that incur head injuries.

Figure 1

Concussions as a percentage of total injuries sustained.



Gessel LM, Fields SK, Collins CL, et al. Concussions among United States high school and collegiate athletes. J Athl Train 2007;42(4):500

9. Review of Literature

(a) Definition of Concussion

The International Consensus Group on Concussion in Sport recognizes concussion as a subset of TBI and defines concussion as a complex pathophysiological process affecting the brain, induced by biomechanical forces, and the injury can be caused by a direct blow to the head, face or neck, or by a blow elsewhere to the body with force transmitted to the head (McCrory, Meeuwisse et al., 2013a). Having said this, within the literature, there are numerous definitions suggested for concussion. This may be due to varying theories regarding the pathophysiological process related to concussion, as well as differences in concussion assessment and management recommendations (Blume & Hawash, 2012; Choe, Babikian, Difiori, Hovda, & Giza, 2012; Cohen, Gioia, Atabaki, & Teach, 2009; Davis & Purcell, 2013; Guskiewicz & Valovich McLeod, 2011; Karlin, 2011; Kirkwood, Yeates, & Wilson, 2006; Schnadower, Vazquez, Lee, Dayan, & Roskind, 2007). The importance of the definition of concussion was demonstrated in a study of 472 current and former athletes that were asked to provide a simple history of the number of concussions which they had suffered in their lifetime (Robbins et al., 2014). During telephone interviews each subject was initially asked to provide the number of concussions he or she thought they had suffered during their life. After providing their initial answer, a definition of concussion was explained to the subject and he or she was again asked to give their total number of concussions. It was found that the post-definition concussion total was on average double that of the number given prior to knowledge of the medical definition of concussion. This effect was consistent across all levels of competition and type of sport. From this, it was concluded that the athlete's understanding of concussion did not align with current medical definitions of concussion (Robbins et al., 2014).

Since clinicians can use one of a variety of definitions during the diagnostic process, and often lack one clear physiological cause of the person's symptoms, the severity of concussion is no longer determined at the time of injury, nor during the process of recovery. The true severity of a concussive injury can only be definitively determined after the athlete has fully recovered from his or her symptoms (McCrory et al., 2013a). The pathophysiological processes associated with concussion injuries remain an area of extensive investigation, with few concrete answers. In order for a concussion to be diagnosed the injured athlete must present with deficits in one or more of the following domains (McCrory et al., 2013a):

1. Symptoms (somatic, cognitive or emotional)
2. Physical signs (e.g. loss of consciousness)
3. Behavioral changes (e.g. irritability)
4. Cognitive impairment (e.g. concentration difficulties)
5. Sleep disturbance

Among the most common symptoms reported in adult populations are anxiety, fatigue and headache related symptoms (Alla, John Sullivan, & McCrory, 2012). Children may be affected differently due to the nature of their continuous development, maturation and cognitive needs during childhood (Karlin, 2011). Also, the younger the child, the more difficult it may be for them to verbalize signs or symptoms associated with a head injury (Arbogast et al., 2013; Davis & Purcell, 2013; Karlin, 2011). The Child SCAT 3 has attempted to address the differences between children and adults, and now requires further study to hopefully validate its utilization for the age group in which it is intended (Choe & Giza, 2015).

Although, symptoms of concussion usually resolve within 7-10 days post-injury (Arbogast et al., 2013), the literature indicates that some individuals can develop longer lasting post-concussion syndrome (PCS) (Arbogast et al., 2013; Babcock et al., 2013; Choe et al., 2012; Choe & Giza, 2015; Landre, Poppe, Davis, Schmaus, & Hobbs, 2006). PCS is not well defined, but is generally accepted in the literature as any concussion symptom that does not resolve within the 7-10 day post-injury window (McCrory et al., 2013a). Studies investigating the incidence of PCS in children seem to show large variations in findings. The rates for occurrence of PCS in children range from 1.5% to 35% within four different studies (Arbogast et al., 2013; Choe & Giza, 2015; Davis & Purcell, 2013; Guskiewicz & Valovich McLeod, 2011). While the literature draws no specific conclusions about why there is such a wide range of incidence statistics for PCS in children, possible explanations include a lack of a consistent definition of PCS as well as a lack of valid and reliable tools for assessing individuals younger than 13 years of age (Arbogast et al., 2013; Babcock et al., 2013; Davis & Purcell, 2013; Guskiewicz & Valovich McLeod, 2011). As of February 2014, all 50 states in the United States had passed concussion laws in order to protect youth athletes. These laws, generally include that a licensed health care provider must evaluate the athlete following injury and medically clear him or her prior to a return to sport (Rose, Weber, Collen, & Heyer, 2015). As such, the development of evidence based and age appropriate management strategies requires further investigation.

(b) Concussion Assessment and Management

While figure 1 provides a glimpse of concussion incidence in a high school population, the United States Government Accountability Office (GAO) presented alarming testimony regarding the occurrence of concussion in high school sports (Jinguji, Krabak, & Satchell, 2011). The GAO believed that the estimate of occurrence of concussion is not available due to multiple definitions of concussion, poor recognition and underreporting in the high school setting (Jinguji et al., 2011) As a result, they suggested that the incidence of concussion is likely underestimated in youth sports. The implications of this assertion are somewhat disturbing in regards to concussion in younger children. Sporting activities in the high school, university and professional settings are much more likely to have qualified medical professionals working directly with their teams in comparison to children's community based teams. The lack of medical presence at most of the younger age group sports or activities makes the incidence of concussion in children even more difficult to predict and adds to the potential that a large number of children's concussions could go undetected or unreported.

Many medical conditions have a gold-standard testing procedure that is utilized in order to make a diagnosis, such as magnetic resonance imaging as one example. Whereas, a number of pediatric concussion assessment tools have been developed mainly on consensus and opinion. Relative to the number of studies conducted using adults as subjects within concussion studies, a smaller body of research exists regarding pediatric concussion assessment tools. DeMatteo et al (2015), reported finding eight different sources of defined guidelines that were intended for use in the pediatric population, but mention that each of the guidelines were primarily consensus based, not evidence based. Among the sources for these concussion management guidelines were the Center for Disease Control in the United States, the American Academy of Pediatrics and the Montreal Children's Hospital (Dematteo et al., 2015).

Even though there are reputable groups developing guidelines for concussion management, there is currently no gold-standard test available for use when evaluating a concussion in either an adult or child, and there is no concussion assessment tool that has been validated for use in children younger than 13 years of age (Choe & Giza, 2015; Davis & Purcell, 2013). Due to this absence of research, there is also a lack of normative data on which to compare any current child concussion assessment studies (Zimmer, Piecora, Schuster, & Webbe, 2013).

Numerous concussion assessment tools have been developed within the last decade and each is designed to assess specific aspects of concussion or a combination of potential deficits. Baseline neuropsychological and cognitive testing of athletes has attempted to add to the accuracy of post-injury assessments. Individualized testing utilizing comparisons between baseline and post-injury test have become one of the recommended methods for practitioners to conduct portions of their clinical concussion assessments (Dessy, Rasouli, Gometz, & Choudhri, 2014; McCrory et al., 2013a). Computer based neuropsychological and cognitive assessments have become widely used within the athletic community as the trend towards individualized assessment and management has progressed. One prominent test that has amassed a wealth of normative data is the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT®). Paper and pencil tests such as the King-Devick test have also been included in some assessment protocols (McCrory et al., 2013a). The International Consensus Group on Concussion in Sport clearly indicates that no one test should be used as all-encompassing diagnostically, but each can be considered one part of a battery of clinical tests needed to comprehensively assess different aspects of brain function. Ultimately, the diagnosis of a concussion is still based on the clinical judgement of medical professionals (McCrory et al., 2013a).

Following the diagnosis of a concussion, a patient must be assessed as asymptomatic by a medical professional prior to returning to play (McCrory et al., 2013a; Rose, Weber, Collen, & Heyer, 2015). Attempts to define the term asymptomatic have created much debate within the concussion literature (Alla et al., 2012; Kirkwood, Randolph, & Yeates, 2012; McCrory, Meeuwisse et al., 2013b). McCrory, Meeuwise et al (2013b), asked the question: “What is the lowest threshold to make a diagnosis of concussion?" From their research, they found that mean symptom report scores during baseline testing of uninjured collegiate athletes ranged from 3.7 to 18.1 and mean symptom severity scores ranged from 4.2 to 27.5. Data such as this adds to the complicated nature of concussion assessment and management, as it suggests the existence of symptoms similar to those of a concussion may be present, prior to any concussive injury.

Recognition of a concussion can require long-term observation, individualized assessment and exclusion of conditions that may mimic a concussion in order to ensure an accurate diagnosis (McCrory et al., 2013b). Tests such as basic MRI and CT scans can provide concrete answers if there is a life-threatening structural injury, but to date these types of tests have not enhanced the accuracy of concussion diagnosis. Other clinical tests, such as Functional MRI (FMRI) have shown some promise, but studies are ongoing to validate the application of these tests within a concussion assessment setting.

When a concussion is reported and subsequently assessed by a health care professional, a number of studies have found that individuals may not receive consistent care. In other words, there is some discrepancy in the diagnosis and management of concussion, especially in children (Arbogast et al., 2013; Cohen et al., 2009; Davis & Purcell, 2013; Kirkwood et al., 2006; Shultz et al., 2013). In a survey of pediatric medical providers working in an emergency room setting, researchers found there to be large variation in the use of written recommendations for patients at discharge, as well as moderate variation in the prescription of cognitive rest following discharge (Arbogast et al., 2013). A high degree of variability has also been reported regarding the manner in which clinicians emphasize different factors related to concussion recognition, diagnosis and return to play criteria (Shultz et al., 2013). Having said this, there is some consensus regarding the important role that baseline testing plays during injury diagnosis and the prescription of an individualized plan for recovery to pre-injury status (Kirkwood et al., 2006). Unfortunately, due to the ongoing maturation process in children, baseline testing may require more stringent parameters than those in adults. As well, the impact of early diagnosis and intervention, and the injured athlete's acute clinical status may potentially correlate to the long-term prognosis of post-concussive symptoms in children (Ponsford et al., 2001; Yeates et al., 2009). Currently, these parameters are not yet well defined (Gioia, 2015a). Gioia (2015), recommends that baseline cognitive testing should be conducted on an annual basis for children in order to account for developmental changes over that time frame, yet there is still a need to refine and validate the clinical assessment tools used for this purpose.

(c) Modifying Factors in Concussion Assessment and Management

Beyond the assessment difficulties listed above, there are also a number of modifying factors that can create difficulties when assessing, recognizing and managing concussions. Studies involving non-concussed populations have shown the presence of concussion-like signs and symptoms under certain conditions. Baseline symptom scores appear to be affected by the following variables in high school and college aged individuals: dehydration (Patel, Mihalik, Notebaert, Guskiewicz, & Prentice, 2007), depression (G. L. Iverson, 2006), orthopedic injuries (Hutchison, Comper, Mainwaring, & Richards, 2011; Landre et al., 2006; Yeates et al., 2012), gender (Covassin et al., 2006; G. Iverson & Stearne, 2006; Valovich McLeod, Bay, Lam, & Chhabra, 2012), school grade/age (McCrory et al., 2013a) and concussion history (Landre et al., 2006). As mentioned earlier, debate within the literature exists regarding what may constitute an acceptable symptom score during baseline testing. Therefore, the effect that the modifying factors may have on assessment scores should be accounted for when interpreting results (Alla et al., 2012).

Within the literature there are a limited number of studies that have investigated the presence of concussion-like symptoms in non-injured children under the age of 13. One study utilized the original SCAT (McCrory et al., 2005) as a testing tool to investigate the differences in symptom scores between children with a previous history of concussion and those without a history of concussion (Schneider, Emery, Kang, Schneider, & Meeuwisse, 2010). Their findings suggest that concussion symptoms can vary due to developmental and gender differences. Developmental differences among children of similar chronological age can affect scoring on concussion assessment tools due to substantial variability in cognitive capacities, emotional control, capability and willingness to disclose their injury to others (Gioia, 2015a). Younger children can be more overt, (e.g. crying), but their ability to self-identify and articulate symptoms may be limited (Gioia, 2015a). These findings suggest that the collection of detailed demographic information, an understanding of each individual's injury history, as well as their current mental and physical status are all important for the completion of an accurate baseline evaluation. Investigations focusing on children who had sustained a mild TBI have looked at factors such as symptom exaggeration after injury (Kirkwood, Peterson, Connery, Baker, & Grubenhoff, 2014), as well as the use of the Standardized Assessment of Concussion (SAC) in a pediatric emergency department (Grubenhoff, Kirkwood, Gao, Deakyne, & Wathen, 2010). In the study using the SAC, Grubenhoff et al (2010) observed that the graded symptom checklist reliably identified mTBI symptoms for children 6 years and older and SAC scores had a tendency to be lower in younger children, but did not reach significance. These researchers concluded that additional research is needed to identify cognitive deficits in order to better classify mTBI severity in children (Grubenhoff, Kirkwood, Deakyne, & Wathen, 2011). Kirkwood et al (2014), suggest that a small subset of children who had persistent complaints after a mild TBI may be exaggerating their symptoms which further adds to the list of factors that complicate childhood concussion assessment

Practice or learning effects must also be considered in children due to their continuous development and maturation. For many children and adolescents, a baseline concussion assessment can be their first experience with such a test. A study by Valovich, Perrin and Gansneder (2003), looked at the possibility of learning effects within balance and cognitive variables. It was concluded that a repeat administration effect did occur with the Balance Error Scoring System (BESS), yet no practice effect with the SAC in high school student athletes was evident (Valovich, Perrin, & Gansneder, 2003).

(d) Evolution of the Child SCAT 3

In recognition of the modifying factors and the inconsistencies involved in the management of concussion, the International Consensus Group on Concussion in Sport has worked to improve the quality of care of individuals with concussion. The Sport Concussion Assessment Tool (SCAT) was developed in 2004 (McCrory et al., 2005) and since this time has evolved into the current SCAT 3 and Child SCAT 3 (McCrory et al., 2013a). The Child SCAT 3 includes nine sections within its evaluation and is designed to assess children between the ages of 5 and 12 years old. The assessment portion of the Child SCAT 3 includes assessments for symptoms, physical signs, impaired brain function and abnormal behavior using the following nine categories: 1. Glasgow Coma Scale, 2. Sideline assessment – Child Maddocks Score, 3. Child Symptom Report/Severity, 4. Parent Symptom Report/Severity, 5. Standardized Assessment of Concussion – Child Version (SAC-C), 6. Neck Examination, 7. Balance Examination, 8.

Coordination Examination, and 9. SAC-C Delayed Recall. Each of these sections are scored individually and can contribute either negatively or positively to a potential total score. The components of the Child SCAT 3 appear to have been merged from other assessment tools and its development appears to be based on consensus and usual practice (Rivera, Roberson, Whelan, & Rohan, 2014). There are also a number of self-report symptom lists which currently exist within the available concussion assessment tool literature (Piland, Ferrara, Macciocchi, Broglio, & Gould, 2010). The current SCAT 3 utilizes the Post-Concussion Symptom Scale (PCSS) (McCrory et al., 2013), whereas the Child SCAT 3 includes a symptom questionnaire that has been modified from the Child and Parent Versions of the Health and Behavior Inventory (Ayr, Yeates, Taylor, & Browne, 2009; McCrory et al., 2013). Some normative and reliability data does exist for the adult version of the PCSS (Lovell et al., 2006), but limited data is available regarding the reliability of concussion symptom assessment in children.

Another of the main components of the Child SCAT 3 is the Standardized Assessment of Concussion – Child Version (SAC-C). In a study performed within a pediatric emergency room setting, the SAC – ER version was used to evaluate 6-18 year olds with and without a head injury (Grubenhoff et al., 2011). Grubenhoff and colleagues found that SAC scores tended to be lower in injured subjects versus controls, but these results did not reach significance within their statistical analysis. The SAC-ER version contains 6 sections, including: orientation, immediate memory, graded symptoms, neurologic screening, concentration and delayed recall (McCrea et al., 1998). Whereas, the SAC-C component of the Child SCAT 3, only contains the orientation, immediate memory, concentration and delayed recall sections within its test battery.

The Child SCAT 3 lists eight references in its supportive documentation, but a critical review highlights the fact that only one of these eight references sights research conducted on children within the 5-12 year old age group. A study by Ayr, Yeates, Taylor and Browne (2009), utilized the Health and Behavior Inventory, Parent and Child Versions, in order to assess factors that reflect cognitive, somatic, emotional and behavioral dimensions of mTBI in 15 year old children. The Health and Behavior Inventory appears to have been modified from its original 50 items to 20 for its inclusion in the Child SCAT 3 (Ayr, Yeates, Taylor, & Browne, 2009)

Two recent review articles agree with this finding and suggest that a significant need exists for further investigation into refining clinical assessment and management methods for concussion type injuries in the pediatric population (Gioia, 2015b; Rose et al., 2015). Within one of the above mentioned studies, Gioia (2015) listed numerous factors that may affect the reliability of symptom reporting in young children, including a lack of familiarity with symptom terminology, affirmative response styles to please an inquiring adult, difficulty in judging grades of symptoms, and less developed social and emotional security among other factors.

The lack of medically trained individuals directly involved in children's sport, current concussion incidence statistical issues and multiple factors that affect the accuracy of diagnosis and management, point to the need for continued research and continual development of comprehensive, valid, reliable and accessible concussion assessment tools. Concussion evaluations need to be valid and reliable for their intended uses and several types of reliability should be assessed: internal consistency, interrater reliability and test-retest reliability over certain time frames. A review of literature suggests that there is a lack of research available on assessments such as the psychometrics of pediatric concussion symptom scales (Gioia, Schneider, Vaughan, & Isquith, 2009) and no published studies exist that have investigated the reliability of the new Child version of the SCAT3.

(e) Reliability of Concussion Assessment Tools

Test-retest reliability of a number of concussion assessment tools has been performed with somewhat variable results (Table 1). In a study where 48 high school student athletes were tested on two different occasions using four neuropsychological assessment tools, no gender differences were found in test-retest reliability, but poor test-retest reliability was found overall when using reliable change index scores (Barr, 2003). Another reliability study, that used a test-retest design and included 118 university aged individuals, investigated the reliability of three concussion assessment tools: ImPACT®, the Concussion Sentinel and the Concussion Resolution Index. Each subject completed a baseline test and subsequent retests on day 45 and day 50. The Intra-class Correlation Coefficient (ICC) results ranged from .15 to .66 across the three tests (baseline to day 45 comparison) and from 0.03 to 0.66 (day 45 to day 50 comparison) (Broglio et al., 2007). Evidence demonstrating the need for investigation of a child specific tool is shown in a study of reliability of the SCAT 2. Twenty-two children (14 females and 8 males) with a mean age of 10.3 were included in a test-retest study using the SCAT 2 as the assessment tool (Chan et al., 2013). The children were tested 1 week apart with a total SCAT 2 score ICC calculated at 0.446. Some individual components appeared to yield better reliability results in comparison to the total score (balance = 0.725, SAC = 0.523 and symptom severity = 0.488). From these findings, Chan et al (2013) also recommended that medical professionals should be careful using change scores over time to make clinical decisions. Table 1 details some of the findings within a number of concussion reliability studies over the last decade. The main focus of the research over this time period appears to have been mainly on tools that assess symptom scores, balance or computer based assessments.

Table 1. Reliability of Concussion Assessment Tools

Author(s)/Year	Type of Study/Concussion Assessment Component Studied	Subject details	Findings
(Broglio, Ferrara, Macciocchi, Baumgartner, & Elliott, 2007)	Repeated measures (Baseline to day 45) / total scores on different assessment tools	118 university students	Reliability of concussion assessments: ImPACT® ICC= 0.15 - 0.39 Concussion Sentinel ICC=0.23 - 0.65 Concussion Resolution Index ICC=0.15 - 0.66
(Chan et al., 2013)	Repeated measures (2 testing sessions 1 week apart) / SCAT 2	22 children (mean age 10.3) and 73 adults (mean age 22.6)	Total SCAT 2: ICC= 0.367(adults) ICC= 0.446(Children) Children better reliability for individual components: Balance ICC= 0.725 SAC ICC= 0.523 Symptom Severity ICC= 0.488
(Cole et al., 2013)	Repeated measures (2 testing sessions mean= 32 days apart) / 4 different tools tested (CNS Vital Signs, ANAM4, CogState, ImPACT)	215 total (active duty military)	Range of component reliability values: CNS Vital Signs ICC= 0.29 - 0.79 ANAM4 ICC= 0.40 - 0.79 CogState ICC= 0.22 - 0.79 ImPACT ICC= 0.50 - 0.83
(Lovell et al., 2006)	Normative data collection with comparison to individuals with concussion	Normative: (1746 high school and university students) Concussed: (260 students-H.S. and univ. age)	Cronbach's alpha for normative data: Men= 0.89 Women= 0.94 -women reported more symptoms than men
(Mailer, McLeod, & Bay, 2008)	Repeated measures / Graded Symptom Scale from Head Injury Scale Self-Report Concussion Symptom Scale	126 middle school students	Total symptom score ICC= 0.93 Total # of symptoms ICC= 0.88 Individual symptoms ICC= 0.65-0.89
(McLeod & Leach, 2012)	Literature Review / psychometric properties	60 articles between 1995 and 2008	2 test-retest reliability studies Post-concussion scale – Spearman r= 0.55 Post-concussion scale (ImPACT® 21 item) Pearson r= 0.65 -no ICC's reported
(Sady, Vaughan, & Gioia, 2014)	Repeated measures / Post-concussion symptom inventory (self-report)	81 uninjured 8-12 year olds	Total symptom score ICC= 0.89 (components range 0.73 - 0.89)
(Schatz & Ferris, 2013)	Repeated Measures / ImPACT	25 university students	ICC values by component: Verbal memory = 0.79 Visual memory = 0.60 Reaction time = 0.77 Total symptoms = 0.81 No practice effect was found

Within the studies that utilized the ICC as a measure of reliability, only a few of the total score and component scores reached even the general 0.75 level deemed as good reliability (Portney & Watkins, 2000) and the results appear quite variable with large ranges of reliability values.

(f) Exercise and Concussion Assessment

Exercise is an extremely important variable within concussion assessment, since concussions that occur during athletic activities are being assessed as athletes are removed from the field of play. Depending on the sport and the level of effort required at certain times within different sports, varying levels of exercise intensity can be occurring at the time of injury. Also, the return to play process after concussion involves monitoring of the injured athlete during a six step, progressive exercise protocol (McCrory et al., 2013a). Over the last decade researchers have also begun to examine the potential impact that exercise may have on the reliability and validity of concussion assessment results (Covassin, Weiss, Powell, & Womack, 2007; Fox, Mihalik, Blackburn, Battaglini, & Guskiewicz, 2008; Gaetz & Iverson, 2009; Mrazik, Naidu, Lebrun, Game, & Matthews-White, 2013; Schneiders et al., 2008a; Wilkins, McLeod, Perrin, & Gansneder, 2004). In adults, there are a number of studies that have shown a tendency for exercise to affect scores in each of the domains being tested within concussion assessments (Table 2). Due to the symptoms that exercise may create, investigators have attempted to determine the amount of recovery time needed after exercise in order to get a true measure of symptoms with no interference from the effects of exercise. As a result, a range of 8-20 minutes of rest has been suggested as a sufficient time frame for one aspect of concussion assessment (postural control) to return to baseline levels post-exercise (Fox et al., 2008; McCrory et al., 2013a; Susco, Valovich McLeod, Gansneder, & Shultz, 2004). Currently, the Child SCAT 3 suggests 10 minutes of rest after exercise, prior to completing the assessment.

Studies involving post-exercise symptom assessments have been performed on both high school and adult populations. Research has demonstrated that exercise in a controlled setting can elicit a change in symptom scores on a number of commonly used concussion evaluation instruments (Alla, Sullivan, McCrory, Schneiders, & Handcock, 2010; Covassin et al., 2007; Fox et al., 2008; Gaetz & Iverson, 2009; Schneiders et al., 2008a). Exercise has been shown to affect balance, cognitive function and self-reported symptom scores as well. Table 2 displays a summary of the current research which examined the impact of exercise on concussion-like signs and symptoms in adult populations.

While the majority of studies have focussed on individuals 18 years and older, there are some studies that look at the cognitive and emotional effects that exercise may have on children. Gallotta et al (2015), investigated the attentional performance of primary school students after different levels of exertion and found that variations in the type of exertion had beneficial influences on the level of attention in children (Gallotta et al., 2015). An article from 2011 also highlights the complexity of the impact that physical activity has on mental function in children and suggests that its impact is likely moderated by the child's fitness level, health status and a number of psycho-social factors (Tomporowski, Lambourne, & Okumura, 2011). These findings introduce yet another potential difficulty associated with completing accurate concussion assessments. Unfortunately, there is currently a lack of research that directly investigates how exercise effects childhood concussion evaluation scores on current assessment tools.

In order for a diagnostic tool to be useful for evaluating injury, it must demonstrate good test-retest reliability in a normal population (Makdissi, Davis, & McCrory, 2015).

Table 2. Exercise and Concussion-like Symptom Presentation in Uninjured Adults

Author(s)/Year	Type of Study	Subject details	Findings
(Alla et al., 2010)	Cross-over randomized design	60 subjects (30male, 30 female) 18-35 years old	-exercise can provoke neurological symptoms in healthy individuals and symptoms are related to exercise intensity
(Covassin et al., 2007)	Repeated measures design	102 subjects (experimental group -54, control group -48 18-24 years	-maximal exercise test had a limiting effect on cognitive function within ImPACT computerized neuropsychological test
(Fox et al., 2008)	Repeated measures	36 subjects (18 male, 18 female) Mean age 19 $\pm$ 1.01 years	- anaerobic and aerobic exercise protocols adversely affected postural control -postural control returned to baseline between 8 and 13 minutes after exercise
(Gaetz & Iverson, 2009)	Pre-test, Post-test, non-equivalent groups design	75 subjects (45 female and 30 Male) 18-24 years old	- Symptoms decreased in the emotional domain, (females only) -reported headaches decreased in females -self-reported concentration problems decreased in males only -balance problems, reported numbness, tingling and fatigue all increase post-exercise
(Schneiders et al., 2008b)	Repeated measures	30 subjects (15 male, 15 female) 19-24 year olds	- moderate-intensity exercise facilitated performance of dynamic balance and coordination tasks - no evidence to suggest a significant decrease in static balance performance following exercise
(Susco et al., 2004)	Repeated measures	100 subjects (80 test, 20 control) 18-25 year olds	- decrease in BESS performance after the exertion in all test groups, with exertion having the greatest effect on the tandem and single-leg stance conditions - all subjects recovered by posttest II, which was administered 20 minutes after the exertion protocol

(g) Aerobic Exercise Testing in Children

Aerobic fitness can be measured directly using gas analysis during specific exercise tests or indirectly using calculations derived from field type exercise tests. The Progressive Aerobic

Cardiovascular Endurance Run (PACER) test by FITNESSGRAM® is one example of a field test used to assess aerobic fitness levels. It is widely used in North America as an option for school based fitness testing. The PACER test involves the individual running a shuttle type course that can be 15 meters or 20 meters in length. An audio recording is used to time the laps and the time allowed per lap within the PACER test progressively gets shorter as the test goes on. Using a test such as the PACER test allows the researcher access to a wealth of normative fitness data for school aged children.

A common measure used to express maximal aerobic fitness is maximal aerobic capacity (VO_{2max}). When using tests such as the PACER test, VO_{2max} can be estimated using calculations from variables such as the subject's age, body mass index (BMI), their score on the test and the speed at which they are travelling on their last completed lap (Heyward & Gibson, 2014; Melo et al., 2011). According to the test administration manual provided by The Cooper Institute©, the PACER test includes healthy fitness zone statistics for children of multiple ages. For example, in order for 10 year old females to reach the healthy fitness zone they must reach a VO_{2max} of greater than 38 ml/kg/min, 11 year olds – 37 ml/kg/min and 12 year olds – 36 ml/kg/min (Meredith & Welk, 1999). Within one large study of over 20,000 school age chidlren, females among the 9-12 year old age group produced average VO_{2max} values bewteen 33 ml/kg/min and 38 ml/kg/min (Carrel et al., 2012).

Evaluators must also be aware that shuttle run type test performance is an estimation of aerobic fitness, not a direct measure (Mayorga-Vega, Aguilar-Soto, & Viciana, 2015). In instances where VO_{2max} is being estimated, especially in children, the value may be more accurately represented as VO_{2peak} (Heyward & Gibson, 2014). Multiple calculations for estimating VO_{2peak} are available for use. One such equation that has been developed and validated is

VO_{2peak}=31.025+3.238(speed) – 3.248(age)(speed)(Léger, Mercier, Gadoury, & Lambert, 1988). This equation allows the researcher to estimate VO_{2peak} as long as the subject's age and running speed are known. A participant's running speed can be calculated using the distance travelled over the time within a lap or level during a shuttle run type exercise test. A limitation that must be recognized when using calculations such as Leger's VO_{2peak} prediction equation is that there is some systematic bias inherent within it (Melo et al., 2011). This systematic bias can result in an over-prediction of VO_2 in less fit participants and some under-prediction in participants with higher fitness levels (Melo et al., 2011).

Exertion levels must also be considered when determining whether an individual has reached VO_{2max} or not during an exercise test in a non-laboratory setting. One method that has previously been used to determine exertion levels is percent heart rate maximum (% HR_{max}) (Heyward & Gibson, 2014). When using % HR_{max}, the person's actual HR_{max} must be either known or predicted by equations such as: HR_{max}=208-0.7(age), (Mahon, Marjerrison, Lee, Woodruff, & Hanna, 2010). The above equation can closely predict mean HR_{max} in children, but one must be aware that individual variation is still possible due to physical and physiological maturity differences within younger age groups (Mahon et al., 2010).

(h) Statistical Analysis Review

The main objective of this study was to gain insight into the reliability of the Child SCAT 3 over repeated testing sessions in both baseline and post-exercise settings. In order to evaluate the null hypothesis, type 1 and type 2 errors must be avoided. A Type 1 error occurs when a researcher concludes that a real difference exists, when the difference is in fact due to chance (Portney &

Watkins, 2000). A Type 2 error involves a conclusion that the differences are due to chance when they are actually due to a true difference between groups of test results (Portney & Watkins, 2000). Both types of error can be affected by factors such as sample size and effect size, or in other words the power of the study. Power relates to the probability that a study can detect a true difference between two sets of scores. Small sample sizes may increase the chance of type 1 or type 2 error since power of a study decreases with a smaller sample size. The researcher must set a level of significance (alpha) in order to introduce a standard for accepting or rejecting the null hypothesis within a study (Portney & Watkins, 2000). Investigators must have the desired level of accuracy in mind when setting the level of significance and must consider the meaning of both statistical significance as well as clinical. For example, if an examiner was to look at children's flexibility on the sit and reach test at two different times as a test of their own reliability of their measurements, their study could potentially show a statistical difference from test one to test two. Yet clinically, the actual amount of difference between the scores is an important factor. If these children only showed a mean of 1 cm difference between tests, clinically the examiner could conclude that this is reasonable variation between scores that does not show a significant clinical difference.

Accuracy of a test like the Child SCAT 3 would ultimately be determined by how well it does its job of recognizing signs and symptoms of concussion, when the individual has actually suffered a concussion injury. Within the limits of the study, if the Child SCAT 3 is an accurate tool, the assumption would be made that individuals whom have not suffered a concussion should display results that support the null hypothesis. The ICC is such a statistic that provides a standardized, objective value of reliability in order to determine the reproducibility of results.

Reliability theory partitions an observed score into two components: a true component and an error component. The true component represents the real value under ideal conditions and error component represents all other sources of variance that influence the outcome of a measurement (Portney & Watkins, 2000). Therefore, since the current study is concerned with a set of repeated measurements collected by one person, all observed variance should theoretically be the result of error. The assumption in this case would be that the true response component has not changed from test #1 to test #2 because we are assessing the same person and using the same rater. The difficulty with this determination is that there are numerous variables, other than error, that have the potential to affect Child SCAT 3 scores, such as dehydration (Patel et al., 2007), and depression (G. L. Iverson, 2006) as well as a number of other modifying factors previously listed in section 4(c). In reality, reliability within the context of this study is based on the amount of error variance as well as true variance present in a set of scores.

Historically, testing reliability involves the use of correlation coefficients. However, there are two problems with the use of standard correlation coefficients:

1. They are limited as reliability coefficients because they are bivariate (only 2 ratings can be correlated at one time).

2. Correlation is not able to separate variance components due to error or true differences within a data set.

In the present study, the focus is to determine whether the Child SCAT 3 scores are correlated and statistically different, or poorly correlated and not statistically different. The intra-class correlation coefficient (ICC) is an index that is able to help answer these questions

The intra-class correlation coefficient is used to assess reliability between scores collected by the same examiner and ranges from 0.00 to 1.00. It is an important statistic in reliability studies because it represents both the degree of correspondence and degree of agreement among ratings. (Portney & Watkins, 2000). Recommended levels of reliability include 0.75 – 1.00 for good reliability, and less than 0.75 would be considered poor to moderate reliability (Portney & Watkins, 2000). However, Portney and Watkins (2000), suggest that ICC values should exceed 0.90 for clinical measurements, but ultimately this level must be set by the examiner according to what he or she determine to be an appropriate level of reliability within the context of their research. There are a number of different models of ICC calculations. In order to decide on the appropriate model to use within a study, the purpose, design and type of measurements being collected must all be taken into consideration. The ICC (model 3, 1) is appropriate for measuring intra-rater reliability where multiple scores are collected by the same rater.

To aid in the interpretation of reliability scores such as the ICC, confidence intervals can also be included in the results. Confidence intervals can be set at different levels, 90%, 95% or 99% and they establish a range of scores within which the researcher can be confident that the mean of the subjects' scores will fall. The calculation used for establishing confidence intervals is: CI = mean $\pm$ (t)(standard error). Standard error is determined by dividing the standard deviation by the square root of the total number of subjects (n) and the t value depends upon the confidence level set by the researcher (Portney & Watkins, 2000).

The ICC does however have a limitation. If the between subjects' variation is low, the ICC value can also come out lower than expected and an invalid negative or a misleading, low value can be produced. In this case, method error (ME) and the coefficient of variation of method error (CV_{ME}) can be used to examine the response stability in a test-retest situation (Portney & Watkins, 2000).

Method error reflects the percentage of variation or in other words, the response stability from trial to trial. It is commonly used as an adjunct to test-retest correlation statistics for this reason. Also, method error is not affected by a lack of variation in scores in the way in which the ICC can be (Portney & Watkins, 2000). The Standard error of measurement (SEM) can also be used as a measure of response stability, but in order to calculate it properly, the researcher must know the reliability coefficients from previous test-retest studies. In the absence of this knowledge, the CV_{ME} and ME are options for determining response stability values. ME looks at difference scores and the amount of variation between the test-retest scores. However, to get a true picture of response stability, these values must be interpreted relative to the size of the mean difference scores (Portney & Watkins, 2000). These calculations produce CV_{ME} values. The interpretation of CV_{ME} results is dependent upon the level of error described as acceptable by the researcher. Statistical as well as clinical considerations must be evaluated in order to set appropriate levels of error (Portney & Watkins, 2000). Method error is based on the variability within difference scores, however one drawback is that it does not account for any systematic variation between test 1 and test 2 scores (Portney & Watkins, 2000).

When investigating categorical data, non-parametric methods such as the kappa statistic and percent agreement can also be used as reliability measures. The Kappa statistic is a measure of agreement that takes into account a potential portion of the agreement that may be due to chance (Portney & Watkins, 2000). Its upper and lower limits are 0.00 and 1.00 respectively, A positive result occurs if the level of agreement is determined to be better than chance. Whereas, percent agreement measures the number of times in which two sets of scores match exactly from trial to trial.

Paired t-tests can be used to evaluate for systematic bias between test-retest scores. The primary purpose of t-tests is for detecting differences between sets of data. T-tests allow for the investigation of data sets by analyzing the difference scores so that the subjects' scores are only compared within themselves. The ability to look for systematic differences between data sets is imperative to test-retest type research, as it allows the researcher to utilize a concrete number within a normal distribution curve to determine whether a statistical difference exists or not between test scores.

Peripheral correlation data between physiological measurements (i.e. heart rate) and total Child SCAT 3 scores may add to the information regarding the relationship between exercise and Child SCAT 3 scores in children. The Pearson Product-Moment correlation coefficient can be used to determine whether a relationship exists between changes in heart rate and Child SCAT 3 scores. It also allows the researcher to determine the direction of the relationship between variables, i.e. a negative or positive correlation. The Pearson Product-Moment correlation coefficient is interested in the analysis of covariance between two variables (e.g. large score in variable one correlates with a large score in variable two). Correlations such as these are important to understand in order to develop the need to control for certain variables when health care providers are assessing any injury. Controlling for specific variables can work to improve the stability and reliability of an assessment tool by minimizing modifying factors which correlate to changes in assessment scores not related to the main function or purpose of the assessment.

Overall, within reliability research the investigator must be especially cognizant of the intended application of the data and the degree of precision that is required, within each reliability calculation, in order to be able to infer meaningful clinical decisions (Portney & Watkins, 2000).

(i) Summary

Concussion assessment and management has become an extremely important area of investigation, yet difficulties with the assessment process are still evident within the current literature. Assessment and management of concussion in children may involve even more challenges than adult assessment, as such, there is a need for a valid and reliable tool. Exercise is just one variable that can alter concussion assessment scores in adults and more investigation is required to see what acute exercise does to concussion assessment scores in children.

Since its inception, the Consensus Group on Concussion in Sport has made progress in the development of concussion assessment tools such as the Child SCAT 3. There is now a need to assess the performance of this tool in baseline and post-exercise settings in order to better understand how uninjured children score on the Child SCAT 3. In order to obtain baseline scores that will be useful comparisons for both on field and clinical post-injury assessments, we must understand the tool's reliability in uninjured children before and after they have been exercising. The consensus group itself recognizes the shortcomings of its assessment tools, such as the Child SCAT 3, and recommends that they not be used as stand-alone measurements of concussion, but as one piece of the concussion assessment puzzle (McCrory et al., 2013a). The consensus statement discusses the different physiological response, longer recovery and specific risks (e.g. diffuse cerebral swelling) of children versus adults with concussion injury. A more conservative return to play approach is recommended for children emphasizing the importance of accurate assessment to ensure that children are not needlessly pulled form athletic and academic activities and more importantly, not returned to these activities too soon after a concussive injury. The consensus group recommends that more research is needed in the area of concussion assessment and management, especially as it applies to children (McCrory et al., 2013a). With this in mind, the reliability of any assessment tool used to assess for concussions in children appears to be of utmost importance to ensure that proper care is being provided to our youth.

10. Objectives

The main objective of this study is to investigate the test-retest reliability of the Child SCAT 3 and its components in both a baseline and post-exercise setting in 9-12 year old females. There are three aims of this investigation:

1. To investigate the test-retest reliability of baseline and post-exercise Child SCAT 3 assessments.
2. To determine whether there is a difference between baseline and post-exercise Child SCAT 3 assessment scores.
3. To investigate if a correlation exists between physiological measurements and Child SCAT 3 scores in uninjured individuals.

11. Hypothesis

The Child SCAT 3 is a reliable concussion assessment tool when used in a baseline and post-exercise setting.

12. Methodology

(a) Participants

Healthy 9-12 year old female athletes were enrolled in the study. Assent from the child and informed consent from the parent/legal guardian were obtained prior to the subject commencing the study protocol. Each child's parent also completed a Physical Activity Readiness Questionnaire (PAR-Q) (Appendix 4) in order to ensure the safety of the child during the exercise component of this study's protocol.

The study was approved by the Biomedical Research Ethics Board of the University of Manitoba, ethics # B2014:069 (Appendix 5)

At the time of recruitment each subject had been participating in at least one organized sport. There was a wide variety of sports of which the individuals were enrolled (e.g. basketball, hockey, ringette, volleyball, soccer).

(b) Screening procedures

Exclusion criteria included the following:

1. Current symptomatic concussion.

2. Any orthopedic injury from which the individual has not recovered.

3. Underlying medical conditions precluding the individual from exercise participation, as indicated by the PAR-Q.

All testing procedures were explained thoroughly in order to ensure both the participant and their accompanying parent understood the procedures. Following the completion of the informed consent (Appendix 2) and assent (Appendix 3) forms, as well as the PAR-Q form by each participant and their parent or legal guardian, subjects completed a short questionnaire regarding their demographics. Each subject's standing height, seated height and weight were then measured for use in the calculation of the estimated age to peak height velocity (aphv). The Background section of the Child SCAT 3, including injury history and concussion co-morbidity questions, was then completed. (Appendix 1).

(c) Study Design

A repeated-measures design was used to evaluate the test-retest reliability of the Child SCAT 3 during two separate testing sessions. Each session evaluated the Child SCAT 3;

1) Prior to exercise (Baseline).

2) After the exercise test was completed (Post-exercise). A 10 minute rest period was given prior to administration of the Child SCAT 3 (as per the Child SCAT 3 instructions).

Each session consisted of an initial baseline test using the Child, SCAT 3 prior to the completion of a modified version of a graded field exercise test called the FITNESSGRAM© PACER test. Due to the size of the available gymnasium, the test was modified to the 15 meter distance instead of the standard 20 meter version.

Each child wore a Polar© heart rate monitor throughout the testing session in order to record heart rate values at the time of both Child SCAT 3 assessments as well as to determine their maximum heart rate during the exercise test. The child's initial resting heart rate was recorded just prior to the first Child SCAT 3 assessment. The heart rate was then monitored throughout the exercise test and the child's maximum heart rate during the test was recorded. Lastly, in order to monitor the child's recovery during the 10 minute rest period post-exercise, the subject's heart rate was recorded at the end of the rest period.

The first Child SCAT 3 assessment within each session was considered a baseline test. Then a post-exercise Child SCAT 3 test was administered following a 10 minute rest, after the exercise protocol was completed. All testing using the Child SCAT 3 was administered in accordance with the guidelines included on page 3 of the Child SCAT 3 protocol document. The standard instructions listed within the Child SCAT 3 were read to each child in order to ensure no bias was introduced by the study investigator during each assessment. These instructions and procedures are discussed in more detail in section 7(d) of this document. Each individual's lap count, maximum heart rate during the exercise test and Child SCAT 3 component scores (baseline and post-exercise) were recorded. All subject's heart rate values were recorded in order to utilize the physiological measurements in correlation with the Child SCAT 3 scores in each session. The effect of exercise on Child SCAT 3 scoring was determined by comparing baseline scoring versus post-exercise scoring following the administration of an aerobic field exercise test. In addition, the relationship between physiological parameters, such as heart rate, were examined in concert with scoring from the Child SCAT 3. Following the completion of the initial testing session, subjects were scheduled for a second session. Participants were asked to continue their regular home, school and physical activities over the course of their study involvement.

(d) Child SCAT 3 Administration

The Child SCAT 3 assessment is made up of 9 different sections and each section utilized within this study was applied using the instructions given on page 3 of the Child SCAT 3 document. Section 1, the Glasgow Coma Scale, was not used during this study because it is an assessment of consciousness after head injury and not necessary for the evaluation of uninjured individuals. Section 2 is the Child Maddocks Score is meant to be asked immediately after a concussion happens and is normally not asked upon follow-up. For the purposes of this reliability study, it was included in each retest session. The Child Report Symptom Evaluation, (section 3), was delivered as an interview and each child was asked to answer according to how she felt at the time of each assessment. For the 20 different symptoms listed, the child must rate each individual symptom on a scale of 0-3, where 0 = never, 1 = rarely, 2 = sometimes, 3 = often. At the end of this section the total number of symptoms as well as the total symptom severity score were calculated. Instructions were slightly different for parents to complete their part, the Parent Report of symptoms and severity (section 4). Each parent was asked to complete the baseline symptom report according to how the child has been over the past 24 hour period. Since the parent had somewhat limited interaction with the child during the 10 minute rest after exercise, they were asked to use their perception of how the child felt after exercising. Although, the parent and child were allowed to converse during the rest period. Scores for the parent symptom report components (number of symptoms and severity) were calculated in the same manner as the child symptom report.

For the Standardized Assessment of Concussion – Child Version (SAC-C) (section 5), different instructions were required for each different component of the SAC-C. Orientation questions were asked as listed in the tool. Immediate memory instructions were: “I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order" (McCrory et al., 2013a). Five words were then listed with an approximate one second pause between words. This section requires that the list of words be completed 3 times. Instructions for trials 2 and 3 were: "I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before" (McCrory et al., 2013a). A total score for the immediate memory component was then calculated as the sum of all correct answers within the three trials. None of the subjects were informed that delayed recall was to be tested upon completion of the other sections of the Child SCAT 3.

Next, the concentration section consisted of two parts, digits backwards and days of the week in reverse order. The instructions for the digits backwards section were, "I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you." (McCrory et al., 2013a). A two digit example was also given at that time. "If I say 6-2, you would say 2-6." One point was given for each string of numbers that were correctly completed. Subjects were then asked to list the days of the week in reverse order starting with Sunday and one point was given for completing the sequence correctly.

Examination of balance came next using the modified Balance Error Scoring System (BESS) (Guskiewicz, 2003). Each subject was informed that their balance was being tested, and that the test consisted of two parts, the double leg stance and tandem stance. A demonstration was given by the examiner in order to help the children understand the positions in which they were expected to stand. For the double leg stance, each participant was asked to stand with their feet together, hands on their hips and their eyes closed. They were informed that I was counting the number of times that the child moved out of position and that each test would be 20 seconds in duration. Children were then tested in the tandem stance positon which consists of standing with their non-dominant foot behind their dominant foot in a heel to toe fashion. All other aspects of the test were the same: hands on hips, eyes closed and test duration was 20 seconds. Types of errors for which the examiner was watching were as follows (as listed within the Child SCAT 3): 1.Hands lifted off iliac crest, 2. Opening eyes, 3. Step, stumble or fall, 4. Moving hip into >30 degrees of abduction, 5. Lifting forefoot or heel, 6. Remaining out of test position > 5 seconds. (McCrory et al., 2013a). One point was recorded per error on each balance test to give a total score for each of the different balance tests within this section of the Child SCAT 3.

A tandem gait exam was then performed. Each subject was instructed as follows: “Start with your feet together behind the start line, with shoes removed, then walk forward in a heel-toe fashion as quickly and accurately as possible. Once you reach the end of the 3m line, turn around and return to the starting point using the same gait throughout the test” (McCrory et al., 2013a). Participants were timed according to how long it took them to complete one lap to the end of the 3m line and back. Their best time over four trials was used as their score.

Section eight consisted of an upper limb coordination test or finger-to-nose task (FTN). The instructions read as follows: “I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm outstretched. When I give you a start signal, I would like you to perform five successive finger-to-nose repetitions using your index finger to touch the tip of your nose as quickly and accurately as possible.” (McCrory et al., 2013a). The tester also demonstrated the action that was expected of the subject. This test was timed and one point was earned if the participant completed the task accurately in less than four seconds. Failure to complete the five repetitions in under 4 seconds was scored as zero.

Finally, delayed recall was tested using the five words from the earlier immediate memory test. The subjects were asked, “Do you remember the list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order.” (McCrory et al., 2013a) The total score for delayed recall equaled the total number of words recalled out of a total of five.

(e) Statistical Analysis

Scores for each component of the Child SCAT 3 and the SAC-C component scores were recorded. The SAC-C component incorporated the Orientation, Immediate Memory, Concentration and Delayed Recall portions of the Child SCAT 3.

Statistically, the ICC (model 3,1) was calculated for each individual component score, the SAC-C scores within baseline and post-exercise assessment settings. Generally, values above 0.75 are reported to indicate good reliability and scores below 0.75 - poor to moderate reliability (Portney & Watkins, 2000). Because the clinical diagnosis of a concussion can be made simply by the presence of one symptom on the child symptom report, reliability findings within the study were held to a higher standard. A value of .85 was set as the minimum ICC value in order for the Child SCAT 3 or any of its components scores to obtain the rating of good reliability. As an adjunct to the ICC scores confidence intervals were calculated for each of the components. The confidence intervals were calculated using all sixty scores from each of the baseline and post-exercise test –retest scenarios at the level of 95% confidence.

Due to low variability of scores among subjects within certain components of the Child SCAT 3 assessment, method error (ME) and its coefficient of variation CV_{ME} were also calculated. The CV_{ME} allowed for the calculation of data regarding the response stability of each component.

Since the coefficient of variation is calculated in relation to the mean scores, the clinical significance of these values was determined individually.

Within components with categorical data, there was one dichotomous variable within the Child SCAT 3 (coordination). The Kappa statistic was used to look at the reliability for this component. Kappa values above 80% represented excellent agreement, between 60% and 80% demonstrated substantial levels of agreement, 40%-60% show moderate agreement and below 40% poor to fair agreement. For all other categorical data percent agreement calculations were used to help understand the reliability within these components.

Paired t-tests were performed in order to determine whether any systematic differences existed in four different situations:

- Baseline 1 vs baseline 2
- Post-exercise 1 vs post-exercise 2
- Session 1 (baseline and post-exercise scores)
- Session 2 (baseline and post-exercise scores).

Lastly, in order to investigate the relationship between recovery from exercise and Child SCAT 3 scores, the Pearson Product-Moment correlation coefficient was used. The use of this correlation also allowed for the determination of the direction of the relationship between variables (i.e. a negative or positive correlation).

Heart rate difference scores were calculated by subtracting the participant's initial resting heart rate from their heart rate after the 10 minute rest (post-exercise). This calculation allowed for the investigation of how closely each individual recovered back to their initial resting heart rate. Therefore, greater heart rate difference scores represented slower cardiovascular recovery within the participants. Correlations were then conducted in order to investigate a relationship between these heart rate measurements and scores on the total Child SCAT 3 assessment and two of its components, the Child Symptom Report (CSR) and Child Symptom Severity Report (CSS) for each testing session.

A formal sample size calculation was performed based on conventional effect sizes. Portney and Watkins (2000), describe conventional effect sizes as small (d=0.20), medium (d=0.50) and large (d=0.80). Since exercise has previously demonstrated an effect on concussion assessment scores in adults, a large effect size was assumed for this study. With d=0.80 at a power set at a minimum of 0.80, 26 subjects were required for this study. In order to account for possible attrition, 30 subjects were recruited to begin this investigation of the Child SCAT 3.

13. <u>Results</u>

(a) Demographics

Table 3 illustrates the demographic data for participants enrolled in this investigation. Subjects ranged from 9 to 12 years of age with a mean age of 10.8 upon recruitment to this study. The subjects reported being involved in a variety of sports including volleyball, ringette, hockey, synchronized swimming, basketball and track and field. Subjects participated in two sessions which occurred on average 32 days apart. As expected with a group of children approaching adolescence, a wide range of aphv values were found (28.8 months before the predicted aphv to 13.2 months beyond their expected date of aphv). Corresponding to this wide range of estimated aphv, the subjects also showed a large range in height (137cm - 186cm) and weight (28.3kg – 75kg) measurements. Paired t-tests revealed, a statistical difference for aphv, height and weight from session 1 to session 2, but clinically the differences appear minimal. For example, mean height changed by less than 1 cm and weight by less than 1 kg from measurements taken within session 1 to session 2**.**

Table 3. Demographics

Child SCAT 3 Component	Session 1 (n=30)	Session 2 (n=30)	t-test results (p value)
Chronological age	10.8±1.0 (9-12)	10.9±1.0 (9-12)	0.16
Predicted months to age of Peak Height Velocity (aphv)	-7.2±10.8 (-28.8 – 13.2)	-6.0±10.8* (-28.8 – 13.2)	<0.001
Height (cm)	149.7±8.68 (137.0 – 168.0)	150.5±8.8 * (137.2 – 168.0)	<0.001
Weight (kg)	38.9±10.2 (27.9 – 73.6)	39.6±10.4* (28.3 – 75)	<0.001
BMI	17.2±3.1 (14.6 – 26.1)	17.3±3.0 (14.8 – 26.3)	0.08
Days between testing sessions		32.2±17.7 (9-76)	

Values are mean ± standard deviation (range)

(b) Exercise Data

Table 4 provides key data regarding subject's participation in exercise. The average participant ran for approximately 10 minutes during their exercise test. On average the subjects reached 100% of their estimated heart rate maximum in each of the sessions during the exercise portion of the investigation. Within each of the heart rate measurements there was some variation among subjects which was reflected by the ranges in resting, maximal and recovery heart rates. VO_{2peak} was calculated using the equation: VO_{2peak} = 31.025+3.238(speed) – 3.248(age) (speed) (Léger et al., 1988). The estimated VO_{2peak} values for each session fell within the healthy fitness zone ($\geq$ 40.2 ml/kg/min), as listed within FITNESSGRAM® normative data for individuals in the age group which was tested. Mean VO_{2peak} values are represented in figure 2. None of the exercise data exhibited a significant statistical difference between session 1 and session 2 achievements of the participants. These exercise results revealed a relatively homogeneous and relatively physically fit group of 9-12 year old females that achieved very similar results on their exercise tests within the two different sessions.

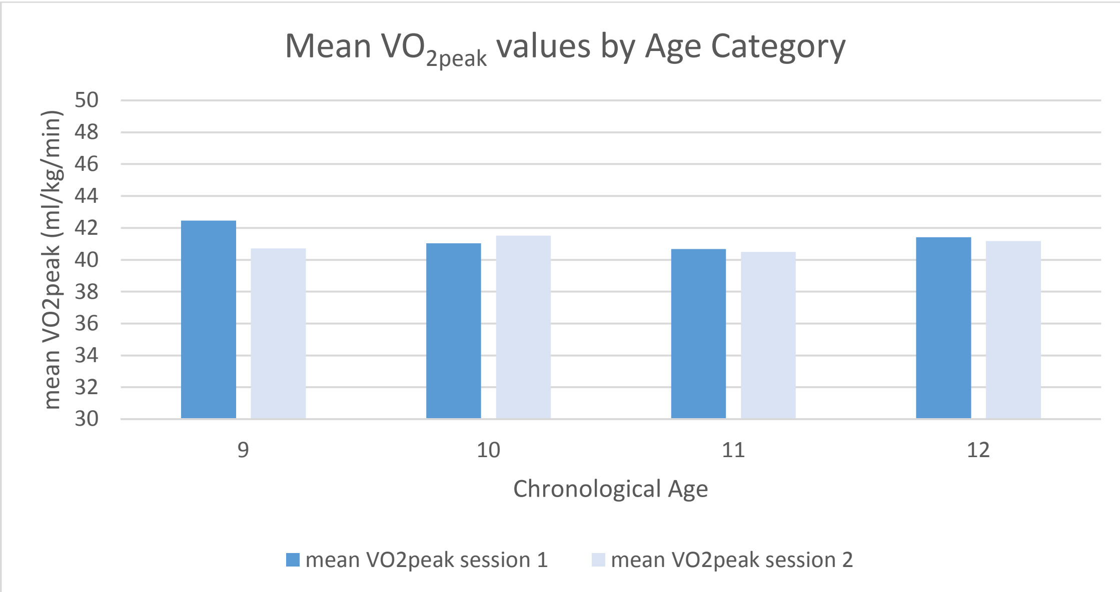
Within the literature, studies comparing different versions of the 20m shuttle run/PACER test yielded a range of reliability correlation coefficients from to .84 to .89 (Dinschel, 1995; Léger et al., 1988; Mahar et al., 1997). The ICC for the exercise test used in the current study was .85 when session1 and session 2 exercise test scores were compared. All data related to the exercise portion of the protocol is presented in Table 4.

Table 4. Exercise Data

Child SCAT 3 Component	Session 1 (n=30)	Session 2 (n=30)	t-test results (p value)
Exercise score (total laps)	92.3±27.89 (34-144)	92.7±30.41 (30 - 144)	p=0.89
VO2 peak (ml/kg/min)	41.1±4.31 (30.28 – 47.43)	40.9±4.78 (28.13 – 47.43)	p=0.68
Heart rate at time of 1st Child SCAT 3 test	84.5±12.12 (70-114)	85.7±9.95 (70 – 113)	p=0.46
Maximum heart rate during exercise	203.6±10.91 (170 – 219)	200.9±10.45 (184 – 219)	p=0.20
Heart rate at time of 2nd Child SCAT 3 test (after 10 minute rest)	104.1±12.10 (80 – 128)	100.3±12.08 (80 – 130)	p=0.40
Percentage of heart rate max achieved during exercise (%)	101.6±5.42 (84.9 – 107.7)	100.3±5.27 (89.9 – 107.2)	p=0.21

Values are mean ± standard deviation (range); Max heart rate estimation for children: = 208 – 0.7(age). (Mahon, et al 2010)

Figure 2.



(c) Reliability of the Child SCAT 3 at Baseline

Data demonstrating the level of reliability of Child SCAT 3 baseline scores is presented in table 5. Across the various components of the SCAT 3, very different ICC results were found. Only two components, the Child Symptom Report and Child Symptom Severity scores resulted in good reliability values (.83 and .87 respectively) with corresponding confidence intervals of 6.21 to 9.13 and 7.50 to 11.90 respectively.

Parent symptom report scores were complicated by the fact that the same parent (mother or father) could not bring his or her child to both testing sessions. Therefore, separate scores were calculated for those that had the same parent attend both sessions versus those participants that had different parents bring them to each session. The ICC when the same parent completed the symptom report and symptom severity report in each session was 0.66 and 0.68 respectively at baseline. These values miss reaching the threshold set for good reliability (0.85). ICC values were substantially lower, 0.27 (parent symptom report) and 0.41 (parent symptom severity report) when different parents evaluated the child in the baseline setting.

Tandem gait testing also revealed moderate reliability results. The ICC for tandem gait at baseline was 0.67 with a confidence interval of 13.28 seconds to 14.52 seconds. All of the other components had ICC values at or below 0.40. Difficulties with low variability among subject's scores likely attributed to the low, and in some cases invalid ICC values. These findings can be misleading. For example, the Child Maddocks and Orientation scores resulted in negative or invalid ICC scores. The highest possible raw scores within the Child Maddocks and Orientation categories were 4. Therefore, the potential for variability amongst scores was quite low and most subjects either scored a 3 or 4 out of 4 in each of these components during each testing session. Other variables such as Immediate Memory, Delayed Recall and the SAC-C all had low ICC scores that can also likely be attributed to low variability amongst the raw scores within each category. This appears to be demonstrated by the confidence intervals for these components which resulted in narrow confidence intervals (Table 5). For example, the confidence interval for delayed recall scores was 4.37 to 4.73.

Method error (ME) its coefficient of variation (CV_{ME}) were therefore used as an adjunct to ICC calculations to better understand the variability amongst subjects scores in the above categories. These values are also represented within tables 7 and 8, and are reported in more detail within section 13(e) of this document.

Table 5.

Test-Retest Reliability (ICC) by Component at Baseline

Child SCAT 3 Component	Baseline Test-retest reliability (ICC) n=30	95% Confidence Intervals (n=60)
Child Maddocks	0.070	(3.56, 3.84)
Child Symptom report	0.833	(6.21, 9.13)
Child Symptom severity	0.873	(7.50, 11.90)
Parent Symptom Report	ICC (all) = 0.537 ICC (same parent) = 0.655 ICC (different parent) = 0.271	(5.95, 8.31)
Parent Symptom Severity	ICC (all) =0.592 ICC (same parent)=0.681 ICC (different parent)=0.413	(6.57, 9.57)
Orientation	ICC=-0.081	(3.67, 3.89)
Immediate Memory	ICC=0.159	(14.13, 14.57)
Concentration	ICC=0.383	(3.91, 4.59)
BESS Tandem Stance	ICC=0.408	(1.09, 1.97)
Tandem Gait	ICC=0.674	(13.28, 14.52
Delayed Recall	ICC=0.289	(4.37, 4.73)
SAC-C total (orientation, immediate memory, concentration, delayed recall)	ICC=0.304	(26.35, 27.41)

(d) Reliability of the Child SCAT 3 Post-Exercise

Symptom report component scores were one facet of the assessment that produced evidence of improvement of the reliability scores from the baseline assessment to the post-exercise assessment. For example, the Child Symptom Report and Child Symptom Severity ICC values were 0.87 and 0.91 in the post-exercise setting, in comparison to 0.83 and 0.87 respectively at baseline.

Parent Symptom Report and Parent Symptom Severity report scores for those test-retest situations that involved the same parent evaluating the child's symptoms were 0.80 for the symptom report and 0.83 for symptom severity. Confidence intervals again showed a wider range of values in both the child and parent symptom score component as compared with other components of the Child SCAT 3.

The reliability value for Tandem Gait was 0.72 in the post-exercise setting which again shows moderate reliability. This improvement from 0.67 in the baseline setting may be attributable to the subjects learning how to perform the test more efficiently in subsequent repetitions of the test. Each participant's first attempt at the Tandem Gait test was likely during their first baseline testing session within this study, and the BESS has shown a learning effect within the available literature (Valovich et al., 2003).

Immediate Memory ICC scores improved from 0.16 to 0.42 from the baseline to post-exercise setting, but there was also slightly larger variability within this component's score when comparing post-exercise scores to baseline scores. These results add to the evidence that insufficient variability contributed to low ICC values, since the variability increased slightly, yet the reliability appeared to improve from baseline to post-exercise tests. Two components also produced invalid negative ICC values within both baseline and post-exercise Child SCAT 3 test settings (Child Maddocks and Orientation). As mentioned earlier, all other reliability scores that appear low have potentially been affected by the same issue of low variability amongst subject scores within those categories. The following components were investigated for this issue: Child Maddocks, Orientation, Immediate Memory, Concentration, BESS Tandem Stance, SAC-C Delayed Recall, and the total SAC-C). Within each of these components the range of scores was quite small. In a similar fashion to the baseline scores, the confidence intervals for the above listed components demonstrated narrow ranges within the post-exercise test scores. Response stability was therefore investigated next in order to account for the lack of variability amongst these Child SCAT 3 component scores.

Table 6.

Test-Retest Reliability (ICC) by Component Post-Exercise

Child SCAT 3 Component (n=30)	Post-exercise Test-retest reliability (ICC)	95% Confidence intervals (n=60)
Child Maddocks	ICC=-.015	(3.65, 3.89)
Child Symptom report	ICC=0.874	(5.23, 8.03)
Child Symptom severity	ICC=0.910	(6.19, 10.31)
Parent Symptom Report	ICC (all)=0.644 ICC (same parent)=0.795 ICC (different parent)=0.207	(5.32, 7.92)
Parent Symptom Severity	ICC (all) = 0.663 ICC (same parent)=0.828 ICC (different parent)=0.247	(5.96, 9.04)
Orientation	ICC=-0.074	(3.87, 3.99)
Immediate Memory	ICC=0.420	(13.48, 14.12)
Concentration	ICC=0.235	(4.32, 4.88)
BESS Tandem Stance	ICC=-0.008	(1.32, 2.24)
Tandem Gait	ICC=0.717	(12.28, 13.56)
Delayed Recall	ICC=-0.109	(3.66, 4.30)
SAC-C total (orientation, immediate memory, concentration, delayed recall)	ICC=0.259	(25.74, 26.90)

(e) Response Stability

Method Error (ME) and its coefficient of variation (CV_{ME}) were used to investigate the response stability within the difference scores of all components of the Child SCAT 3 including the total score. ME and CV_{ME} add to the reliability story by measuring the percent of variation from trial to trial in relation to the mean scores. The ICC does not account for this variation and the CV_{ME} was used as an adjunct to the ICC data already presented. ME and CV_{ME} findings are presented in figure 7 (Baseline) and figure 8 (Post-Exercise).

One CV_{ME} value that particularly stands out in both the baseline and post-exercise settings is the BESS Tandem Stance. The values produced were 83% at baseline and 103% post-exercise, meaning that error increased with exercise, but scores already appeared quite variable even in a baseline test. Here, low mean values may account for statistically high CV_{ME} calculations. Therefore, clinically if the mean score is only 1, then an increase of 1 error from test 1 to test 2 would cause a 100% increase in error. In balance testing, one error is not likely considered a clinically significant change in test-retest situations, especially when it comes to balance testing.

Among the different components of the Child SCAT 3, there was a wide range of CV_{ME} scores. The range of CV_{ME} scores amongst the 13 categories listed in figure 7 and 8 ranged from 5% to 83% at baseline and 6% to 103% after exercise. Some of the larger variability values came from the BESS Tandem Stance (83%), Parent Symptom Report (48%), Parent Symptom Severity (47%), Child Symptom Report (29%), Child Symptom Severity (29%), and Concentration (23%) at baseline. After exercise, the higher CV_{ME} values included the BESS Tandem Stance (103%), Parent Symptom Report (47%), Parent Symptom Severity (47%), Child Symptom Report (30%), Child Symptom Severity (29%), Concentration (20%) and SAC-C Delayed Recall (33%). Each of these percentages represents the variability within the difference scores from test 1 to test 2 and are calculated in relation to the mean scores for each of the components.

Table 7.

Test-Retest Response Stability (ME & CV_{ME}) by Component at Baseline

Child SCAT 3 Component	Method Error (ME)	Method Error – Coefficient of variation (CV_{ME})	Percent Agreement Within Component Scores
Child Maddocks	0.55	14.86%	60.00%
Child Symptom report	2.19	28.59%	13.33%
Child Symptom severity	2.78	28.66%	16.67%
Parent Symptom Report	3.40	48.29%	20.00%
Parent Symptom Severity	3.77	46.72%	13.33%
Orientation	0.43	16.12%	63.33%
Immediate Memory	0.74	5.16%	33.33%
Concentration	0.98	23.06%	20.00%
BESS Tandem Stance	1.27	83.01%	23.33%
Tandem Gait	1.38	9.93%	N/A
Delayed Recall	0.59	12.97%	36.67%
SAC-C total (orientation, immediate memory, concentration, delayed recall)	1.37	5.09%	N/A

Table 8.

Test-Retest Response Stability (CV_{ME}) by Component Post-Exercise

Child SCAT 3 Component (n=30)	Method Error (ME)	Method Error – Coefficient of variation (CV_{ME})	Percent Agreement Within Component Scores
Child Maddocks	0.45	11.95%	63.33%
Child Symptom report	1.96	29.54%	26.67%
Child Symptom severity	2.40	29.03%	23.33%
Parent Symptom Report	3.09	46.71%	10.00%
Parent Symptom Severity	3.55	47.33%	10.00%
Orientation	0.26	6.62%	86.67%
Immediate Memory	0.89	6.41%	30.00%
Concentration	0.94	20.35%	40.00%
BESS Tandem Stance	1.83	103.0%	20.00%
Tandem Gait	1.33	10.00%	N/A
Delayed Recall	1.33	33.38%	36.67%
SAC-C total (orientation, immediate memory, concentration, delayed recall)	1.83	6.95%	N/A

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(f) Non-Parametric Statistical Analysis

Kappa for Coordination Component of the Child SCAT 3

The coordination component of the Child SCAT 3 involves the child reaching out as far as they can, then touching their nose accurately 5 times within 4 seconds. If the participant did not complete the 5 repetitions accurately within the 4 second limit, the individual received a score of 0. If the repetitions were completed successfully within the time limit, then the participant received a score of 1. Since this component is a dichotomous variable, the Kappa statistic was used as a measure of agreement, to investigate the reliability of this one component. The measures of agreement are shown in table 9 as the Kappa statistic data for Baseline scores, Post-exercise scores as well as for the within session scores for each of the 2 sessions.

The rate of agreement for the baseline setting versus the post-exercise setting remained consistently poor (0.394 and 0.379 respectively). Although, within sessions the coordination scores improved to moderate to substantial levels of agreement (0.559 and 0.706) in comparison to between sessions scores (0.394 and 0.379). The Kappa values were higher in the second session in comparison to the first session demonstrating a potential learning effect for this coordination test.

Table 9. **Kappa for coordination component scores**

Test - Retest comparison	Kappa values	Significance level (p value)
Baseline (baseline 1 to baseline 2)	0.394	0.015
Post-Exercise (post-exercise1 to post-exercise 2)	0.379	0.037
Session 1 (baseline 1 to post-exercise 1)	0.559	0.001
Session 2 (baseline 2 to post-exercise 2)	0.706	0.0001

Percent Agreement

Utilization of percent agreement as a calculation of reliability demonstrated the vast variability both within and amongst Child SCAT 3 components. There were a few components, such as the BESS double leg stance, Child Maddocks, and coordination that showed percent agreement values that were as high as 90-100%, yet most of the other components produced agreement values at or below the 50% level.

Table 10. Percent Agreement

Child SCAT 3 component	Baseline 1- Baseline 2	Session 1: Baseline – Post-exercise	Session 2: Baseline – Post-exercise	Post-exercise 1- Post-exercise 2
Child Maddocks	18/30 = 60.0%	26/30 = 86.7%	26/30 = 86.7%	19/30 = 63.3%
Child Symptom Report	4/30 = 13.3%	8/30 = 26.7%	13/30 = 43.3%	8/30 = 26.7%
Child Symptom Severity	5/30 = 16.7%	8/30 = 26.7%	10/30 = 33.3%	7/30 = 23.3%
Parent Symptom Report	6/30 = 20.0%	12/30 = 40.0%	10/30 = 33.3%	3/30 = 10.0%
Parent Symptom Severity	4/30 = 13.3%	10/30 = 33.3%	9/30 = 30.0%	3/30 = 10.0%
Orientation	19/30 = 63.3%	26/30 = 86.7%	22/30 = 73.3%	26/30 = 86.7%
Immediate Memory	10/30 = 33.3%	10/30 = 33.3%	10/30 = 33.3%	9/30 = 30.0%
Concentration	6/30 = 20.0%	9/30 = 30.0%	12/30 = 40.0%	12/30 = 40.0%
BESS double leg stance	29/30 = 96.7%	29/30 = 96.7%	30/30 = 100%	30/30 = 100%
BESS tandem stance	7/30 = 23.3%	7/30 = 23.3%	14/30 = 46.7%	6/30 = 20.0%
Coordination	20/30 = 66.7%	24/30 = 80.0%	27/30 = 90.0%	23/30 = 76.7%
Delayed Recall	18/30 = 60.0%	15/30 = 50.0%	15/30 = 50.0%	11/30 = 36.7%

(g) T-Test results

Parametric statistics are presented in table 13 (Baseline), table 14 (Post-Exercise), table 15 (Session 1, pre and post-exercise) and table 16 (Session 2, pre and post-exercise). P-values associated with two of the t-tests are also provided in tables 5 and 7 (Baseline) and tables 6 and 8 (Post-Exercise).

T-tests were performed to investigate for systematic variation between test scores in four different circumstances: Baseline, post-exercise, within session 1 (baseline and post-exercise) and within session 2 (baseline and post-exercise) for the Child Symptom Report, Child Symptom Severity, Parent Symptom Report, Parent Symptom Severity, BESS Tandem Stance and Tandem Gait components. Baseline Child SCAT 3 scores within each of the above listed components demonstrated a significant difference in scores between test 1 and test 2 ($p \leq 0.01$). Within session 1, the Child Symptom Report, Child Symptom Severity, Parent Symptom Severity Report, and Tandem Gait components all demonstrated significant statistical differences between baseline and post-exercise assessments ($p \leq .01$). Again within session 2, all of these components were found to show a difference between baseline and post-exercise results at a level of $p \leq 0.01$. Scores between session 1 and session 2 in the baseline and post-exercise setting exhibited the same significant differences within the components of the Child SCAT 3 (Table 14), but the mean difference values decreased from the baseline to post-exercise tests. Overall, the mean absolute difference scores within the symptom report and severity scores (parent and child) ranged from 1-4.

Table 11.

Child SCAT 3 Component Scores: Test-Retest at Baseline

Child SCAT 3 Component	Baseline score: session 1 (n=30)	Baseline score: session 2 (n=30)	Mean Difference Scores:
# of Symptoms (child report)	8.33 ± 5.29 (0-19)	7.00 ± 5.95 (0-19)	2.66**
Symptom Severity (child report)	10.73 ± 8.43 (0-31)	8.67 ± 8.57 (0-32)	3.47**
# of Symptoms (parent report)	7.13 ± 4.46 (0-16)	13.17 ± 5.39 (0-16)	3.20**
Symptom Severity (parent report)	8.47 ± 5.60 (0-20)	7.67 ± 6.02 (0-21)	4.13**
BESS Tandem Stance (errors)	1.13 ± 1.23 (0-5)	2.17 ± 1.78* (0-6)	1.40**
Tandem Gait (seconds)	14.00 ± 2.19 (10.79-19.12)	13.80 ± 2.59 (9.57-21.65)	1.49**

Values are means ± standard deviations (n = 30)
(Range)
*** $p \leq 0.01$*

Table 12.

Child SCAT 3 Component Scores: Test-Retest **Post-exercise** session 1 and 2

Child SCAT 3 Component	Post-exercise score 1 (n=30)	Post-exercise score 2 (n=30)	Mean difference scores
# of Symptoms (child report)	6.87 ± 5.36 (0-19)	6.40 ± 5.54 (0-19)	2.07**
Symptom Severity (child report)	8.67 ± 8.29 (0-32)	7.83 ± 7.70 (0-30)	2.37**
# of Symptoms (parent report)	6.60 ± 4.66 (0-17)	6.63 ± 5.46 (0-17)	3.30**
Symptom Severity (parent report)	7.60 ± 5.77 (0-20)	7.40 ± 6.19 (0-21)	3.87**
BESS Tandem Stance (errors)	1.63 ± 1.52 (0-5)	1.93 ± 2.05 (0-6)	1.83**
Tandem Gait (seconds)	13.07 ± 2.55 (9.35-19.90)	12.76± 2.44 (8.47-19.56)	1.43**

Values are means ± standard deviations
(range)
*** p ≤ 0.01*

Table 13.

Child SCAT 3 Component Scores: Session 1 (Baseline vs Post-exercise)

Child SCAT 3 Component	Baseline score	Post-exercise score	Mean difference scores
# of Symptoms (child report)	8.33 ± 5.29 (0-19)	6.87 ± 5.36* (0-19)	1.80**
Symptom Severity (child report)	10.73 ± 8.43 (0-31)	8.67 ± 8.29* (0-32)	2.40**
# of Symptoms (parent report)	7.13 ± 4.46 (0-16)	6.60 ± 4.66 (0-17)	1.07**
Symptom Severity (parent report)	8.47 ± 5.60 (0-20)	7.60 ± 5.77* (0-20)	1.53**
BESS Tandem Stance (errors)	1.13 ± 1.23 (0-5)	1.63 ± 1.52 (0-5)	1.23**
Tandem Gait (seconds)	14.00± 2.19 (10.79-19.12)	13.07 ± 2.55* (9.35-19.90)	1.67**

Values are means ± standard deviations, (n = 30)
***p ≤ 0.01*

Table 14.

Child SCAT 3 Component Scores: Session 2 (Baseline vs Post-exercise)

Child SCAT 3 Component	Baseline score	Post-exercise score	Mean difference scores
# of Symptoms (child report)	7.00 + 5.95 (0-19)	6.40 + 5.54 (0-19)	1.13**
Symptom Severity (child report)	8.67 + 8.57 (0-32)	7.83 + 7.70* (0-30)	1.37**
# of Symptoms (parent report)	6.39 + 5.39 (0-16)	6.63 + 5.46 (0-17)	1.83**
Symptom Severity (parent report)	7.67 + 6.02 (0-21)	7.40 + 6.19 (0-21)	2.07**
BESS Tandem Stance (errors)	2.17 + 1.78 (0-6)	1.93 + 2.05 (0-6)	1.10**
Tandem Gait (seconds)	13.80 + 2.59 (9.57-21.65)	12.76 + 2.44* (8.47-19.56)	1.35**

Values are means + standard deviations (n = 30)
*** p < 0.01*

(h) Correlation testing of Physiological Data with Total Child SCAT 3 Scores and Child Symptom Report and Severity Scores

Tables 15-16 demonstrate correlation findings for six different comparisons:

- Child Symptom report scores to heart rate difference scores (session 1 and 2), and

- Child Symptom Severity Scores to heart rate difference scores (session 1 and 2).

The child symptom report and child symptom severity scores for session 1 demonstrated a correlation with heart rate difference scores that were significant at the level of $p \leq 0.01$. The correlation for the child symptom report scores and heart rate difference scores was calculated to be, r = 0.539 and for the child symptom severity scores, r = 0.620 (Tables 15 and 16) The critical values for r in this instance with degrees of freedom equal to 28 would be between 0.349 and 0.423 in order to reach a level of significance that would discount the null hypothesis. (Portney & Watkins, 2000). Since both were positive correlations, exercise appeared to cause an increase in the difference scores within session 1. However, within session 2, no such significant correlations were found using the same variables (Tables 15 and 16).

Table 15

Correlations within Sessions (baseline vs post-exercise) Child Symptom Report Difference Scores – Heart Rate Difference Scores	**Pearson Correlation (r)**	**Level of significance (2 tailed) P value**
Session 1	0.539*	0.002
Session 2	-0.173	0.360

Table 16

Correlations within sessions (baseline vs post-exercise) Child Symptom Severity Difference Scores – Heart Rate difference scores	**Pearson Correlation (r)**	**Level of significance (2 tailed) P value**
Session 1	0.620*	0.0001
Session 2	-0.202	0.284

14. Discussion

The present study utilized a prospective, clinical based test-retest design to investigate the reliability of the Child SCAT 3 in baseline and post-exercise settings for 9-12 year old females. Findings from this study provide normative data on Child SCAT 3 results in a healthy, active 9-12 year old female population. The results also aid in establishing the reliability limits of the Child SCAT 3 and its components. These results are significant because they provide important baseline clinical information that to date has not appeared in the concussion testing literature.

The participants within this study represented a homogeneous population of active 9-12 year old females. Subjects declared that they had been involved in a variety of sporting activities during the time span of the current study. Gender has been shown to be a possible modifying factor in the trajectory of concussion recovery and management (Covassin et al., 2006; G. Iverson & Stearne, 2006), therefore the current study included only female children in order to maintain specificity of the results.

As expected within a subject group of pre-teen females, the anthropometric data revealed a wide range of heights and weights. Due to this large range, aphv was calculated to predict each subject's approximate developmental age. Current literature regarding time frames between baseline testing and retesting of baseline assessments recommends that neurocognitive baseline testing be completed at a minimum of once per year for uninjured children due to continual changes in physical and cognitive development (Gioia, 2015c). The mean of 32 days between testing sessions obviously falls well within this guideline, and serves to minimize differences in test scores that would be attributed to true physical development or cognitive maturation.

Clinically, the anthropometric measurements displayed very minimal physical growth among the subjects from session #1 to session #2.

Exercise data revealed a mean predicted VO_{2peak} of just over 40 ml/kg/min, meaning that participants reached VO_{2peak} measurements that were within the healthy fitness zone as reported by FITENSSGRAM® normative data (Meredith & Welk, 1999). Mean heart rate maximums that were achieved during the exercise test were 204 in session one and 201 in session two. Over the two testing sessions, participants' scores on the exercise test showed no significant difference and the test-retest reliability of the current exercise test results was good (ICC of 0.85). High test-retest reliability, such as this, as well as the lack of statistical differences between the two sets of exercise results allows for the assumption that subjects exerted very similar effort in session #1 to session #2 during the exercise component of the study.

In order to obtain and interpret reliability results, the ICC, CV_{ME}, t-tests and the Kappa statistic were all used. The diversity of statistical methods that were used was a result of the variety of components within the Child SCAT 3 assessment. The ICC was only effective in situations where sufficient variation existed among the subjects' scores (e.g. Child symptom report and severity).

For an explanation of lower ICC values, the child's emotional and physical state at the time of the test should be considered as a factor in their symptom reports, as well as a factor that may affect their scores on a number of the other cognitive and physical components. School grade or age, and developmental differences within the pre-adolescent and adolescent age groups have also shown a tendency to affect concussion assessment scores (McCrory et al., 2013a; Schneider et al., 2010). Therefore, these factors may result in lower reliability values, or at the very least make it difficult to control for all variables when assessing children.

Individual components that demonstrated good or near good reliability values included the Child Symptom Report (ICC = 0.83 - 0.87) and Child Symptom Severity scores (ICC = 0.87 - 0.91). In both cases, the reliability scores improved from test session #1 to test session #2. These reliability findings concur with 2 previous studies where the reliability of symptom reporting was measured in adults (Mailer et al., 2008; Sady et al., 2014). ICC values within the studies by Mailer et al. and Sady et al., ranged from 0.65 to 0.89 for individual symptom scores and from 0.88 to 0.93 for total symptom scores. In theory, these reliability values are good, but for the purpose of concussion assessment even just one symptom can preclude an individual from being allowed to participate in an activity.

One previous study that investigated SCAT 2 scores in children (mean age 10.3) provided much lower reliability findings: 0.446 for the total SCAT 2 score, 0.725 for balance testing, 0.523 for SAC and 0.488 for symptom severity (Chan et al., 2013). The current study shows much better reliability for the total Child SCAT 3 scores overall. This may be an indication that modifications to the SCAT 2 for the development of the Child SCAT 3 have possibly caused some improvement in the overall reliability of the concussion assessment for uninjured children. Methodology between the study by Chan et al. and the current study may have contributed to a portion of the differences between the ICC values reported. Chan et al. (2013) used a 1 week interval between the test-retest sessions, whereas the current study used a more random time frame and averaged just over one month between test sessions. Different developmental levels of the children, potential learning effects, differences between males and females, as well as the inherent variability in the children's self-image and emotional status could have contributed to the range of reliability values listed above. Although there are a number of potential causes of variation in child symptom component scores, the confidence intervals discovered within this study allow for a better understanding of this variability, as well as contribute towards the development of preliminary normative data for 9-12 year old female athletes.

Within the current study, the Parent Symptom Report and Parent Symptom Severity scores revealed moderate reliability scores that closely approximated the level of good reliability set for this study, only in the post-exercise situation, where the same parent provided the symptom report in both session one and session two (ICC = 0.80 to 0.83). Symptom reports that were completed by a different parent in test session #1 versus test session #2 revealed much lower ICC values that ranged from 0.21 to 0.41. Also, the parent symptom report and severity scales seemed to rely on the parent's perception of how their child is feeling at the time of the assessment. This perception and therefore the answers within this component in turn, may have varied with the emotional, cognitive and physical state of both the child and parent at the time of the test session.

Lower reliability (ICC) values within other components of the Child SCAT 3 were investigated using calculations for response stability (CV_{ME}). In particular, the Child Symptom Report and Child Symptom Severity components of the assessment contributed CV_{ME} findings that ranged from 28-48% respectively. These percentages would represent approximate actual differences of 2 - 4 symptoms in the test-retest situations in uninjured individuals. Clinically, 2 - 4 symptoms can make a difference since the presence of only one symptom of concussion precludes an individual from progressing through the return to play protocol as suggested within the Consensus Statement on Concussion in Sport (McCrory et al., 2013a).

The highest CV_{ME} values appeared in the following components: Child Symptom Report, Child Symptom Severity, Parent Symptom Report, Parent Symptom Severity and Tandem Stance. One potential difficulty with the Tandem Stance error scores being so high is that the mean values from session #1 were quite low (1.13 and 1.63 respectively). In order to obtain the CV_{ME} scores of 83% and 103%, clinically the mean scores would only have to change by values of 1 to 1.5 respectively. The dichotomous coordination scores showed a range of reliability values using the Kappa statistic. Scores collected within the same session showed higher Kappa values than those collected across sessions, therefore demonstrating a potential practice effect for this specific component of the Child SCAT 3. Paired T-tests were used as an adjunct to ICC and CV_{ME} calculations and allowed for significant differences in test-retest scores within all components of the Child SCAT 3 to be investigated. Within the parametric statistical analysis, significant differences ($p \leq .01$) were found in a number of baseline and post-exercise situations (Child Symptom Report, Child Symptom Severity, Parent Symptom Report, Parent Symptom Severity, Tandem Gait and BESS Tandem Stance). In comparison only the Child Maddocks and Immediate Memory components showed a significant difference ($p \leq .01$) within the post-exercise test-retest scenario. This high number of statistically significant differences within these component scores may potentially be attributed to the participants' lack of experience with this test. All but two subjects had never experienced an assessment using the Child SCAT 3 prior to their first session in this study. Therefore, there may have been a learning effect within the first session in particular. More investigation is required to determine whether these differences can be attributed to learning effects, true differences in scores or strictly error.

An interesting finding of this investigation involves the Child Symptom Report and Child Symptom Severity component scores. When scores from before and after exercise were compared within each session, all mean scores within these two components decreased from the pre-exercise (baseline) to the post-exercise test scores. For example, the confidence interval in the baseline setting for the Child Symptom Severity component was 7.50 to 11.90 and after exercise the interval was 6.19 to 10.31. These results contradict previous adult studies that showed an increase in symptom reporting after exercise (Alla et al., 2010; Covassin et al., 2007). These studies unfortunately cannot be directly compared, as the adult studies used different symptom assessment tools than the one that Child SCAT 3 employs. Figure 3, displays a number of studies that concluded that exercise provoked neurological symptoms, headaches, concentration problems, and fatigue among other symptoms (Alla et al., 2010; Gaetz & Iverson, 2009).

A possible explanation for the decrease in symptom scores after exercise was offered within the study by Gaetz and Iverson (2009). They found that symptoms in the emotional domain, as well as reported headaches, decreased in females after exercise. The manner in which the symptom report is written for children in the Child SCAT 3 may possibly align their symptom report with how they are feeling emotionally and self-esteem wise. For example, the children are given statements about themselves such as "I have problems remembering what people tell me". Depending on the child's state of mind at the time of the assessment, and depending what has occurred recently at home or at school, these factors will contribute to their response about the reported symptoms, and the frequency at which they report these symptoms as occurring (never, rarely, sometimes or often). Basically, their answers to questions such as these could possibly be affected by their self-image at the time of the test. As concluded by Gaetz and Iverson (2009), their emotional state can be improved by exercise. The impact physical activity has on mental function in children has also been reported to be moderated by the child's fitness level (Tomporowski, Lambourne, & Okumura, 2011). In other words, more fit individuals are affected by bouts of exercise in a more positive manner cognitively and emotionally than less fit children (Tomporowski et al, 2011). As mentioned earlier, the participants within this study were found to be a relatively fit group of 9-12 year old females and therefore may have had the same potential for improvement on symptom scores after exercise. Interestingly, this study found a positive correlation between the total number and severity of symptoms reported by those children who had heart rates that were slower to recover from the exercise session in comparison to those that recovered closer to their resting heart rate within the 10 minute rest period. A wide range in resting heart rates was found within the study. This range in resting heart rates may possibly be attributed in part to anxiety, but the level of anxiety within the subjects was not measured during this investigation.

Significant correlations did exist between measures of recovery and Child Symptom Report and Child Symptom Severity scores in session one, but not session two. Therefore, care must be taken when children in this demographic are given the Child SCAT 3 for the first time. Learning effects must be investigated further. It is likely that the test should be given more than once in the baseline setting to ensure that children fully understands the manner in which they are to answer each of the symptom questions as well as understand the proper completion of each task.

15. **Study Limitations**

Learning effects may have contributed to the increased number of components appearing to be affected by exercise as this was the first time 28 of the 30 subjects had been exposed to the Child SCAT 3 assessment. A literature review suggested that previous practice and learning influences balance and cognitive variables of concussion assessment tools (Valovich et al., 2003). Therefore, it is possible that subjects may have developed an increased comfort level in completing the tasks within the Child SCAT 3 over the second, third and fourth repetitions of the assessment throughout the current study's protocol. One practice session with the Child SCAT 3 assessment may have been beneficial prior to the start of this study to help decrease the possibility of this practice effect.

Another difficulty was the scheduling of sessions. Due to the lack of availability of gym time, as well as the busy schedules of the children and their parents it was not possible to set standard times between sessions for each child. The longer time lapse (up to 76 days) between sessions may have increased the chance of true developmental change in the children.

The exercise test allowed for a somewhat realistic sport setting where the children were encouraged to give their best effort, but ultimately it was up to each child to individually determine their level of exertion.. The indirect measurement methods of the field exercise test was cause for estimation of the subjects' VO_{2peak} values. Recovery data that monitored heart rates, as the participants' heart rates returned toward a resting state, was utilized in order to estimate each individual's recovery from exercise. In the future, more direct measurement of physiological parameters may be beneficial to determine both exercise intensity as well as directly monitor recovery from exercise in order to correlate the data with concussion assessment scores.

The cohort of participants that were recruited for this study allowed for specificity as it relates to 9-12 year old females, but this weakens the generalizability to the entire population for which the Child SCAT 3 is intended (5-12 year old children).

16. Future Directions of Research

Future studies should involve the Child and Parent Symptom Report components of the Child SCAT 3, as well as a subject pool that includes males of the same age in order to compare the results to the 9-12 year old female cohort. Since the Child SCAT 3 is suggested to be used for the assessment of 5-12 year old children, younger children should also be examined. These comparisons would allow for improved generalizability of results, as well as contributing to a valuable base of normative data relative to the population for which the Child SCAT 3 is intended.

The Child Symptom Report component of the Child SCAT 3 may be especially worthy of further study. Since the symptom report items appear somewhat linked to the child’s emotional state and/or their self-esteem at the time of assessment, further investigation in this area would be extremely helpful. This could include neuro-psychological assessments within a reliability study of symptom reporting in children, as it may help in the explanation of changes in symptom reporting both in a baseline setting as well as after exercise.

The use of the Child SCAT 3 as a field or clinical tool must still be considered only part of a complete concussion assessment. It appears that the Child SCAT 3 may be overly sensitive to symptoms as the mean number of symptoms in uninjured individuals ranged from 6-8 prior to and after a bout of aerobic exercise. Its validity and sensitivity are still in need of investigation in injured individuals, as a comparison between injured and uninjured children was not part of this study's protocol. As with many aspects of concussion evaluation in children, further study is required in order to ensure advancement of the assessment techniques for injured individuals. Accuracy of specific symptom reports, as well as concussion assessments in general, remain of utmost importance when health care providers are attempting to make return to play and return to learn decisions.

17. Conclusion

Overall, the Child SCAT 3 appears to be a moderately reliable tool that can be used by health care professionals trained in concussion assessment, but the varying levels of reliability of the components of the tool can come into question. Therefore, health care providers still need to be aware that the Child SCAT 3 should be used as one piece of the puzzle of within a concussion assessment and it still does not appear to be all encompassing. Accuracy of symptom reports and concussion assessments in general, continue to be an extremely important aspect when managing concussions. In particular, the accuracy or reliability of an assessment tool is magnified when a health care provider has to make a return to learn or return to play decision for an injured child. More study is necessary to continue working towards a gold standard concussion assessment tool for 5-12 year old children.

18. **Bibliography**

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Appendix 1

Child-SCAT3™

FIFA FEI

Sport Concussion Assessment Tool for children ages 5 to12 years

For use by medical professionals only

What is childSCAT3?[1]

The ChildSCAT3 is a standardized tool for evaluating injured children for concussion and can be used in children aged from 5 to 12 years. It supersedes the original SCAT and the SCAT2 published in 2005 and 2009, respectively[2]. For older persons, ages 13 years and over, please use the SCAT3. The ChildSCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool[1]. Preseason baseline testing with the ChildSCAT3 can be helpful for interpreting post-injury test scores.

Specific instructions for use of the ChildSCAT3 are provided on page 3. If you are not familiar with the ChildSCAT3, please read through these instructions carefully. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision and any reproduction in a digital form require approval by the Concussion in Sport Group.

NOTE: The diagnosis of a concussion is a clinical judgment, ideally made by a medical professional. The ChildSCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgement. An athlete may have a concussion even if their ChildSCAT3 is "normal".

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and/or symptoms (like those listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of any one or more of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more severe brain injury. If the concussed child displays any of the following, then do not proceed with the ChildSCAT3, instead activate emergency procedures and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Deteriorating mental status
- Potential spinal injury
- Progressive, worsening symptoms or new neurologic signs
- Persistent vomiting
- Evidence of skull fracture
- Post traumatic seizures
- Coagulopathy
- History of Neurosurgery (eg Shunt)
- Multiple injuries

1 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

Potential signs of concussion?

If any of the following signs are observed after a direct or indirect blow to the head, the child should stop participation, be evaluated by a medical professional and **should not be permitted to return to sport the same day** if a concussion is suspected.

Any loss of consciousness?	Y N
"If so, how long?"	
Balance or motor incoordination (stumbles, slow/laboured movements, etc.)?	Y N
Disorientation or confusion (inability to respond appropriately to questions)?	Y N
Loss of memory:	Y N
"If so, how long?"	
"Before or after the injury?"	
Blank or vacant look:	Y N
Visible facial injury in combination with any of the above:	Y N

2 Sideline Assessment – child-Maddocks Score[3]

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

Where are we at now?	0	1
Is it before or after lunch?	0	1
What did you have last lesson/class?	0	1
What is your teacher's name?	0	1
child-Maddocks score		of 4

Child-Maddocks score is for sideline diagnosis of concussion only and is not used for serial testing.

Any child with a suspected concussion should be REMOVED FROM PLAY, medically assessed and monitored for deterioration (i.e., should not be left alone). No child diagnosed with concussion should be returned to sports participation on the day of injury.

BACKGROUND

Name: ______ Date/Time of Injury: ______

Examiner: ______ Date of Assessment: ______

Sport/team/school: ______

Age: ______ Gender: M F

Current school year/grade: ______

Dominant hand: right left neither

Mechanism of Injury ("tell me what happened"?): ______

For Parent/carer to complete:

How many concussions has the child had in the past?	
When was the most recent concussion?	
How long was the recovery from the most recent concussion?	
Has the child ever been hospitalized or had medical imaging done (CT or MRI) for a head injury?	Y N
Has the child ever been diagnosed with headaches or migraines?	Y N
Does the child have a learning disability, dyslexia, ADD/ADHD, seizure disorder?	Y N
Has the child ever been diagnosed with depression, anxiety or other psychiatric disorder?	Y N
Has anyone in the family ever been diagnosed with any of these problems?	Y N
Is the child on any medications? If yes, please list:	Y N

SYMPTOM EVALUATION

3 Child report

Name: ______________________

	never	rarely	sometimes	often
I have trouble paying attention	0	1	2	3
I get distracted easily	0	1	2	3
I have a hard time concentrating	0	1	2	3
I have problems remembering what people tell me	0	1	2	3
I have problems following directions	0	1	2	3
I daydream too much	0	1	2	3
I get confused	0	1	2	3
I forget things	0	1	2	3
I have problems finishing things	0	1	2	3
I have trouble figuring things out	0	1	2	3
It's hard for me to learn new things	0	1	2	3
I have headaches	0	1	2	3
I feel dizzy	0	1	2	3
I feel like the room is spinning	0	1	2	3
I feel like I'm going to faint	0	1	2	3
Things are blurry when I look at them	0	1	2	3
I see double	0	1	2	3
I feel sick to my stomach	0	1	2	3
I get tired a lot	0	1	2	3
I get tired easily	0	1	2	3

Total number of symptoms (Maximum possible 20)

Symptom severity score (Maximum possible 20 x 3 = 60)

☐ self rated ☐ clinician interview ☐ self rated and clinician monitored

4 Parent report

The child	never	rarely	sometimes	often
has trouble sustaining attention	0	1	2	3
is easily distracted	0	1	2	3
has difficulty concentrating	0	1	2	3
has problems remembering what he/she is told	0	1	2	3
has difficulty following directions	0	1	2	3
tends to daydream	0	1	2	3
gets confused	0	1	2	3
is forgetful	0	1	2	3
has difficulty completing tasks	0	1	2	3
has poor problem solving skills	0	1	2	3
has problems learning	0	1	2	3
has headaches	0	1	2	3
feels dizzy	0	1	2	3
has a feeling that the room is spinning	0	1	2	3
feels faint	0	1	2	3
has blurred vision	0	1	2	3
has double vision	0	1	2	3
experiences nausea	0	1	2	3
gets tired a lot	0	1	2	3
gets tired easily	0	1	2	3

Total number of symptoms (Maximum possible 20)

Symptom severity score (Maximum possible 20 x 3 = 60)

Do the symptoms get worse with physical activity? ☐ Y ☐ N

Do the symptoms get worse with mental activity? ☐ Y ☐ N

☐ parent self-rated ☐ clinician interview ☐ parent self-rated and clinician monitored

Overall rating for parent/teacher/coach/carer to answer.
How different is the child acting compared to his/her usual self?

Please circle one response:

no different | very different | unsure | N/A

Name of person completing Parent report: ______________________

Relationship to child of person completing Parent report: ______________________

Scoring on the ChildSCAT3 should not be used as a stand-alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion.

COGNITIVE & PHYSICAL EVALUATION

5 Cognitive assessment

Standardized Assessment of Concussion – Child Version (SAC-C)[4]

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1

Orientation score of 4

Immediate memory

List	Trial 1		Trial 2		Trial 3		Alternative word list		
elbow	0	1	0	1	0	1	candle	baby	finger
apple	0	1	0	1	0	1	paper	monkey	penny
carpet	0	1	0	1	0	1	sugar	perfume	blanket
saddle	0	1	0	1	0	1	sandwich	sunset	lemon
bubble	0	1	0	1	0	1	wagon	iron	insect
Total									

Immediate memory score total of 15

Concentration: Digits Backward

List	Trial 1		Alternative digit list		
6-2	0	1	5-2	4-1	4-9
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 5					

Concentration: Days in Reverse Order (1 pt. for entire sequence correct)

Sunday-Saturday-Friday-Thursday-Wednesday-Tuesday-Monday 0 1

Concentration score of 6

6 Neck Examination:

Range of motion Tenderness Upper and lower limb sensation & strength

Findings: ______________________

7 Balance examination

Do one or both of the following tests.

Footwear (shoes, barefoot, braces, tape, etc.) ______________________

Modified Balance Error Scoring System (BESS) testing[5]

Which foot was tested (i.e. which is the **non-dominant foot**) ☐ Left ☐ Right

Testing surface (hard floor, field, etc.) ______________________

Condition

Double leg stance: Errors

Tandem stance (non-dominant foot at back): Errors

Tandem gait[6,7]

Time taken to complete (best of 4 trials): ________ seconds

If child attempted, but unable to complete tandem gait, mark here ☐

8 Coordination examination

Upper limb coordination

Which arm was tested: ☐ Left ☐ Right

Coordination score of 1

9 SAC Delayed Recall[4]

Delayed recall score of 5

Since signs and symptoms may evolve over time, it is important to consider repeat evaluation in the acute assessment of concussion.

INSTRUCTIONS

Words in *italics* throughout the ChildSCAT3 are the instructions given to the child by the tester.

Sideline Assessment – child-Maddocks Score

To be completed on the sideline/in the playground, immediately following concussion. There is no requirement to repeat these questions at follow-up.

Symptom Scale[8]

In situations where the symptom scale is being completed after exercise, it should still be done in a resting state, at least 10 minutes post exercise.

On the day of injury

- the child is to complete the Child Report, according to how he/she feels now.

On all subsequent days

- the child is to complete the Child Report, according to how he/she feels today, **and**
- the parent/carer is to complete the Parent Report according to how the child has been over the previous 24 hours.

Standardized Assessment of Concussion – Child Version (SAC-C)[4]

Orientation

Ask each question on the score sheet. A correct answer for **each question scores 1 point.** If the child does not understand the question, gives an incorrect answer, or no answer, then the score for that question is 0 points.

Immediate memory

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Complete all 3 trials regardless of score on trial 1 & 2. Read the words at a rate of one per second. **Score 1 pt. for each correct response.** Total score equals sum across all 3 trials. Do not inform the child that delayed recall will be tested.

Concentration

Digits Backward:

"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1, you would say 1-7."

If correct, go to next string length. If incorrect, read trial 2. **One point possible for each string length.** Stop after incorrect on both trials. The digits should be read at the rate of one per second.

Days in Reverse Order:

"Now tell me the days of the week in reverse order. Start with Sunday and go backward. So you'll say Sunday, Saturday ... Go ahead"

1 pt. for entire sequence correct

Delayed recall

The delayed recall should be performed after completion of the Balance and Coordination Examination.

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Circle each word correctly recalled. **Total score equals number of words recalled.**

Balance examination

These instructions are to be read by the person administering the childSCAT3, and each balance task **should be demonstrated to the child.** The child should then be asked to copy what the examiner demonstrated.

Modified Balance Error Scoring System (BESS) testing[5]

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[5]. A stopwatch or watch with a second hand is required for this testing.

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of two different parts."

(a) Double leg stance:

The first stance is standing with the feet together with hands on hips and with eyes closed. The child should try to maintain stability in that position for 20 seconds. You should inform the child that you will be counting the number of times the child moves out of this position. You should start timing when the child is set and the eyes are closed.

(b) Tandem stance:

Instruct the child to stand heel-to-toe with the non-dominant foot in the back. Weight should be evenly distributed across both feet. Again, the child should try to maintain stability for 20 seconds with hands on hips and eyes closed. You should inform the child that you will be counting the number of times the child moves out of this position. If the child stumbles out of this position, instruct him/her to open the eyes and return to the start position and continue balancing. You should start timing when the child is set and the eyes are closed.

Balance testing – types of errors – Parts (a) and (b)

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the child. The examiner will begin counting errors only after the child has assumed the proper start position. **The modified BESS is calculated by adding one error point for each error during the two 20-second tests. The maximum total number of errors for any single condition is 10.** If a child commits multiple errors simultaneously, only one error is recorded but the child should quickly return to the testing position, and counting should resume once subject is set. Children who are unable to maintain the testing procedure for a minimum of **five seconds** at the start are assigned the highest possible score, ten, for that testing condition.

OPTION: For further assessment, the same 2 stances can be performed on a surface of medium density foam (e.g., approximately 50cm x 40cm x 6cm).

Tandem Gait[6,7]

Use a clock (with a second hand) or stopwatch to measure the time taken to complete this task. Instruction for the examiner – **Demonstrate the following to the child:**

The child is instructed to stand with their feet together behind a starting line (the test is best done with footwear removed). Then, they walk in a forward direction as quickly and as accurately as possible along a 38mm wide (sports tape), 3 meter line with an alternate foot heel-to-toe gait ensuring that they approximate their heel and toe on each step. Once they cross the end of the 3m line, they turn 180 degrees and return to the starting point using the same gait. **A total of 4 trials are done and the best time is retained.** *Children fail the test if they step off the line, have a separation between their heel and toe, or if they touch or grab the examiner or an object. In this case, the time is not recorded and the trial repeated, if appropriate.*

Explain to the child that you will time how long it takes them to walk to the end of the line and back.

Coordination examination

Upper limb coordination

Finger-to-nose (FTN) task:

The tester should **demonstrate it to the child.**

"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended). When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose as quickly and as accurately as possible."

Scoring: 5 correct repetitions in < 4 seconds = 1

Note for testers: Children fail the test if they do not touch their nose, do not fully extend their elbow or do not perform five repetitions. **Failure should be scored as 0.**

References & Footnotes

1. This tool has been developed by a group of international experts at the 4th International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2012. The full details of the conference outcomes and the authors of the tool are published in The BJSM Injury Prevention and Health Protection, 2013, Volume 47, Issue 5. The outcome paper will also be simultaneously co-published in other leading biomedical journals with the copyright held by the Concussion in Sport Group, to allow unrestricted distribution, providing no alterations are made.

2. McCrory P et al., Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. British Journal of Sports Medicine 2009; 43: i76–89.

3. Maddocks, DL; Dicker, GD; Saling, MM. The assessment of orientation following concussion in athletes. Clinical Journal of Sport Medicine. 1995; 5(1): 32–3.

4. McCrea M. Standardized mental status testing of acute concussion. Clinical Journal of Sport Medicine. 2001; 11: 176–181.

5. Guskiewicz KM. Assessment of postural stability following sport-related concussion. Current Sports Medicine Reports. 2003; 2: 24–30.

6. Schneiders, A.G., Sullivan, S.J., Gray, A., Hammond-Tooke, G. & McCrory, P. Normative values for 16-37 year old subjects for three clinical measures of motor performance used in the assessment of sports concussions. Journal of Science and Medicine in Sport. 2010; 13(2): 196–201.

7. Schneiders, A.G., Sullivan, S.J., Kvarnstrom, J.K., Olsson, M., Yden, T. & Marshall, S.W. The effect of footwear and sports-surface on dynamic neurological screening in sport-related concussion. Journal of Science and Medicine in Sport. 2010; 13(4): 382–386.

8. Ayr, L.K., Yeates, K.O., Taylor, H.G., & Brown, M. Dimensions of post-concussive symptoms in children with mild traumatic brain injuries. Journal of the International Neuropsychological Society. 2009; 15:19–30.

CHILD ATHLETE INFORMATION

Any child suspected of having a concussion should be removed from play, and then seek medical evaluation. The child must NOT return to play or sport on the same day as the suspected concussion.

Signs to watch for

Problems could arise over the first 24–48 hours. The child should not be left alone and must go to a hospital at once if they develop any of the following:

- New Headache, or Headache gets worse
- Persistent or increasing neck pain
- Becomes drowsy or can't be woken up
- Can not recognise people or places
- Has Nausea or Vomiting
- Behaves unusually, seems confused, or is irritable
- Has any seizures (arms and/or legs jerk uncontrollably)
- Has weakness, numbness or tingling (arms, legs or face)
- Is unsteady walking or standing
- Has slurred speech
- Has difficulty understanding speech or directions

Remember, it is better to be safe.
Always consult your doctor after a suspected concussion.

Return to school

Concussion may impact on the child's cognitive ability to learn at school. This must be considered, and medical clearance is required before the child may return to school. **It is reasonable for a child to miss a day or two of school after concussion, but extended absence is uncommon.** In some children, a graduated return to school program will need to be developed for the child. The child will progress through the return to school program provided that there is no worsening of symptoms. If any particular activity worsens symptoms, the child will abstain from that activity until it no longer causes symptom worsening. Use of computers and internet should follow a similar graduated program, provided that it does not worsen symptoms. This program should include communication between the parents, teachers, and health professionals and will vary from child to child. The return to school program should consider:

- Extra time to complete assignments/tests
- Quiet room to complete assignments/tests
- Avoidance of noisy areas such as cafeterias, assembly halls, sporting events, music class, shop class, etc
- Frequent breaks during class, homework, tests
- No more than one exam/day
- Shorter assignments
- Repetition/memory cues
- Use of peer helper/tutor
- Reassurance from teachers that student will be supported through recovery through accommodations, workload reduction, alternate forms of testing
- Later start times, half days, only certain classes

The child is not to return to play or sport until he/she has successfully returned to school/learning, without worsening of symptoms. Medical clearance should be given before return to play.

If there are any doubts, management should be referred to a qualified health practitioner, expert in the management of concussion in children.

Return to sport

There should be no return to play until the child has successfully returned to school/learning, without worsening of symptoms.
Children must not be returned to play the same day of injury.
When returning children to play, they should **medically cleared and then follow a stepwise supervised program,** with stages of progression.

For example:

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
No activity	Physical and cognitive rest	Recovery
Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity, 70% maximum predicted heart rate. No resistance training	Increase heart rate
Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
Non-contact training drills	Progression to more complex training drills, eg passing drills in football and ice hockey. May start progressive resistance training	Exercise, coordination, and cognitive load
Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
Return to play	Normal game play	

There should be approximately 24 hours (or longer) for each stage and the child should drop back to the previous asymptomatic level if any post-concussive symptoms recur. Resistance training should only be added in the later stages.
If the child is symptomatic for more than 10 days, then review by a health practitioner, expert in the management of concussion, is recommended.
Medical clearance should be given before return to play.

Notes:

CONCUSSION INJURY ADVICE FOR THE CHILD AND PARENTS / CARERS

(To be given to the **person monitoring** the concussed child)

This child has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. It is expected that recovery will be rapid, but the child will need monitoring for the next 24 hours by a responsible adult.

If you notice any change in behavior, vomiting, dizziness, worsening headache, double vision or excessive drowsiness, please call an ambulance to transport the child to hospital immediately.

Other important points:

- Following concussion, the child should rest for at least 24 hours.
- The child should avoid any computer, internet or electronic gaming activity if these activities make symptoms worse.
- The child should not be given any medications, including pain killers, unless prescribed by a medical practitioner.
- The child must not return to school until medically cleared.
- The child must not return to sport or play until medically cleared.

Clinic phone number

Patient's name

Date/time of injury

Date/time of medical review

Treating physician

Contact details or stamp

Appendix 2

Research Participant Information and Consent Form

Title of Study: Child Sport Concussion Assessment Tool 3 (Child SCAT 3) Component Scores in Non-Concussed Children at Rest and After Exercise

Protocol Number: ________

Principal Investigator: Dr. Jason Peeler, University of Manitoba, 102-745 Bannatyne Ave, Winnipeg, Manitoba, R3E 0J9, (204) 272-3146

Co-Investigator 1: Jeff Leiter, Pan Am Clinic Foundation, 75 Poseidon Bay, Winnipeg, Manitoba, R3M 3E4, (204) 927-2665

Co-investigator 2: Jeff Billeck, 400 Spence St., Winnipeg, Manitoba, R3B 2E9, (204) 391-3047

You and your child are being asked to participate in a research study. Please take your time to review this consent form and discuss any questions either of you may have with the study staff. You may take your time to make your decision about participating in this study as well as allowing your child to participate. You may discuss it with your friends, family or your doctor before you make your decision. This consent form may contain words that you or your child do not understand. Please ask the study staff to explain words or information that you do not clearly understand.

Purpose of Study

This research study is being conducted to study the effects of maximal exercise on Child SCAT 3 scores in non-injured children. The objective of this study is to investigate the reliability of the Child SCAT 3 in both a baseline and post-exercise setting.

A total of 29 participants will participate in this study.

Study Procedures

If you take part in this study, you will have the following procedures:

1. A baseline Child SCAT 3 test prior to exercise. The Child SCAT 3 is an assessment tool that is currently used to detect concussions in children. It asks questions to the parent and child regarding how your child is feeling and acting, as well as testing other brain functions, such as balance, coordination and memory.

2. An exercise test will then be conducted. The exercise test consists of a progressively difficult exercise test (PACER test) that will help us measure the child's aerobic fitness level. This is a test that most children have completed previously within their school's physical education curriculum.
3. A Child SCAT 3 test 10 minutes after the exercise test is completed.

These procedures will be followed during two separate sessions conducted at Pan Am Clinic Foundation facility. Each visit will take approximately 45 minutes to complete all testing.

Participation in the study will be for 2 sessions conducted approximately 30 days apart.

The researcher may decide to take your child off this study if he/she has any current medical problems that preclude him/her from exercise participation or a history of concussion within the last 12 months.

Your child can stop participating at any time. However, if you or your child decide to stop participating in the study, we encourage you to talk to the study staff first.

Individual results may be provided upon request after each testing session has been completed.

<u>Risks and Discomforts</u>

Potential risks and discomforts are related to the maximal exercise test. Muscle soreness and fatigue may result from the completion of the PACER test.

<u>Benefits</u>

There may or may not be direct benefit to you or your child from participating in this study. This study will provide your child with a measure of his/her cardiovascular fitness as well as provide him/her with a baseline concussion assessment. We hope the information learned from this study will benefit other people with concussions in the future.

<u>Costs</u>

All the procedures, which will be performed as part of this study, are provided at no cost to you or your child. The study is receiving professional fees and financial support from the Pan Am Clinic Foundation to conduct this study.

Confidentiality

Information gathered in this research study may be published or presented in public forums, however you or your child's name and other identifying information will not be used or revealed. Despite efforts to keep all personal information confidential, absolute confidentiality cannot be guaranteed. Personal information may be disclosed if required by law. All study related documents will bear only you and your child's assigned study number.

Child SCAT 3 scores, VO2 max test results as well as physiological data (e.g. heart rate, blood pressure) will be entered into a computer and may be transmitted electronically with only the child's participant number used to identify him or her. Only the study staff will have access to this information and all computers and/or USB drives used will be password protected.

The University of Manitoba Health Research Ethics Board may review records related to the study for quality assurance purposes.

All records will be kept in a locked secure area and only those persons identified will have access to these records. If any of you or your child's research records need to be copied to any of the above, all names and identifying information will be removed. No information revealing any personal information such as your name, address or telephone number will leave the Pan Am Clinic Foundation.

Voluntary Participation/Withdrawal from the Study

You and your child's decision to take part in this study is voluntary. You and your child may refuse to participate or may withdraw from the study at any time. A decision not to participate or to withdraw from the study will not affect your care at this centre. If the study staff feel that it is in your child's best interest to withdraw from the study, they will remove your child without your consent.

We will tell you and your child about any new information that may affect your health, welfare or willingness to stay in this study.

Medical Care for Injury Related to this Study

In the case of injury or illness resulting from this study, necessary medical treatment for your child will be available at no extra cost to you.

You and your child are not waiving any of your legal rights by signing this consent form nor releasing the investigators from their legal and professional responsibilities.

Questions

You and your child are free to ask any questions that you may have about the procedures and your rights as research participants. If any questions come up during or after the study or if your child has a research-related injury, contact the study staff: Jeff Billeck at (204) 391-3047 or Dr. Jason Peeler at (204) 272-3146.

For questions about you and your child's rights as a research participant, you may contact The University of Manitoba, Bannatyne Campus Research Ethics Board Office at (204) 789-3389.

Do not sign this form unless you and your child have had a chance to ask questions and have received satisfactory answers to all of your questions.

Statement of Consent

I have read this consent form with my child and we have had the opportunity to discuss this research study with Dr. Jason Peeler or his study staff. We have had our questions answered by them in language we understand. The risks and benefits have been explained to me.   I believe that my child and I have not been unduly influenced by any study team member to participate in the research study by any statements or implied statements. Any relationship (such as employer, supervisor or family member) my child or I may have with the study team has not affected my decision to participate. We understand that participation in this study is voluntary and that we may choose to withdraw at any time. My child and I freely agree to participate in this research study. We understand that information regarding my personal identity will be kept confidential, but that confidentiality is not guaranteed. I authorize the inspection of any of my child's records that relate to this study by The University of Manitoba Research Ethics Board for quality assurance purposes.

By signing this form, we have not waived any of the legal rights that we have as participants in a research study.

We agree to be contacted for future follow-up in relation to this study, Yes _____ No ______

Parent/legal guardian's signature ____________________________ Date : _______________

(Day/month/year)

Parent/legal guardian's printed name ______________________________

Child's signature ___________________________ Date: ________________

(Day/month/year)

Child's printed name ________________________________

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has knowingly given their consent.

Printed name ______________________________ Date: _________________

Signature _______________________________

Role in the study: ____.

Relationship (if any) to study team members: ___________________________________.

Appendix 3

Assent Form for Children 7-13 Years Old

<u>Study Title</u>: Child SCAT 3 Component Scores in Non-Concussed Children at Rest and After Exercise

<u>Investigators</u>: Dr. Jason Peeler, Dr. Jeff Leiter, Jeff Billeck

<u>Why are you here</u>?

The researchers want to tell you about a study about the assessment of concussions in children. They want to see if you would like to be in this study. This form tells you about the study. If there is anything you do not understand please ask your parent or guardian, or the study staff.

<u>Why are they doing this study</u>?

They want to see how exercise might affect scores on a test that is used to assess for concussions.

<u>What will happen to you?</u>

If you want to be in the study these things will happen:

1. The study will last about 45 minutes on 2 different days. These days will be approximately one month apart (30 days).
2. The tests will consist of questions we will ask you about how you are feeling, balance and movement testing as well as memory tests. All of these tests are part of what is called the Child Sport Concussion Assessment Tool 3rd Edition or Child SCAT 3. This assessment will be done 2 times during each session, once before exercising and once after.
3. The exercise test that you will complete is called the Progressive Aerobic Cardiovascular Endurance Run or PACER test. You have likely performed a version of this test previously, as it is also known as the beep test and many schools use it as a fitness test for students. You will also wear a heart rate monitor that will measure your heart beats.

<u>Will the study hurt?</u>

No, but you will be asked to exercise very hard while running so it is normal if you feel that your leg muscles are tired near the end of the exercise test.
If during the exercise test you feel any pain, or feel anything you think is strange or different from other times you have exercised you must tell your parent and one of the study staff right away.

<u>What if you have any questions?</u>

You can ask questions at any time, now or later. You can talk to the study staff or your family. Please call Jeff Billeck at (204) 391-3047 if you have any questions that come up at any time before or after the testing session.

Who will know what I did in the study?

Any information you give the study staff will be kept private. Your name will not be used on any study paper and no one but the study staff will know that it was you who was in the study.

Do you have to be in the study?

You do not have to be in the study. No one will be mad at you if you don't want to do this.
If you don't want to be in the study, just say so. We will ask your parents if they would like you to be in the study. Even if your parents want you to be in the study you can still say no. Even if you say yes now, you can change your mind later. It is up to you.

Do you have any questions?

What questions do you have?

Assent

I want to take part in this study. I know I can change my mind at any time.

____________________ Verbal assent given YES [ ]
Print name of child

Written assent if child chooses to sign the assent.

________________________	_____	________________
Signature of child	Age	Date

I confirm that I have explained the study to the participant to the extent compatible with the participant's understanding, and the participant has agreed to the study.

________________________	______________________	____________
Printed name of Person obtaining consent	Signature of person Obtaining consent	Date

Appendix 4

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PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

Regular physical activity is fun and healthy, and more people should become more physically active every day of the week. Being more physically active is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

SECTION 1 - GENERAL HEALTH

	Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1.	Has your doctor ever said that you have a heart condition OR high blood pressure?	☐	☐
2.	Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	☐	☐
3.	Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4.	Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)?	☐	☐
5.	Are you currently taking prescribed medications for a chronic medical condition?	☐	☐
6.	Do you have a bone or joint problem that could be made worse by becoming more physically active? Please answer NO if you had a joint problem in the past, but it does not limit your current ability to be physically active. For example, knee, ankle, shoulder or other.	☐	☐
7.	Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.

Go to Section 3 to sign the form. You do not need to complete Section 2.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow the Canadian Physical Activity Guidelines for your age (www.csep.ca/guidelines).
- You may take part in a health and fitness appraisal.
- If you have any further questions, contact a qualified exercise professional such as a CSEP Certified Exercise Physiologist® (CSEP-CEP) or CSEP Certified Personal Trainer® (CSEP-CPT).
- If you are over the age of 45 yrs. and NOT accustomed to regular vigorous physical activity, please consult a qualified exercise professional (CSEP-CEP) before engaging in maximal effort exercise.

If you answered YES to one or more of the questions above, please GO TO SECTION 2.

Delay becoming more active if:

- You are not feeling well because of a temporary illness such as a cold or fever – wait until you feel better
- You are pregnant – talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the PARmed-X for Pregnancy before becoming more physically active OR
- Your health changes – please answer the questions on Section 2 of this document and/or talk to your doctor or qualified exercise professional (CSEP-CEP or CSEP-CPT) before continuing with any physical activity programme.

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SECTION 2 - CHRONIC MEDICAL CONDITIONS

Please read the questions below carefully and answer each one honestly: check YES or NO.		YES	NO
1.	Do you have Arthritis, Osteoporosis, or Back Problems?	☐ If yes, answer questions 1a-1c	☐ If no, go to question 2
1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	☐	☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	☐	☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	☐	☐
2.	Do you have Cancer of any kind?	☐ If yes, answer questions 2a-2b	☐ If no, go to question 3
2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and neck?	☐	☐
2b.	Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)?	☐	☐
3.	Do you have Heart Disease or Cardiovascular Disease? This includes Coronary Artery Disease, High Blood Pressure, Heart Failure, Diagnosed Abnormality of Heart Rhythm	☐ If yes, answer questions 3a-3e	☐ If no, go to question 4
3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	☐	☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g. atrial brillation, premature ventricular contraction)	☐	☐
3c.	Do you have chronic heart failure?	☐	☐
3d.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer YES if you do not know your resting blood pressure)	☐	☐
3e.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	☐	☐
4.	Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes	☐ If yes, answer questions 4a-4c	☐ If no, go to question 5
4a.	Is your blood sugar often above 13.0 mmol/L? (Answer YES if you are not sure)	☐	☐
4b.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, and the sensation in your toes and feet?	☐	☐
4c.	Do you have other metabolic conditions (such as thyroid disorders, pregnancy-related diabetes, chronic kidney disease, liver problems)?	☐	☐
5.	Do you have any Mental Health Problems or Learning Difficulties? This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome)	☐ If yes, answer questions 5a-5b	☐ If no, go to question 6
5a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	☐	☐
5b.	Do you also have back problems affecting nerves or muscles?	☐	☐

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Please read the questions below carefully and answer each one honestly: check YES or NO.		YES	NO
6.	Do you have a Respiratory Disease? This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure	☐ If yes, answer questions 6a-6d	☐ If no, go to question 7
6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	☐	☐
6b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	☐	☐
6c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	☐	☐
6d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	☐	☐
7.	Do you have a Spinal Cord Injury? This includes Tetraplegia and Paraplegia	☐ If yes, answer questions 7a-7c	☐ If no, go to question 8
7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	☐	☐
7b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	☐	☐
7c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	☐	☐
8.	Have you had a Stroke? This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event	☐ If yes, answer questions 8a-c	☐ If no, go to question 9
8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	☐	☐
8b.	Do you have any impairment in walking or mobility?	☐	☐
8c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	☐	☐
9.	Do you have any other medical condition not listed above or do you live with two chronic conditions?	☐ If yes, answer questions 9a-c	☐ If no, read the advice on page 4
9a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months OR have you had a diagnosed concussion within the last 12 months?	☐	☐
9b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	☐	☐
9c.	Do you currently live with two chronic conditions?	☐	☐

Please proceed to Page 4 for recommendations for your current medical condition and sign this document.

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If you answered NO to all of the follow-up questions about your medical condition, you are ready to become more physically active:

› It is advised that you consult a qualified exercise professional (e.g., a CSEP-CEP or CSEP-CPT) to help you develop a safe and effective physical activity plan to meet your health needs.

› You are encouraged to start slowly and build up gradually – 20-60 min. of low- to moderate-intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.

› As you progress, you should aim to accumulate 150 minutes or more of moderate-intensity physical activity per week.

› If you are over the age of 45 yrs. and NOT accustomed to regular vigorous physical activity, please consult a qualified exercise professional (CSEP-CEP) before engaging in maximal effort exercise.

If you answered YES to one or more of the follow-up questions about your medical condition:

› You should seek further information from a licensed health care professional before becoming more physically active or engaging in a fitness appraisal and/or visit a or qualified exercise professional (CSEP-CEP) for further information.

Delay becoming more active if:

› You are not feeling well because of a temporary illness such as a cold or fever – wait until you feel better

› You are pregnant - talk to your health care practitioner, your physician, a qualified exercise profesional, and/or complete the PARmed-X for Pregnancy before becoming more physically active OR

› Your health changes - please talk to your doctor or qualified exercise professional (CSEP-CEP) before continuing with any physical activity programme.

SECTION 3 - DECLARATION

› You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.

› The Canadian Society for Exercise Physiology, the PAR-Q+ Collaboration, and their agents assume no liability for persons who undertake physical activity. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

› If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

› Please read and sign the declaration below:

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that a Trustee (such as my employer, community/fitness centre, health care provider, or other designate) may retain a copy of this form for their records. In these instances, the Trustee will be required to adhere to local, national, and international guidelines regarding the storage of personal health information ensuring that they maintain the privacy of the information and do not misuse or wrongfully disclose such information.

NAME ______________________________ DATE ______________________________

SIGNATURE ______________________________ WITNESS ______________________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________________

For more information, please contact:
Canadian Society for Exercise Physiology
www.csep.ca

KEY REFERENCES

1. Jamnik VJ, Warburton DER, Makarski J, McKenzie DC, Shephard RJ, Stone J, and Gledhill N. Enhancing the eectiveness of clearance for physical activity participation; background and overall process. APNM 36(S1):S3-S13, 2011.
2. Warburton DER, Gledhill N, Jamnik VK, Bredin SSD, McKenzie DC, Stone J, Charlesworth S, and Shephard RJ. Evidence-based risk assessment and recommendations for physical activity clearance; Consensus Document. APNM 36(S1):S266-s298, 2011.

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or BC Ministry of Health Services.

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Appendix 5

UNIVERSITY OF MANITOBA | BANNATYNE CAMPUS
Research Ethics Board

P126 - 770 Bannatyne Avenue
Winnipeg, Manitoba
Canada R3E 0W3
Telephone 204-789-3255
Fax 204-789-3414

BIOMEDICAL RESEARCH ETHICS BOARD (BREB)
CERTIFICATE OF FINAL APPROVAL FOR NEW STUDIES
Full Board Review

PRINCIPAL INVESTIGATOR:	INSTITUTION/DEPARTMENT:	ETHICS #:
Dr. J. Peeler	U of M/Department of Human Anatomy and Cell Science	B2014:069
BREB MEETING DATE: June 23, 2014	**APPROVAL DATE:** August 25, 2014	**EXPIRY DATE:** June 23, 2015
STUDENT PRINCIPAL INVESTIGATOR SUPERVISOR (If applicable):		

PROTOCOL NUMBER:	PROJECT OR PROTOCOL TITLE:
NA	Child Sport Concussion Assessment Tool 3 Scores in Non-Concussed Children at Rest and After Exercise
SPONSORING AGENCIES AND/OR COORDINATING GROUPS: Pan Am Clinic Foundation	

Submission Date(s) of Investigator Documents:	REB Receipt Date(s) of Documents:
May 29, July 29, August 15 and August 24, 2014	June 2, August 6, August 15 and August 24, 2014

THE FOLLOWING ARE APPROVED FOR USE:

Document Name	Version(if applicable)	Date
Protocol:		
Protocol (including revised submission form submitted July 29, 2014)		July 28, 2014(submitted July 29, 2014)
Consent and Assent Form(s):		
Research Participant Information and Consent Form		August 18, 2014
Assent Form for Children 7 – 13 Years Old		July 29, 2014
Other:		
Bulletin/Study Advertisement		July 27, 2014
PAR-Q+ - The Physical Activity Readiness Questionnaire for Everyone © 2012		September 12, 2011
Child SCAT 3 Study - Intake Form (for parent/guardian to complete)		June 28, 2014
Participant Information Form		July 29, 2014
Child-SCAT3™ - Sport Concussion Assessment Tool for Children Ages 5 to 12 Years © 2013(downloaded May 28/2014)		submitted July 29, 2014

CERTIFICATION
The University of Manitoba (UM) Biomedical Research Board (BREB) has reviewed the research study/project named on this ***Certificate of Final Approval*** at the ***full board meeting*** date noted above and was found to be acceptable on ethical grounds for research involving human participants. The study/project and documents listed above was granted final approval by the Chair or Acting Chair, UM BREB.

BREB ATTESTATION
The University of Manitoba (UM) Biomedical Research Board (BREB) is organized and operates according to Health Canada/ICH Good Clinical Practices, Tri-Council Policy Statement 2, and the applicable laws and regulations of Manitoba. In respect to clinical trials, the BREB complies with the membership requirements for Research Ethics Boards defined in

- 1 -

www.umanitoba.ca/faculties/medicine/ethics

Division 5 of the Food and Drug Regulations of Canada and carries out its functions in a manner consistent with Good Clinical Practices.

QUALITY ASSURANCE

The University of Manitoba Research Quality Management Office may request to review research documentation from this research study/project to demonstrate compliance with this approved protocol and the University of Manitoba Policy on the Ethics of Research Involving Humans.

CONDITIONS OF APPROVAL:

1. The study is acceptable on scientific and ethical grounds for the ethics of human use only. ***For logistics of performing the study, approval must be sought from the relevant institution(s).***
2. This research study/project is to be conducted by the local principal investigator listed on this certificate of approval.
3. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to the research study/project, and for ensuring that the authorized research is carried out according to governing law.
4. **This approval is valid until the expiry date noted on this certificate of approval.** **A Bannatyne Campus Annual Study Status Report** must be submitted to the REB within 15-30 days of this expiry date.
5. Any changes of the protocol (including recruitment procedures, etc.), informed consent form(s) or documents must be reported to the BREB for consideration in advance of implementation of such changes on the **Bannatyne Campus Research Amendment Form.**
6. Adverse events and unanticipated problems must be reported to the REB as per Bannatyne Campus Research Boards Standard Operating procedures.
7. The UM BREB must be notified regarding discontinuation or study/project closure on the **Bannatyne Campus Final Study Status Report**.

Sincerely,

L Nicolle

Lindsay Nicolle, MD, FRCPC
Chair, Biomedical Research Ethics Board
Bannatyne Campus

Please quote the above Human Ethics Number on all correspondence.
Inquiries should be directed to the REB Secretary **Telephone:** (204) 789-3255/ **Fax:** (204) 789-3414