Externalising behaviours and history of concussions in high school rugby players in Cape Town

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Abstract

The prevalence of concussions in rugby is a major public health concern, especially with its popularity as a high school sport. The associated disruptions in the brain mechanisms responsible for anger, impulsivity and aggression, collectively referred to as externalising behaviours, together with the vulnerability of the adolescent brain, puts high school rugby players at increased risk of developing such behaviours following concussion. In this study, we aimed to investigate the potential effects of a history of sports-related concussion on the externalising behaviours of adolescents. The sample included 34 participants from five high schools in Cape Town, divided into two study groups: a Rugby and a Control (hockey and soccer) group. We administered screening measures, and measures of externalising behaviours, namely, Barratt Impulsiveness Scale-II, Immediate Post-concussion Assessment and Cognitive Testing, and State-Trait Anger Expression Inventory, which were analysed using a series of multiple hierarchical regression models. Our results reveal an overall trend of greater externalising behaviours in the participants that reported a history of formally diagnosed concussion compared to those who report no history of concussion. We also found a history of formally diagnosed concussion to significantly increase the ability to predict impulsivity, but not anger. Despite limitations, such as the study's small sample size which undermines statistical power to detect such differences, studies of this nature may create awareness around the potential externalising behavioural risks and consequences of exposure to sports-related concussions in the developmental stage of adolescence.

Keywords: adolescence; externalising behaviours; impulsivity; rugby; sports-related concussion

Concussions are a major public health concern with annual incidence rates reported well into the millions within the sporting world (Giza & Kutcher, 2014; Halstead, Walter, & Moffatt, 2018). Local data on concussion prevalence and consequences are lacking, however. These "traumatic brain injuries which cause disturbances in the brain" are highly prevalent in the game of rugby (World Rugby, 2017b, p. 2). Rugby, not only one of the most popular contact sports across the globe, but a popular school sport, is a major contributor to sports-related concussions (SRCs) in adolescents (Freitag, Kirkwood, Scharer, Ofori-Asenso, & Pollock, 2015; Giza & Kutcher, 2014). The high prevalence of these injuries reported during adolescence is problematic given that this stage of development is a time of ongoing hormonal changes and brain maturation (Semple et al., 2015). These factors make adolescents particularly vulnerable to the effects of concussion, which have the potential to disrupt brain development and cause both immediate and long-term cognitive as well as internalising (e.g. anxiety and depression) and externalising (e.g. anger, impulsivity, aggression) behavioural complications (Ilie et al., 2014; McCrory et al., 2017; Semple et al., 2015). The areas of the brain most vulnerable during concussion are important in behavioural inhibition, and thus damage to these neuroanatomical areas often results in increased externalising behaviours (Bryant, 2008; Daneshvar et al., 2011). The high concussion rates in rugby, vulnerability of the adolescent brain and the adverse effects of concussions - including externalising behaviours - and the lack in local data of this nature, underscores the need for more research in this area (McCrory et al., 2017).

Sports-related Concussions (SRCs)

Definition of SRCs. SRCs can be defined as "traumatic brain injuries (TBI) induced by biomechanical forces" (McCrory et al., 2017, p. 839), which can be explained by four of its most evident features: (1) SRC results from direct impact to the head, face, neck or indirectly through forces sustained to another part of the body which result in a rapid movement of the head; (2) SRC causes a sudden onset of temporary impairment of neurological functioning. These typically resolve spontaneously, in a somewhat predictive successive order. In some cases, however, impairments may be delayed; (3) Clinical signs and symptoms of SRC may or may not occur with loss of consciousness (LOC). World Rugby (2017b) recognises that whilst LOC is a clear marker of concussion, it occurs in less than 10% of SRC cases; and (4) SRC can result in gross functional disturbances, despite standard procedure structural neuroimaging showing no signs of structural abnormalities (McCrory et al., 2017).

SRCs and rugby. Rugby is one of the most popular team contact sports in the world and a high-risk sport for concussion incidents (Fuller, Taylor, & Raftery, 2015; Giza & Kutcher, 2014). Reports show an increased interest in rugby sport participation with 2.82 million registered and 4.91 million non-registered rugby players growing to a total of 3.2 million and 5.3 million respectively, from 2016 to 2017 (World Rugby, 2017a). Rugby has also gained popularity as a school sport, subsequently making it a significant contributor to the high prevalence of SRCs in children and adolescents (Freitag et al., 2015). World Rugby (2017a) reported that during their 2016 programme, approximately 2 million individuals under the age of 18 years participated in the sport.

Epidemiology. Recent studies estimate that approximately 1.1 million to 1.9 million cases of SRCs, in the United States (US) each year, are related to children and adolescents (Bryan, Rowhani-Rahbar, Comstock, & Rivara, 2016). For every 1000 rugby games and practice sessions participated in by adolescents, there are approximately 4.18 incidences of concussion. This is the highest incidence rate when compared to 12 other sports (Pfister, Pfister, Hagel, Ghali, & Ronksley, 2016). In South Africa, high estimates of between 4-14% of seasonal SRC incidence rates were reported at the high school level; at a senior level, these rates were between 3-23% (Walker, 2015). Moreover, a 2011 South African study from national youth rugby weeks, reported injuries which resulted in SRCs for the following age groups: under 13 (10%), 16 (17%) and 18 (19%) (Brown et al., 2012). These high local incidence reports are of major concern, especially when considering evidence that concussions are frequently left unreported (Bryan et al., 2016).

Pathophysiology. The primary mechanisms of injury in a concussion include rapid acceleration and deceleration forces which act on the brain in either a linear or rotational direction (Ling, Hardy, & Zetterberg, 2015; Riggio & Jagoda, 2016). Exposure to these potentially shearing forces cause the brain and its various components, including blood vessels, neurons and glial cells to stretch and tear, with the resultant effect potentially disrupting their normal functioning (Ling et al., 2015). The axons in the brain, spanning long distances from the cell bodies, are particularly vulnerable to being stretched. Concussive events subsequently result in neuronal connectivity impairments, in addition to an increased risk of diffuse axonal injury, which serves as a basis for the associated symptoms (Giza & Kutcher, 2014; Ling et al., 2015; Riggio & Jagoda, 2016). Neurocognitive testing confirms this relationship between concussions and such impaired brain connectivity (Riggio & Jagoda, 2016).

These mentioned impairments in brain connectivity, together with the known vulnerability of the frontal and temporal lobes of the brain during concussion, makes the uncinate fasciculus (UF) a structure of particular relevance in concussion research. The UF is a white matter association fibre tract consisting of myelinated axons which connects the orbital frontal cortex with the anterior temporal lobe. Furthermore, research on adolescents shows that structures within the frontal and temporal brain regions form a network that is involved in the regulation of behaviour, suggesting the UF to be crucial in behavioural regulation (Goswami et al., 2016; Peper, De Reus, Van Den Heuvel, & Schutter, 2015). The integrity of the white matter connections between these regions is associated with well-regulated aggressive and impulsive behaviours, with decreased connectivity leading to increases in these behaviours (Goswami et al., 2016; Peper et al., 2015; Von Der Heide, Skipper, Klobusicky, & Olson, 2013). Thus, SRC research that reports an association between microstructural alterations in the UF and increased impulsivity and aggression suggest that the regulation of these externalising behaviours may be compromised after sustaining a concussion (Goswami et al., 2016; Von Der Heide et al., 2013).

The adolescent brain. Studies comparing SRCs between high school and university athletes reveal longer recovery time for high school athletes (Ling et al., 2015; Riggio & Jagoda, 2016; Semple et al., 2015). Furthermore, the 4-week recovery time for children and adolescents, compared to the 10-14 days for adults, suggests that the developing adolescent brain is both different to and more vulnerable than, the adult brain (Daneshvar et al., 2011; McCrory et al., 2017). The vulnerability and susceptibility of the adolescent brain can be attributed to several factors. These include the ongoing development and maturation of the brain throughout adolescence, with structural and functional changes persisting into adulthood and, adolescence being a time of pubertal hormonal changes, directly affecting brain functioning and development (Daneshvar et al., 2011; Semple et al., 2015). Thus, concussions sustained during this stage are likely to affect brain development and interfere with these hormonal maturation processes, making adolescents more susceptible to the consequences of concussive injuries and their potentially long-term complications (Iverson et al., 2017; Seichepine et al., 2013; Semple et al., 2015). This makes the high prevalence of SRC in adolescence particularly problematic and its effects necessary to consider - an area of research inadequately addressed by existing studies (Semple et al., 2015). Most studies regarding concussions have been conducted on adult populations, however, these results should not be extrapolated to adolescents, given the neuroanatomical differences between the developing and developed brain (Daneshvar et al., 2011).

Aggression, anger and impulsivity. Post-concussive externalising behaviours, including aggression, anger and impulsivity, are commonly reported in international literature (Keightley et al., 2014; McCrory et al., 2017). Aggression, defined as overt behaviours aimed to deliberately inflict harm to objects, others and even one's self, is frequently associated with impulsivity and anger (Peper et al., 2015). Impulsivity refers to risky actions which can be inappropriate, poorly conceived and prematurely expressed, while anger is an emotional reaction affecting the human body, characterised by extreme displeasure, rage, hostility, annoyance and emotional distress (Rochat, Billieux, Gagnon, & Van der Linden, 2018; Zaidi & Perveen, 2018). Adolescents who have sustained a concussion show greater deficits in these externalising behaviours (McCrory et al., 2017). Systematic reviews report cases of aggressive and impulsive behavioural symptoms persisting beyond a year after sustaining a concussion during adolescence (see e.g., Keightley et al., 2014; McCrory et al., 2017). A significant association has also been found in athletes between previously sustained SRC and higher rates of these externalising behaviours (Kerr et al., 2014; Liu & Li, 2013; Taylor et al., 2015). However, local research on the relationship between these factors is lacking.

Rationale

Rugby is a high-risk contact sport of increasing popularity in schools (Freitag et al., 2015). The high prevalence of SRCs reported during adolescence is problematic given that this developmental stage is associated with unique hormonal and brain maturation changes, making the brain particularly vulnerable (Semple et al., 2015). Areas of the brain responsible for emotion regulation are most vulnerable to the effects of concussion; damage to these vulnerable areas can result in increased externalising behaviours (Daneshvar et al., 2011). However, local knowledge on the effects of SRCs on the adolescent brain is lacking. Awareness of SRCs and their potential sequelae can promote safety in contact sports, effectively advance concussion-management procedures within high risk contact sports, and better inform choices regarding participation in these sports.

Aims and Hypotheses

The study aimed to investigate the potential effects of a history of SRC on the externalising behaviours of adolescents. The following hypotheses were tested:

1. Rugby players who have previously been formally diagnosed with a concussion will report higher levels of externalising behaviours compared to participants of the Rugby and Control group who have no history of formal concussion diagnosis.

2. Participants who have previously been formally diagnosed, as well as those who suspect previously sustaining a concussion, will reflect higher externalising behaviours compared to those who reported no history of formally diagnosed or suspected concussion.

Methods

Design and setting

The study is quantitative and cross-sectional in design. It forms part of the ongoing larger study: *Investigating the neuropsychological effect and long-term outcomes of concussions among high school rugby players,* being conducted by a Masters' student at the University of Cape Town Department of Psychology. This study uses the baseline data collected for the larger study, specifically from the screening measures and the behavioural measures relevant to the measurement of externalising behaviours (anger, aggression and impulsivity).

Participants

Participants were recruited from five local Cape Town schools. All participants were: (1) currently attending one of the high schools, (2) male, (3) aged 16 – 19 years old, and (4) fluent in either English or Afrikaans. Participants in the Rugby group played rugby, while those who formed part of the Control group participated in a non-collision sport (either soccer or hockey) and did not participate in rugby.

Power analysis. In order to have a 95% power in detecting a medium effect size of .50 with a significance level of .05, a minimum of 39 participants were needed to carry out multiple hierarchical regression analyses.

Exclusion criteria. Participants who were excluded from the study (1) scored 21 or higher on the Beck Depression Inventory-Second Edition (BDI-II), (2) currently or had previously been formally diagnosed with a psychiatric illness, learning disability or neurological disease, (3) had current or a known history of alcohol or drug abuse. Lastly, (4) those who had previously been formally diagnosed with a concussion were excluded from the Control group.

A total of 40 participants were recruited, however, after excluding participants that did not meet the criteria a total of 34 participants could only be included in the analysis.

Materials

Screening measures. Participants completed self-report questionnaires which provided the relevant demographic and general health information, as well as information on

control variables (alcohol use, depression and anxiety). This information was used to inform exclusion criteria and provided the relevant information on the concussion history of each participant.

Demographic and medical history questionnaire. Information about language proficiency, learning disabilities, age, weight and height was obtained from this questionnaire. It further revealed any previous or current psychiatric disorders and current (if any) medication intake. Further, questions about previous SRC diagnoses were included.

Alcohol Use Disorders Identification Test (AUDIT). This 10-item self-report measure uses a four-point Likert scale to measure the harmfulness or riskiness of an individual's current and lifelong alcohol consumption, with higher total test scores (closer to 40) indicating more harmful alcohol consumption habits. Globally, a score of 8 and above has proved sensitive in detecting unhealthy alcohol use (Saunders, Aasland, Babor, De la Fuente, & Grant, 1993).

Previous studies have revealed this measure to be cross-culturally sensitive (Saunders et al., 1993) and successful in research pertaining to SRCs (Hume et al., 2017), adolescents (Liskola et al., 2018) and within the South African context (Brittain et al., 2017).

Beck Depression Inventory – Second Edition (BDI-II). This 21-item self-report measure is comprised of groups of statements which measure depression symptoms. Participants respond to the statements by indicating which one in each group reflects their feelings in the two weeks leading up to and including the day on which they were assessed (Beck, Steer, & Brown, 1996). Each statement is allocated a score of zero to three. A total score of 21 or higher is an indication of dysphoria or moderate depression (Beck et al., 1996).

Previous studies have revealed reliable use of BDI-II in South Africa (Makhubela & Mashegoane, 2016), with adolescents (Lee, Lee, Hwang, Hong, & Kim, 2017), and in SRC-related research (Didehbani, Munro Cullum, Mansinghani, Conover, & Hart, 2013). A validation study found BDI-II to have a high test-retest reliability of $r = .93$ (Beck et al., 1996).

State-Trait Anxiety Inventory (STAI). The STAI, which measures an individual's anxiety levels, is divided into two sections: STAI-State and STAI-Trait. The STAI-State contains 20 statements which measures the individual's current anxiety levels, whereas the STAI-Trait contains 20 statements which measures their more general levels of anxiety. We used the later part of the inventory, the STAI-Trait. On a four-point Likert-type scale, the participant indicates to what extent these 40 statements best describe them (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983).

Previous studies have shown that STAI can be used reliably in South African populations (Redinger, Norris, Pearson, Richter, & Rochat, 2018), with adolescents (Sahin, Kasap, Kirli, Yeniceri, & Topal, 2018) and in SRC-related research (Rice et al., 2018). STAI was found to have high internal consistency of above α = .88 in the original validation study (Spielberger & Vagg, 1984).

General Health Questionnaire (GHQ-28). This version of the GHQ is the most widely applied and is a measure used to assess general psychological distress in both adolescents and adults. This measure requires participants to compare their current health status to that of their general state of health. It is comprised of four subscales: anxiety/insomnia, severe depression, social dysfunction and somatic symptoms (Goldberg & Williams, 1988).

Previous studies have reported on the reliable use of the GHQ-28 within research on SRCs (Guskiewicz et al., 2005), with adolescents (Cruz-Sáez, Pascual, Wlodarczyk, & Echeburúa, 2018) and extensively within the context of South Africa (de Kock, Görgens-Ekermans, & Dhladhla, 2014; Richter, Mathews, Nonterah, & Masilela, 2018). This scale has been found to have high reliability ranging between .82 and .92, as well as high internal consistency ranging between .88 and .91 (Nagyova et al., 2000; Richter et al., 2018; Shayan et al., 2015).

Externalising behaviour outcome measures

Barratt Impulsiveness Scale (BIS-II). This 30-item self-report questionnaire uses a four-point Likert-type scale to assess three domains of impulsivity - motor, non-planning impulsiveness and attention impulsiveness - with higher scores being indicative of higher rates of impulsivity (Patton, Stanford, & Barratt, 1995).

Previous studies have shown the reliable use of the BIS-II in research pertaining to SRCs (Goswami et al., 2016), adolescents (Du et al., 2016; Nandogopal et al., 2011) and within the context of South Africa (Dellis et al., 2014; Dunne, Cook, & Ennis, 2018). This scale has a high test-retest reliability of r = .83 and high internal consistency of α = .75 (Vandeweghe et al., 2016) and α = .83 (Reid, Cyders, Moghaddam, & Fong, 2014).

Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT). This is a widely used computerised neuropsychological test battery consisting of three components: a demographic scale, post-concussion screening scale, and a neuropsychological test battery (Barlow, Schlabach, Peiffer, & Cook, 2011; Lovell, Collins, Podell, Powell, & Maroon, 2000). The study only utilized the neuropsychological test battery component and the

information provided by the demographic scale, which was used in addition to that provided by the Demographic and medical history questionnaire.

ImPACT neuropsychological test battery. This component contains measures of multiple cognitive domains, including impulse control (Lovell et al., 2000). Each domain test score is available immediately after test completion with five computer-generated composite scores (Lovell et al., 2000). We only used the impulse control domain scores.

Previous studies have shown the use of ImPACT in research on SRCs, within the South African context and with adolescents (Shuttleworth-Edwards, Whitefield-Alexander, Radloff, Taylor, & Lovell, 2009). This scale has a high test-retest reliability of between .65 and .86 (Iverson, Lovell, & Collins, 2003) and good validity (Van Kampen, Lovell, Pardini, Collins, & Fu, 2006)

State-Trait Anger Expression Inventory (STAXI). This 44-item self-report measure uses a four-point Likert-type scale to measure different aspects of anger. This measure assesses state anger (the participant's current feelings), trait anger (the frequency with which the participant experiences feelings of anger) and three additional domains of anger (anger expression, anger control and the anger expression index; Spielberger, 1988).

Previous studies have shown STAXI to be reliable in research on SRCs (Garraway et al., 1999), adolescents (Lim et al., 2015) as well as within the context of South Africa (Möller & Steel, 2002). STAXI has a high validity, reliability and internal consistency of .72 (Lim et al., 2015; Spielberger, 1988).

Procedure

The Principal and Head of Sport of each of the respective schools were approached and presented with the study aims, design and rationale by a researcher and Principal Investigator of the larger study. Further information about the commitments and requirements of the participating schools, sports coaches, players and parents, were thoroughly discussed. The research process commenced upon consent of the Principal and Head of Sport of each school, at which point information sessions directed at the learners, parents, principals and heads of sport were held. This was done prior to data collection and the commencement of the rugby season. These sessions provided general information about SRCs, the nature, aims, objectives and procedures of the larger study (which includes this study), exclusion criteria of the participants and allowed for any questions or concerns regarding the study to be raised and addressed. We attended and assisted with the setting up of these sessions, which were followed by the distribution of consent forms for Control and Rugby participants (see Appendices A and B, respectively). Upon obtaining the parents'

signed informed consent forms, which we received from the coaches, we invited their respective children to the baseline testing session. This session began with emphasising voluntary participation and obtaining assent from the participants (see Appendices C and D), after which we assisted our co-supervisor with the assessment process.

Pre-season baseline assessments.

Both the Rugby and the Control group participants underwent baseline testing in a private computer room located at each of the participating schools. Each participant completed the mentioned screening and externalising behaviour measures. ImPACT and the remaining testing measures each took between 45-60 minutes, with an approximate total testing time of 90-120 minutes.

Statistical analysis

SPSS (version 25.0) was used to compute and run all the statistical analyses. Alpha was set at .05 when making decisions of statistical significance. All measures were scored, and missing data was adjusted, according to each of the measures' standard protocols.

Descriptive statistics. As depicted in Table 1, the sample was divided to make two groups, which was done in three different ways in order to compare the mean group differences in externalising behaviours. The first groups we compared were divided according to sporting code: The Rugby group, participants who participated in the sport of rugby, and the non-rugby Control group (Rugby/Control). We then divided the sample, only considering the participants history of concussion. Those who had received a formal concussion diagnosis were compared to the second group who either reported having suspected sustaining a concussion or never having sustained a concussion (Diagnosed Concussion/No Diagnosed Concussion). Lastly, those with a suspected concussion were grouped together with those who had a diagnosed concussion, leading to the division of the sample into: Diagnosed and Suspected Concussion/No Concussion. Descriptive statistics were run separately on each of these sets of grouping variables.

Table 1

Sample Grouping

Sample division	Group 1	Group 2
1	Rugby	Control
2	Diagnosed Concussion	No Diagnosed Concussion
3	Diagnosed and Suspected Concussion	No Concussion

Multiple hierarchical regression models. A sequence of hierarchical regressions were run according to the following steps: (1) Age was used as the first predictor, based on the unique developmental trajectory of brain maturation during adolescence (see e.g., Daneshvar et al., 2011; Semple et al., 2015); (2) The Rugby/Control grouping variable was added as a second predictor, the decision to do so was informed by literature's reporting of rugby players' heightened risk of sustaining a concussion (see e.g., Fuller et al., 2015; Pfister et al., 2016) and lastly; (3) A third predictor variable was added to the model, which related to the participants history of concussion in order to determine the effect this may have on their externalising behaviours. Therefore, for the first series of regressions this variable was the Diagnosed Concussion/No Diagnosed Concussion group. For the second series of regressions that were run, this variable was the Diagnosed and Suspected Concussion/No Concussion group.

Ethical Considerations

Ethical approval for this study was obtained from the Faculty of Health Sciences Human Research Ethics Committee, Western Cape Education Department and the Department of Psychology's Research Ethics Committee (see Appendices E-G).

Risks and Benefits

Informed consent and assent. Parents who gave their permission for their child to participate in the study returned signed consent forms to the relevant coaches and teachers. Upon arrival to the baseline assessment, participants provided their own written assent. It was also made clear that they could withdraw their participation at any point without penalty, although this did not occur.

Privacy and confidentially. The identities of the participants were kept anonymous by assigning each a unique reference number. All collected information has been stored on a password-protected computer and locked filing cabinet in the Department of Psychology to ensure it remains private and confidential. The permission to store this data for future was obtained from the parent and participant (see Appendices H and I).

Potential risks. The participants were not put at risk during the testing sessions, although some experienced fatigue and/or irritability due to the length of, and concentration required for the completion of these tasks. Breaks and refreshments were given when needed.

Minimising risk. All rugby participants will receive a debriefing form (see Appendix J) at the end of the larger study, whether they sustained a concussion or not. This form illustrates the aims of the research study and provides participants with the relevant contact

numbers and email addresses of the researchers, giving the participants and/or their parents the opportunity to ask any questions regarding the study.

Potential benefits. Upon completion of the larger study, the rugby coaches, parents/legal guardians, and players will be given access to the results of the study, with the players themselves being given access to their individual results for these tests. Moreover, test results were available to be shared with the medical practitioners who assisted the participant in managing their concussion where applicable. This study further aimed to understand what effect the history of concussion has on these young individuals' externalising behaviours.

Referrals.

Reimbursement for participation. Upon completing the testing process each participant received a R100 Sportsman's Warehouse gift voucher.

Results

We present each of the results below according to the three grouping variables detailed in the methods: Rugby/Control, Diagnosed Concussion/No Diagnosed Concussion and, Diagnosed and Suspected Concussion/No Concussion.

Sample Characteristics

All participants were 16-18 years old and participated in either rugby or a non-collision sport (hockey or soccer). Of the 34 participants in the overall sample, 23 were part of the Rugby group and 11 made up the Control group. Of these 23 Rugby players, 6 (26.09%) had previously received one formal concussion diagnosis, with only one participant reporting having been diagnosed on two separate occasions. From the same group, 10 participants (43.48%) reported that they suspected having sustained a concussion in the past, despite never having received a formal diagnosis. Of the 11 participants in the Control group, only 3 (27.27%) suspected that they had previously sustained a concussion, but no Control group participant had ever received a formal diagnosis of concussion (an exclusion criterion for this study). These results are presented in Table 2.

Table 2

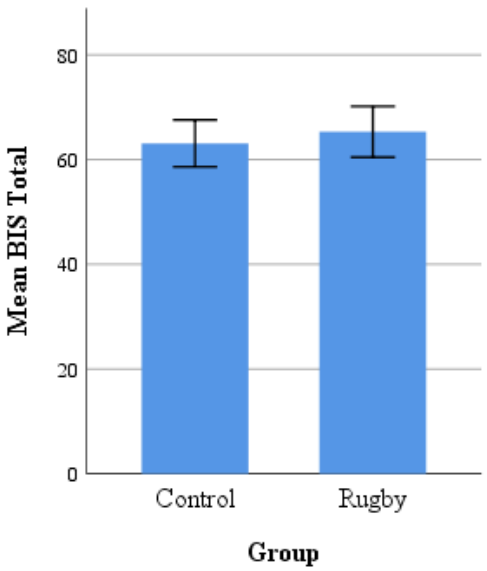
Sample Characteristics

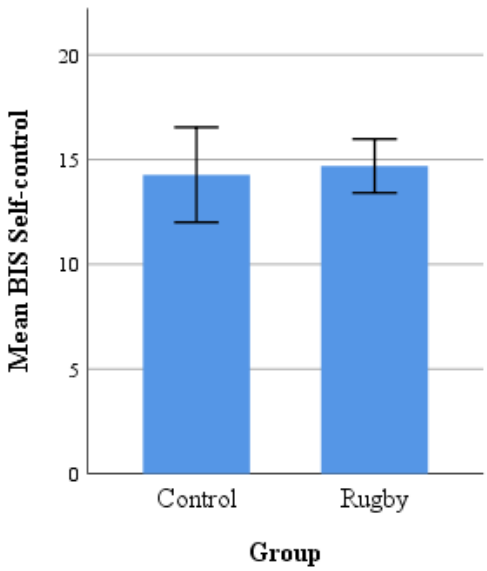
Rugby group			Control group (hockey and soccer)		
23			11		
Concussed		Not concussed	Concussion		Not concussed
16		17	3		8
Diagnosed	Suspected		Diagnosed	Suspected	
6	10		n/a	3	

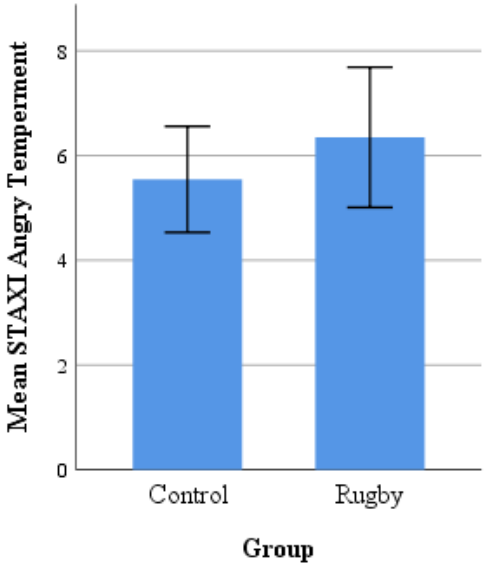
Note. n/a = not applicable based on exclusionary criteria.

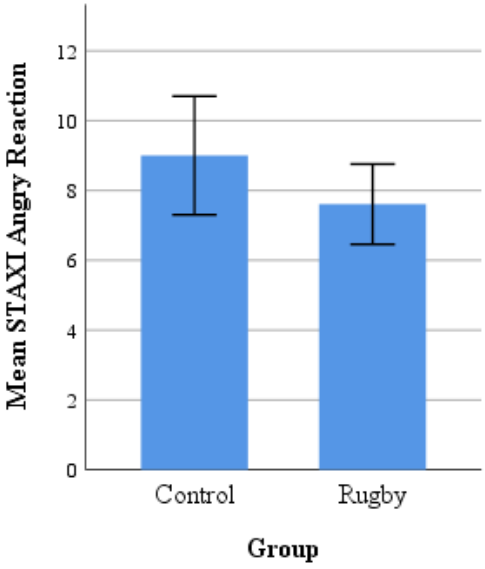
Control/Rugby Group

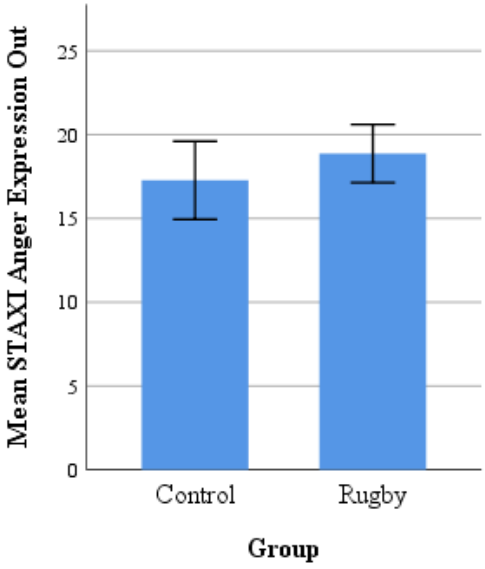
As depicted in the overlapping error bars of the graphs (Figure 1-12), no significant differences were found between the mean ages of the Control (M = 16.45, SD = .42) and Rugby (M = 16.48, SD = .59) groups, or between the screening measure scores of these groups (see Appendix K for detailed means and standard deviations). The graphs also show that the means on the externalising behavioural measures of the Rugby group are greater than those of the Control group, despite these mean group differences not being statistically significant ($p > .05$) (Appendix L). Additionally, no large effect sizes ($d < 0.80$) were found when comparing the Cohen's d of each measure between the groups (see Appendix M). This further illustrates that there were no significant differences between the Rugby and Control groups.

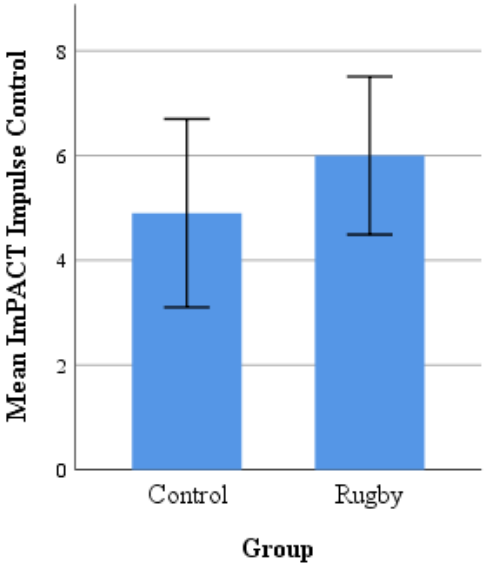


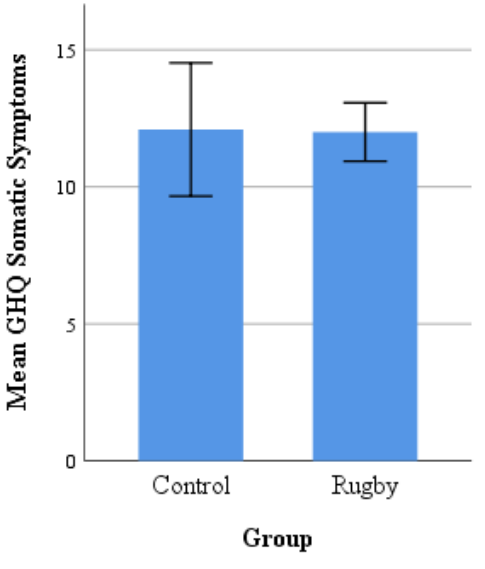


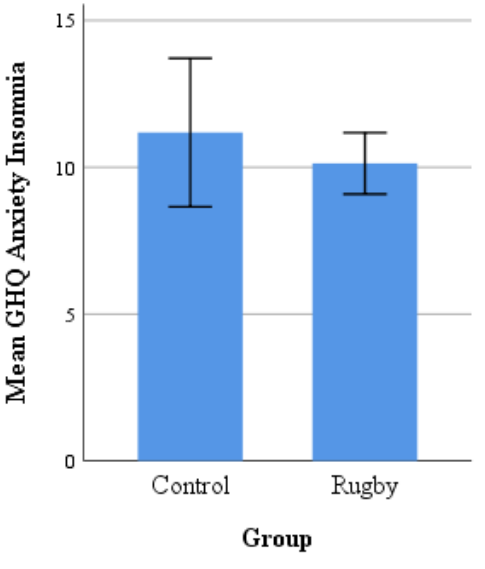

Mean STAXI Angry Temperment
8
6
4
2
0
Control
Rugby
Group

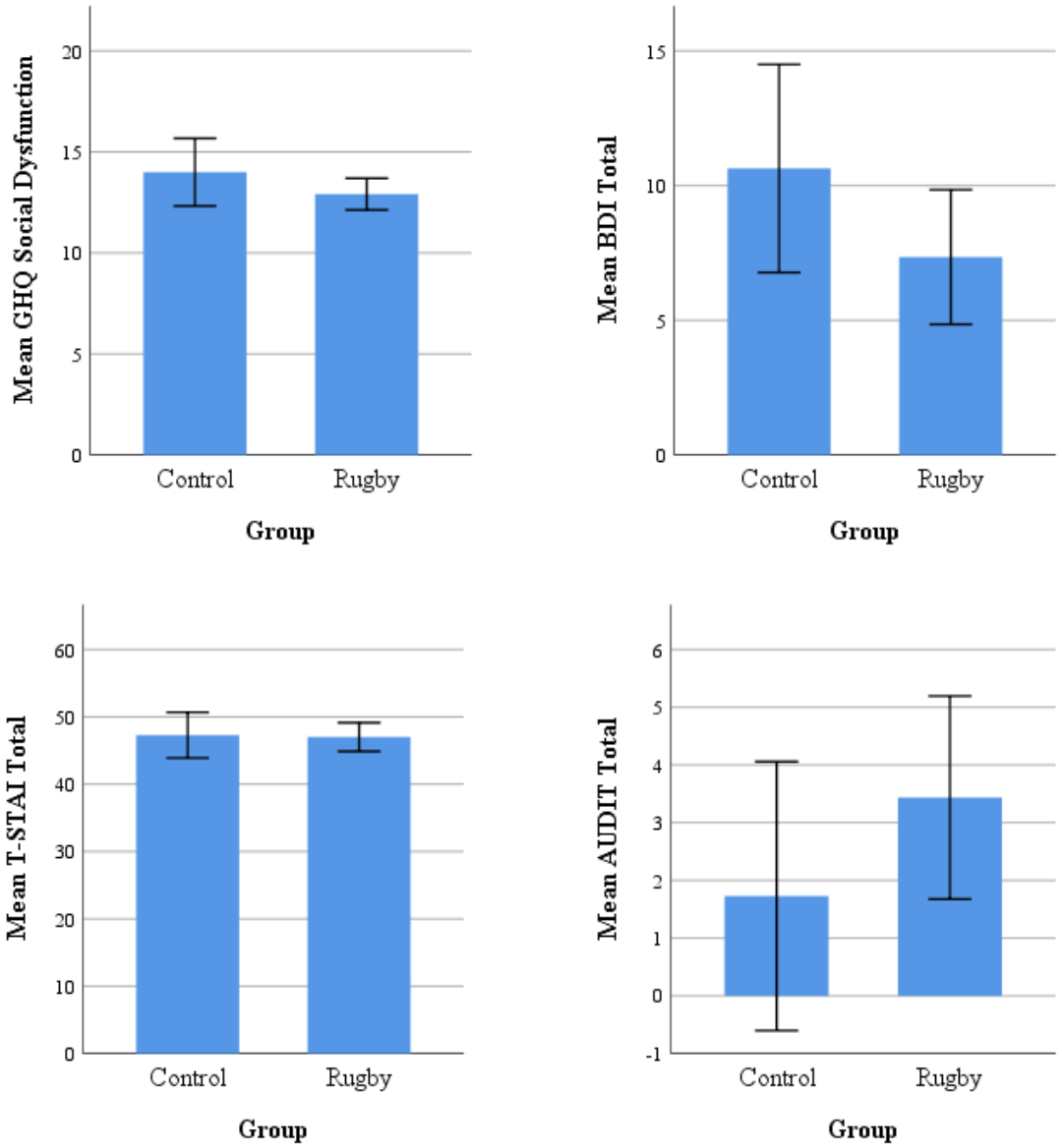

Mean STAXI Angry Reaction
12
10
8
6
4
2
0
Control
Rugby
Group


Mean STAXI Anger Expression Out
25
20
15
10
5
0
Control
Rugby
Group


Mean ImPACT Impulse Control
8
6
4
2
0
Control
Rugby
Group


Mean GHQ Somatic Symptoms
15
10
5
0
Control
Rugby
Group


Mean GHQ Anxiety Insomnia
15
10
5
0
Control
Rugby
Group



Note. BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.

Figure 1-12. Graphical representation of the descriptive statistics for the Control/Rugby grouping variables (N = 34).

Diagnosed Concussion/No Diagnosed Concussion

As depicted in Table 3 and overlapping error bars of graphs (Figure 13-24), there were no statistically significant differences found between the means of the two groups for age or any of the screening measures. Similarly, no statistically significant differences were found between the means of the externalising behavioural measures for these groups (p > .05), although these means were higher, at least descriptively, for the Diagnosed Concussion

group compared to the No Diagnosed Concussion group (Figure 13-24). See Appendices M and N for effect sizes and for detailed means and standard deviations for the remaining variables, respectively.

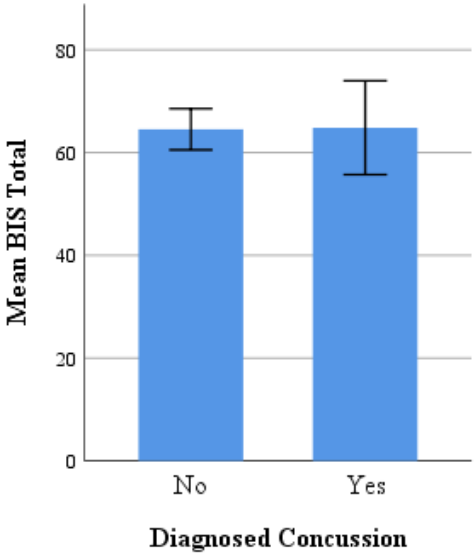
There was, however, a large effect size of .83 for the difference in ImPACT Impulse Control scores between these two groups: Diagnosed Concussion (M = 8.33, SD = 5.32) and No Diagnosed Concussion (M = 5.00, SD = 1.94). Given that higher scores indicate more errors made on the impulse control tasks, these results illustrate the former group to be more impulsive.

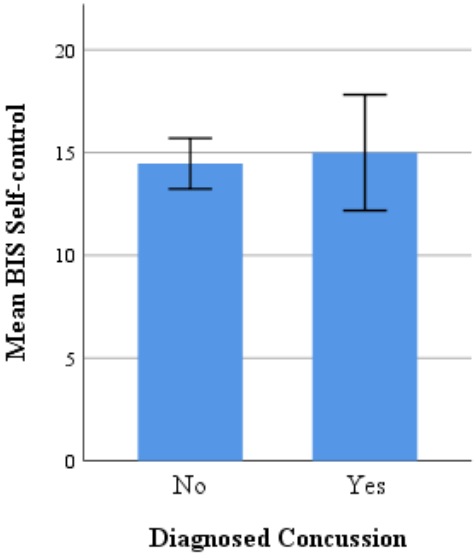
Table 3

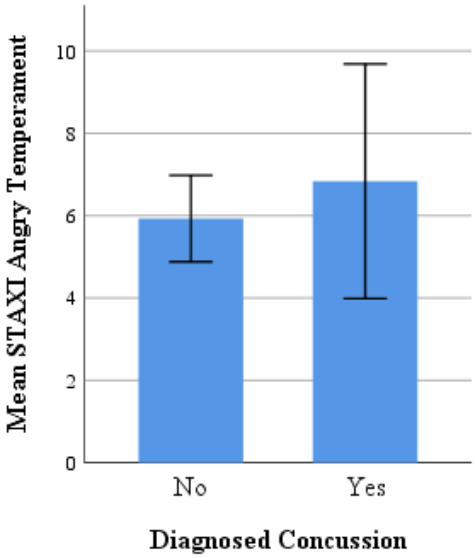
Sample Characteristics for Diagnosed Concussion/No Diagnosed Concussion

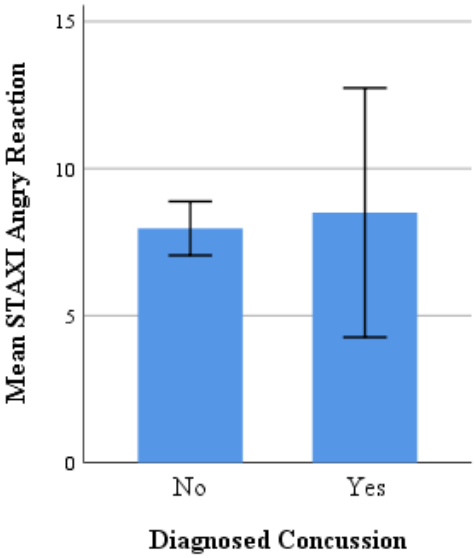
Measure	*df*	*F*	*p*
Age	1,32	3.23	.082
BIS Total	1,32	.00	.948
BIS Self-control	1,32	.15	.704
STAXI Angry Temperament	1,32	.55	.463
STAXI Angry Reaction	1,32	.20	.662
STAXI: ANGER Expression Out	1,32	1.40	.245
ImPACT Impulse Control	1,29	6.74	.015
GHQ Somatic Symptoms	1,32	.25	.622
GHQ Anxiety/Insomnia	1,32	1.12	.298
GHQ Social Dysfunction	1,32	.12	.737
BDI Total	1,32	.63	.433
T-STAI Total	1,32	.05	.820
AUDIT Total	1,32	.18	.677

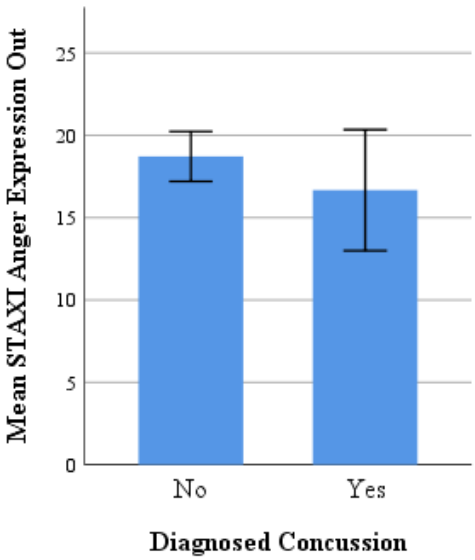
Note. df = degrees of freedom; BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test. All listed *p*-values are two-tailed.

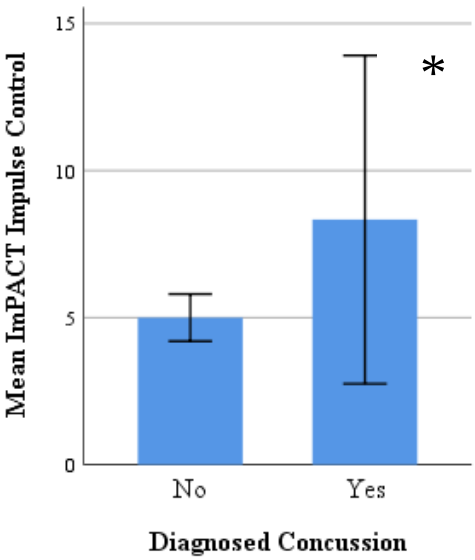

Mean BIS Total
80
60
40
20
0
No
Yes
Diagnosed Concussion

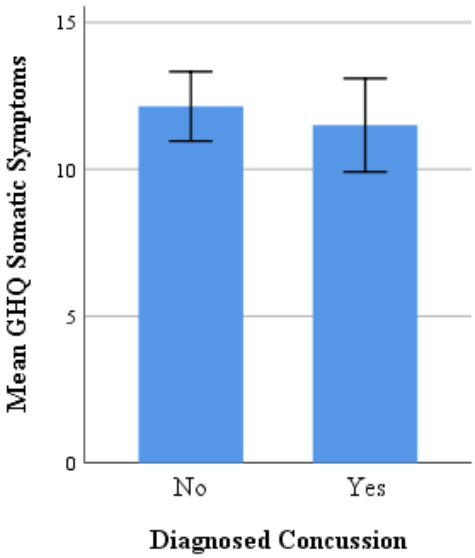

Mean BIS Self-control
20
15
10
5
0
No
Yes
Diagnosed Concussion

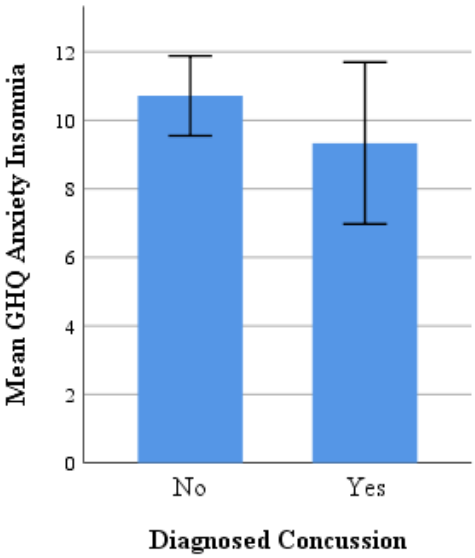

Mean STAXI Angry Temperament
10
8
6
4
2
0
No
Yes
Diagnosed Concussion

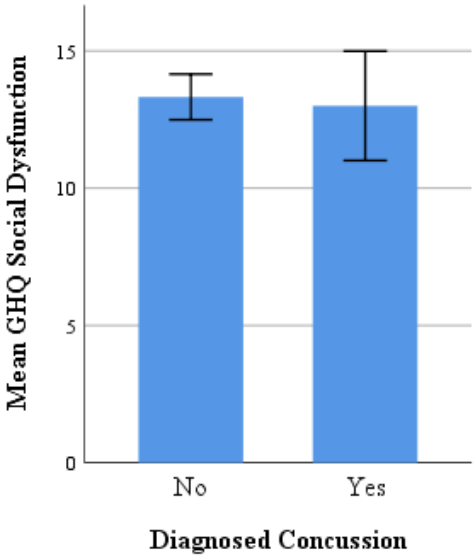

Mean STAXI Angry Reaction
15
10
5
0
No
Yes
Diagnosed Concussion

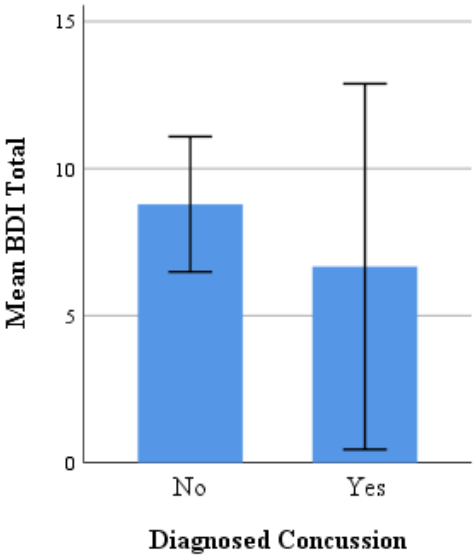

Mean STAXI Anger Expression Out
25
20
15
10
5
0
No
Yes
Diagnosed Concussion

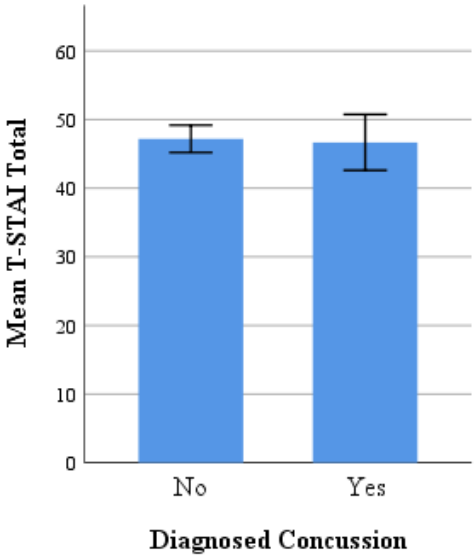

Mean ImPACT Impulse Control
15
10
5
0
*
No
Yes
Diagnosed Concussion

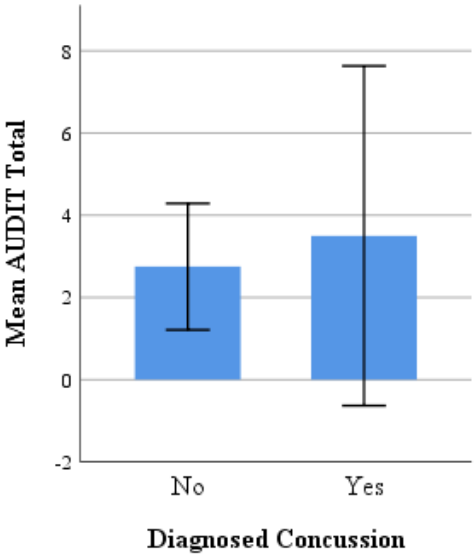

Mean GHQ Somatic Symptoms
15
10
5
0
No
Yes
Diagnosed Concussion


Mean GHQ Anxiety Insomnia
12
10
8
6
4
2
0
No
Yes
Diagnosed Concussion


Mean GHQ Social Dysfunction
15
10
5
0
No
Yes
Diagnosed Concussion


Mean BDI Total
15
10
5
0
No
Yes
Diagnosed Concussion


Mean T-STAI Total
60
50
40
30
20
10
0
No
Yes
Diagnosed Concussion


Mean AUDIT Total
8
6
4
2
0
-2
No
Yes
Diagnosed Concussion

Note. BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.

Figure 13-24. Graphical representation of the descriptive statistics for the Diagnosed Concussion/No Diagnosed Concussion (N = 34).

Multiple hierarchical regression models. As mentioned above no statistically significant mean group differences were found in the screening measure outcomes. This supported our decision to exclude them from the multiple hierarchical regression models and instead, these variables were used only for control purposes. Age and Control/Rugby, however, were included as predictors in our models due to the aforementioned literature, establishing their importance in the domain of concussion research (Daneshvar et al., 2011; Fuller et al., 2015; Pfister et al., 2016; Semple et al., 2015).

A total of six different multiple hierarchical regressions were run, following the steps explained in the Table 4. Age was used as the first predictor (Model 1), the Rugby/Control was added as a second predictor (Model 2). Finally, the Diagnosed Concussion/No Diagnosed Concussion variable was added to Model 3 in order to determine whether this grouping variable was a good predictor for anger and impulsivity for each of the respective outcome measures: (1) BIS Total, (2) BIS Self-control, (3) STAXI Angry Temperament, (4) STAXI Angry Reaction, (5) STAXI Anger Expression Out and, (6) ImPACT Impulse Control. Within each of these hierarchical regression analyses, all relevant assumptions were upheld. None of the models, however, were significant ($p > .05$) thereby suggesting that they did not significantly predict for externalising behaviours (see Appendix O).

Table 4

Hierarchical Model with Diagnosed Concussion/No Diagnosed Concussion as a Predictor Variable

Model	Predictor variables
1	Age
2	Age, Rugby/Control group
3	Age, Rugby/Control group, Diagnosed Concussion/No Diagnosed Concussion group

Predicting ImPACT Impulse Control. As depicted in Table 5, the addition of Diagnosed Concussion/No Diagnosed Concussion as a predictor variable in Model 3 (R^2 = .19, *adjusted* R^2 = .10) results in a significant increase in the model's ability to predict ImPACT Impulse Control (*F change* (1,27) = 5.02, *p* = .034). However, the overall model lacks significance [*F*(3, 27 = 2.11, *p* = .122]. Nevertheless, a total of 19% of the variance in ImPACT Impulse Control is accounted for by this variable, with Diagnosed Concussion (*M* = 8.33, *SD* = 5.32) being associated with higher scores when compared to the No Diagnosed Concussion group (*M* = 5.00, *SD* = 1.94). The members of the Diagnosed Concussion group have poorer impulse control and are, therefore, more impulsive. The regression equation below further demonstrates this, indicating that having a diagnosed concussion increases the ImPACT Impulse Control score by .43 units. The Beta values further depict Diagnosed Concussion (*β* = .43) to have the greatest influence on ImPACT Impulse Control compared to Age (*β = - .02)* and Rugby/Control (*β = .03).*

Regression model equation. Poor Impulse Control= 7.02 - .02*Age + .03* Rugby/Control Group + .43*Diagnosed Concussion.

Table 5

Results of Multiple Hierarchical Regression, Predicting ImPACT using Diagnosed Concussion/No Diagnosed Concussion as the Third Predictor Variable (N = 34)

						Change Statistics				
				Adjusted		R^2	F			
Measure	Model	R	R^2	R^2	SES	Change	Change	*df*1	*df*2	*p*
ImPACT	1	.11	.01	-.02	3.12	.01	.34	1	29	.565
Impulse	2	.20	.04	-.03	3.13	.03	.82	1	28	.374
Control	3	.44	.19	.10	2.92	.15	5.02	1	27	.034*

Model 1. Predictors: (Constant), Age

Model 2. Predictors: (Constant), Age, Rugby/Control

Model 3. Predictors: (Constant), Age, Rugby/Control, Diagnosed Concussion/No Diagnosed Concussion

Note. R = correlation coefficient; SES = standard error of estimate; df = degrees of freedom; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing

*p < .05. All listed *p*-values are two-tailed.

Diagnosed and Suspected Concussion/No Concussion

As illustrated by Table 6 and the overlapping error bars of the graphs (Figure 25-36), no statistically significant differences were found between the means of the two groups for age or any of the screening measures ($p > .05$). See Appendix M and P for effect sizes and for detailed means and standard deviations, respectively. Furthermore, there were no statistically significant differences found for any of the externalising behavioural outcome measures. The means for the Diagnosed and Suspected Concussion group on the externalising behaviour measures were, however, lower than those for the No Concussion group.

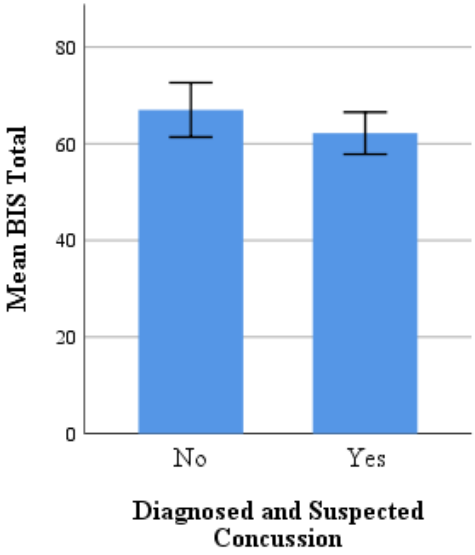
Table 6

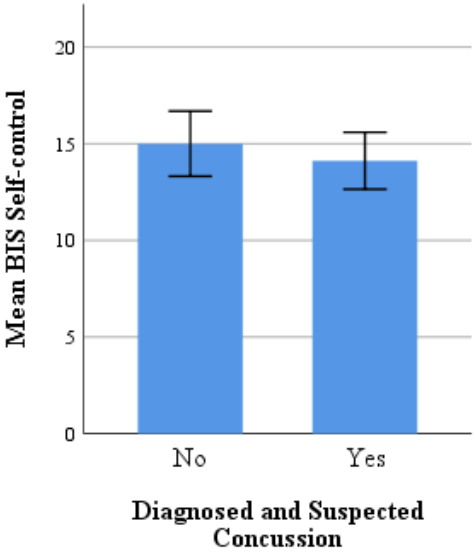
Sample Characteristics for Diagnosed and Suspected Concussion/No Concussion

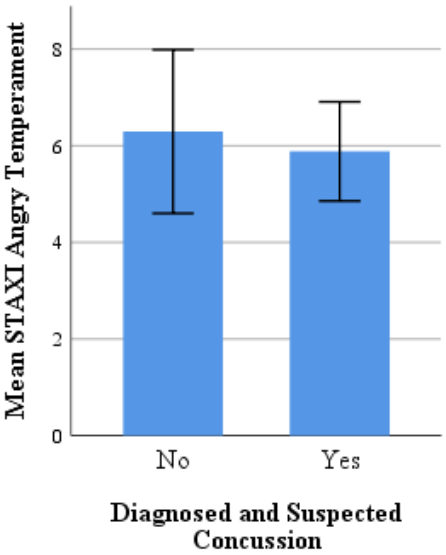
Measure	*df*	*F*	*p*
Age	1,32	1.51	.229
BIS Total	1,32	2.07	.160
BIS Self-control	1,32	.70	.410
STAXI Angry Temperament	1,32	.19	.662
STAXI Angry Reaction	1,32	.15	.705
STAXI: ANGER Expression Out	1,32	.01	.931
ImPACT Impulse Control	1,29	.72	.402
GHQ Somatic Symptoms	1,32	.82	.372
GHQ Anxiety/Insomnia	1,32	.34	.563
GHQ Social Dysfunction	1,32	.17	.687
BDI Total	1,32	.00	1.00
T-STAI Total	1,32	1.54	.224
AUDIT Total	1,32	.76	.389

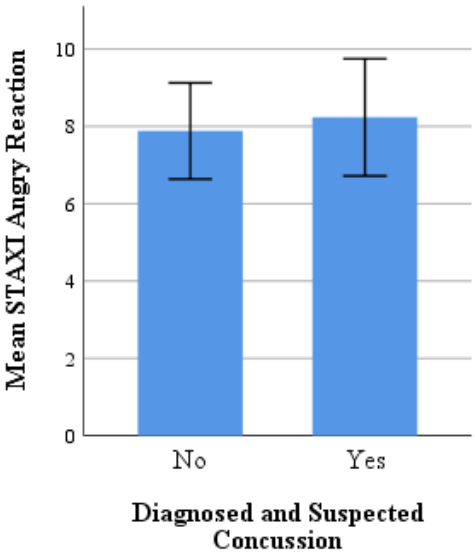
Note. df = degrees of freedom; BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.

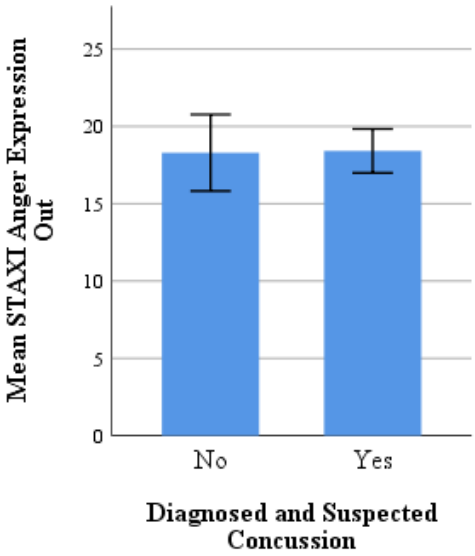
All listed *p*-values are two-tailed.

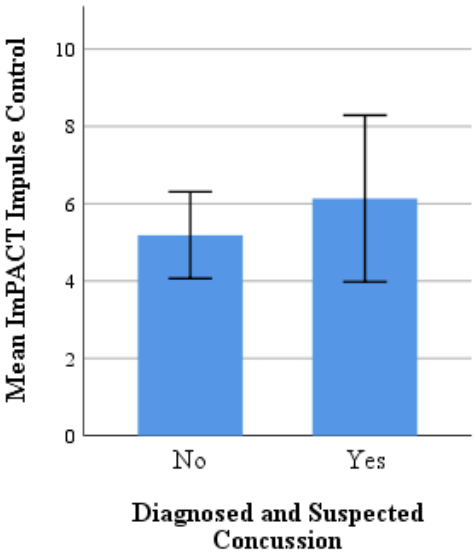

Mean BIS Total
80
60
40
20
0
No
Yes
Diagnosed and Suspected Concussion

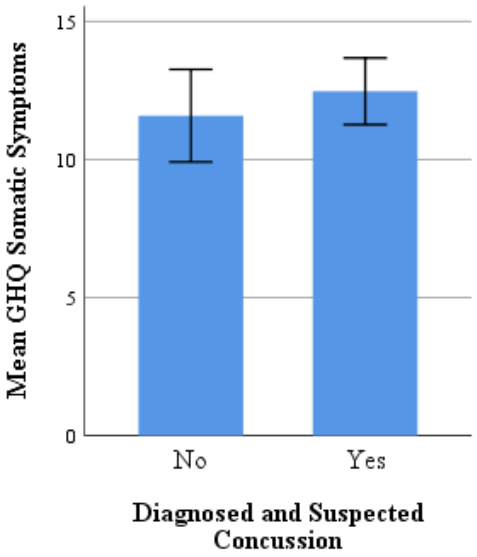

Mean BIS Self-control
20
15
10
5
0
No
Yes
Diagnosed and Suspected Concussion

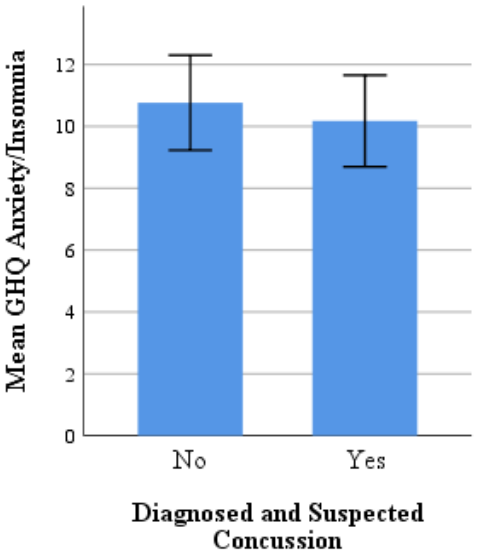

Mean STAXI Angry Temperament
8
6
4
2
0
No
Yes
Diagnosed and Suspected Concussion

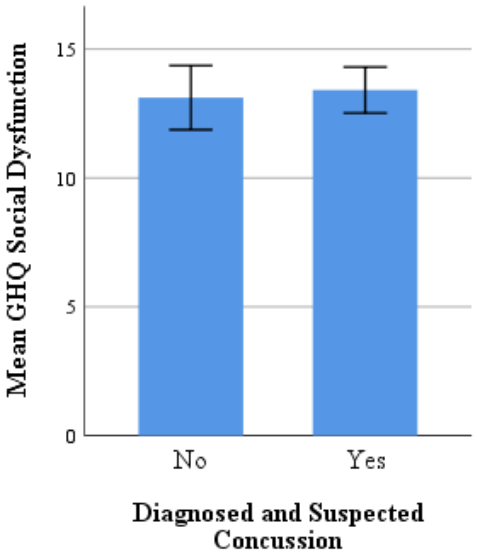

Mean STAXI Angry Reaction
10
8
6
4
2
0
No
Yes
Diagnosed and Suspected Concussion

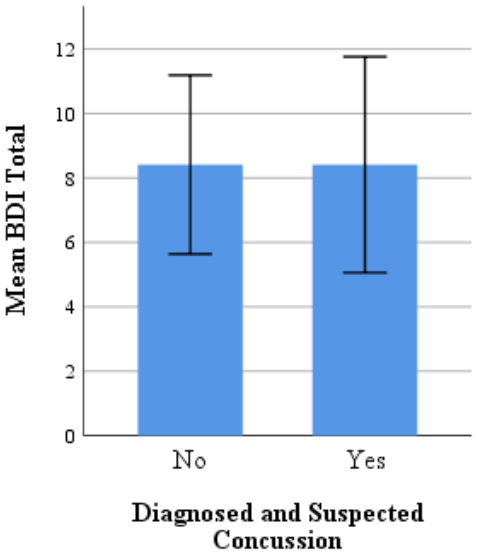

Mean STAXI Anger Expression Out
25
20
15
10
5
0
No
Yes
Diagnosed and Suspected Concussion

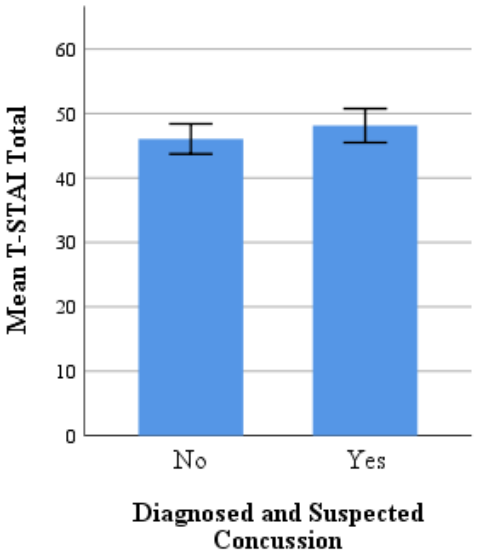

Mean ImPACT Impulse Control
10
8
6
4
2
0
No
Yes
Diagnosed and Suspected Concussion

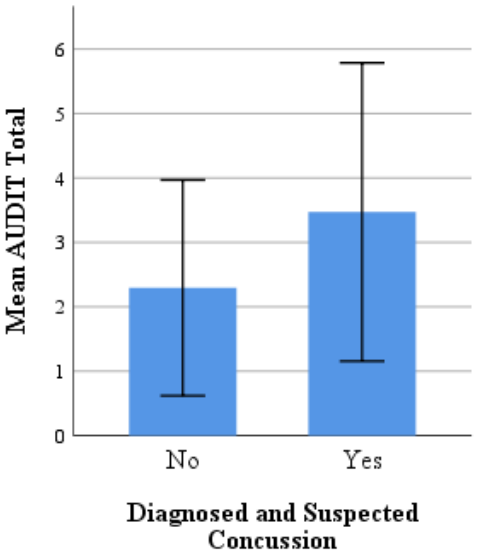

Mean GHQ Somatic Symptoms
15
10
5
0
No
Yes
Diagnosed and Suspected Concussion


Mean GHQ Anxiety/Insomnia
12
10
8
6
4
2
0
No
Yes
Diagnosed and Suspected Concussion


Mean GHQ Social Dysfunction
15
10
5
0
No
Yes
Diagnosed and Suspected Concussion


Mean BDI Total
12
10
8
6
4
2
0
No
Yes
Diagnosed and Suspected Concussion


Mean T-STAI Total
60
50
40
30
20
10
0
No
Yes
Diagnosed and Suspected Concussion


Mean AUDIT Total
6
5
4
3
2
1
0
No
Yes
Diagnosed and Suspected Concussion

Note. BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.

Figure 25-36. Graphical representation of the descriptive statistics for the Diagnosed and Suspected Concussion/No Concussion. (N = 34).

Hierarchical regression models. A further six multiple hierarchical regressions were run, following the steps in Table 7. Diagnosed and Suspected Concussion/No Concussion was added to Model 3 in order to determine whether this was a good predictor for the externalising behaviours measured in each of the respective outcome measures. Within each of these hierarchical regression analyses, all relevant assumptions were upheld. None of the models were statistically significant ($p < .05$), suggesting that being part of either the Diagnosed and Suspected Concussion or No Concussion group did not significantly predict for externalising behaviors (see Appendix Q for model summaries). The results found for the outcome variable BIS Total, however, demonstrate that there may be a trend towards significance.

Table 7

Hierarchical Model with Diagnosed and Suspected Concussion/No Concussion as a predictor variable

Model	Predictor variables
1	Age
2	Age, Rugby/Control group
3	Age, Rugby/Control group, Diagnosed and Suspected Concussion/No Concussion group

Predicting BIS Total. Despite the overall model lacking significance [$F(3, 30 = 1.49$, $p = .239$], Table 8 demonstrates, with the addition of Diagnosed and Suspected Concussion/No Concussion as a predictor variable to Model 3 ($R^2 = .13$, *adjusted* $R^2 = .04$) there is an increase in the models ability to predict BIS Total. This is trending towards statistical significance [*F Change*$(1, 30) = 3.66$, $p = .065$]. A total of 13% of the variance in BIS Total is accounted for by this predictor variable. However, Diagnosed and Suspected Concussion ($M = 62.18$, $SD = 8.47$) was associated with lower BIS Total scores than the No Concussion group ($M = 67.00$, $SD = 10.94$). This finding indicates that the No Concussion

group had higher rates of impulsivity, reflected by a higher mean scores total, when compared to the Diagnosed and Suspected Concussion group.

Table 8

Results of Multiple Hierarchical Regression, Predicting BIS Total using Diagnosed and Suspected Concussion/No Concussion as the Third Predictor Variable (N = 34)

						Change Statistics				
Measure	Model	R	R^2	Adjusted R^2	SES	R^2 Change	F Change	df1	df2	p
BIS	1	.11	.01	-.02	10.03	.01	.40	1	32	.531
Total	2	.15	.02	-.04	10.14	.01	.34	1	31	.564
	3	.36	.13	.04	9.73	.11	3.66	1	30	.065

Model 1. Predictors: (Constant), Age

Model 2. Predictors: (Constant), Age, Rugby/Control

Model 3. Predictors: (Constant), Age, Rugby/Control, Diagnosed and Suspected Concussion/No Concussion

Note. R = correlation coefficient; SES = standard error of estimate; df = degrees of freedom; BIS = Barratt Impulsiveness Scale.

All listed *p*-values are two-tailed.

Discussion

The main aim of this research study was to investigate whether a history of concussion amongst rugby players was associated with greater externalising behaviours in adolescents compared to those who had not previously sustained a concussion. Two hypotheses were tested: (1) Rugby players who have been formally diagnosed with a concussion will report higher levels of externalising behaviours compared to participants of the Rugby group and Control group who have no formal concussion diagnosis; and (2) Participants who have previously been formally diagnosed, as well as those who have suspected a concussion, will report higher levels of externalising behaviours when compared to those who have not reported ever having been formally diagnosed or suspected a concussion. Despite finding no statistically significant differences in all the sets of analyses, our findings reveal overall trends between the groups on each of the externalising behavioural measures. These trends reveal higher externalising behaviour means in those with a history of

concussion compared to those without. We begin by looking at the number of concussions reported by participants in our study, both diagnosed and suspected. We then discuss interesting trends observed in the outcomes for each of the hypotheses in relation to the existing literature on the topic. This will be followed by the limitations of the study and recommendations for future research.

Sample Characteristics

Given that a previously diagnosed concussion was an exclusion criterion for the Control group, these are only reported for the Rugby group. There were higher report rates of suspected concussion (43.38%) compared to diagnosed concussion (26.09%) in the Rugby group. Moreover, a total of 56.52% of the entire sample (both groups) reported having suspected a concussion that did not receive a medical diagnosis or clearance. This demonstrates a lack in the formal reporting and diagnosis of concussions in rugby, but also in other sports. Literature supports the real-world prevalence of this issue (Giza & Kutcher, 2014), with a US study estimating that between 500 thousand and 1.3 million annual cases of SRCs in children are not formally diagnosed by a medical practitioner (Bryan et al., 2016).

Rugby group and Control group

The overall trend of higher externalising behaviours observed in the Rugby group compared to the Control group, although not statistically significant, might lead one to suspect a history of concussion to be associated with higher levels of anger and impulsivity. However, as per the design of the study, the Rugby group contained both those with and without a history of concussion and the Control group contained only those without a history of formally diagnosed concussion. Therefore, a more accurate indication of the effect of a history of concussion on these behaviours required dividing the sample into groups based on concussion history (Diagnosed Concussion/No Diagnosed Concussion and Diagnosed and Suspected Concussion/ No Concussion), on which further analyses were run.

Diagnosed Concussion and No Diagnosed Concussion

Hypothesis 1, which stated that Rugby players who have been formally diagnosed with a concussion will report higher levels of externalising behaviours compared to participants of the Rugby and Control group who have no formal diagnosis, was not supported. The trends in the mean group differences do, however, demonstrate a relationship between having a history of concussion and these behaviours in the expected direction: greater adverse externalising behaviours for those with a diagnosed concussion (see e.g., Ilie et al., 2014; Taylor et al., 2015).

ImPACT Impulse Control. Despite none of these mean group differences reaching statistical significance, Cohen's d shows a large effect size for ImPACT Impulse Control, but not for the other externalising behavioural measures. This suggests a possible meaningful difference in impulsivity between these two groups, with the possibility of obtaining statistical significance with a larger sample size. Furthermore, the addition of Diagnosed/No Diagnosed Concussion to the regression model predicting ImPACT Impulse Control significantly increased the model's predictive power of this outcome variable, despite the overall model not being statistically significant. In controlling for Age and Rugby/Control within this model, the results show impulse control to be significantly affected by a participant having a history of concussion.

This is in line with existing literature which has linked concussion to an increase in impulsivity (see e.g., Rochat et al., 2018; Von Der Heide et al., 2013). Research shows that the frontal and temporal brain regions which are connected by the UF, form the network responsible for behavioural inhibition which are the most vulnerable to concussive forces (Goswami et al., 2016; Peper et al., 2015). Our results support that concussion causes a decrease in the integrity of the UF, ultimately increasing impulsivity, due to the resultant compromise in externalising behavioural regulation (Goswami et al., 2016; Peper et al., 2015; Von Der Heide et al., 2013).

Existing literature reveals higher externalising behaviours in adults who have suffered from multiple concussions, as opposed to those who have only sustained one (Kerr et al., 2014). Our study finds these same trends in externalising behaviours after the adolescents have only reported one concussion, with only one participant having reported two. This supports the idea within the literature of the enhanced vulnerability of the adolescent brain to concussive forces (Barlow et al., 2011; Pfister et al., 2016). Furthermore, the meaningful difference for ImPACT Impulse Control observed between those with a formally diagnosed concussion and those without, in this study's sample population, is potentially suggestive of the true vulnerability of the adolescent brain.

There are, however, two additional factors to consider when looking at these impulsivity trends. Due to the cross-sectional nature of our study, we cannot confidently conclude that the higher levels impulsivity observed in the Diagnosed Concussion group resulted from the concussion itself. These behaviours may already have been present prior to sustaining any concussion (Hollis et al., 2009). Moreover, a reverse relationship may exist between impulsivity and concussion: an athletes' premorbid high impulsivity score is what

might be putting them at risk for sustaining a concussion, which is then what results in the higher incidence rates observed in these more impulsive athletes (Hollis et al., 2009).

Diagnosed and Suspected Concussion and No Concussion

Hypothesis 2 stated that participants who had previously been formally diagnosed with a concussion, as well as those who have suspected a concussion, would report higher levels of externalising behaviours when compared to those who had not reported ever having been formally diagnosed or suspected a concussion. This hypothesis was not supported. Literature establishes a high prevalence of concussions being left unreported (Bryan et al., 2016), due to reasons such as fear of missing games (Meier et al., 2015), not understanding the long-term effects of concussion (Walker, 2015) and a general negative attitude towards reporting a concussion within sporting culture (Davies & Bird, 2015). This led us to suspect that the reports of suspected concussion within our sample may have been classified as true concussions, had they been reported and assessed at the time. We thus included the cases of suspected concussion as part of the concussion group (Diagnosed and Suspected Concussion group). In doing so, trends in the data became contradictory to the direction of the relationship between concussions and externalising behaviours that is supported by a wealth of literature (see e.g., Bryant, 2008; Daneshvar et al., 2011; Ilie et al., 2014; McCrory et al., 2017). It further contradicted the trends in the results we obtained when including suspected concussion as part of the No Concussion group (on the basis that they never received a formal diagnosis). Self-reported concussion histories can, however, be unreliable (Bryan et al., 2016) in the absence of a formal diagnosis and therefore, some of the suspected concussions may in fact not have met the criteria of a formal diagnosis.

Limitations and Recommendations for Future Research

As mentioned above, a limitation to this study was that it was statistically underpowered due to the sample size being smaller than what power analyses indicated would be necessary in order to detect the effects under investigation. A larger sample size would provide more power for the analyses undertaken. Effect sizes suggest these might lead to more significant results. A further limitation is this study's retrospective nature and its dependence on participants' self-reporting of their concussion history and externalising behaviours. Limitations to self-reported data is well known in the literature (Seichepine et al., 2013) due to possible inaccuracies in recall (Liu & Li, 2013), as well as attempts by participants to avoid being associated with socially undesirable behaviours such as anger, aggression and impulsivity. Future research could therefore measure these behaviours sooner after concussion and by means other than self-report in order to overcome the possible social

desirability bias that may have affected the results of our study. Because our study formed part of a larger ongoing study, we used the measures included in the test battery of that larger study, which did not include a specific measure for aggression. Obtaining ethical approval from multiple ethics boards for the inclusion of additional measures did not prove feasible. Nonetheless, literature does show an association between aggression and both impulsivity and anger (Peper et al., 2015) for which our study was able to specifically measure. However, to include an aggression measure would allow for a better understanding as to how this specific behaviour is affected, further providing a more holistic understanding of the relationship between concussion and externalising behaviours.

This study was limited to including participants between the age range of 16 to 19. However, previous studies have found a more prominent effect that concussion has on externalising behaviours in children 10 years old and younger (Taylor et al., 2015), suggesting that future studies should try to incorporate younger individuals within the study sample. Furthermore, literature has found that significant differences in externalising behavioural problems may only arise when multiple, rather than single, concussions have occurred (Liu & Li, 2013). A topic of interest for future studies investigating the effect of concussion on the adolescent brain may then be to consider the effects of multiple concussions in this population. This would allow for a better understanding as to whether the same adverse effect the accumulation of concussions has on the externalising behaviours within the adult population manifests in the same way for adolescents (Goswami et al., 2016).

Summary and Conclusion

Despite these limitations, this study is one of the first to investigate the effects of SRCs on the adolescent brain in relation to externalising behaviours within the South African context. While the findings were mostly non-significant, likely a function of the small sample size, we see an overall trend of greater anger and impulsivity with a history of concussion. The presence of this trend provides reason to believe that concussions sustained during adolescents may have some effect on these externalising behaviours, the significance of which may be expected with a greater sample size. That being said, of the behaviours investigated, impulsivity seems to be the most negatively impacted aspect of externalising behaviours by concussion injury.

Understanding the effects SRCs have on the young, developing brains of adolescents is important especially in a country which highly values the game of rugby. This study offers some insight into the much-needed local research on this topic. Any awareness created around SRCs and their potential adverse effects they may have on an individual may

encourage better measures to be taken in order to increase safety in contact sports. Moreover, knowledge may assist in advancing the concussion-management procedures implemented within high risk contact sports, and further better inform the choices of parents and children regarding participation in such sports.

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Appendix A

Informed Consent Form for Control (non-rugby) Participants

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Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players

Informed consent for your child to participate in research and authorisation for collection, use, and disclosure of protected health information

The neuropsychological (relationship between the brain and behavior) effects of traumatic brain injuries (TBIs) are considered a public health concern, both in South Africa and around the world. A common form of TBI is concussion, which is known to be associated with neuropsychological (thinking and behavioural) difficulties. Some of the outcomes associated with concussion often include difficulties with attention and concentrating, higher order thinking skills (e.g., working with information in one's head), remembering information and the speed at which one thinks or processes information.

Some research suggests that exposure to concussive head injuries over a long period of time, especially when this starts at a young age like in the adolescent years, may result in permanent neuropsychological (thinking and behavioural) and emotional problems in the adult years. There have been some cases for which research has suggested that such long-term exposure to multiple concussions may also be associated with neurodegenerative (loss of structure and function of neurons (brain cells) over time) processes in later life.

Added to this, adolescent athletes seem to show more difficulties and longer recovery times compared to adults following concussion, suggesting that the injury and recovery process may be different between adolescents and adults. Therefore, investigating the effects of concussion among a young adolescent population (aged 16 to 19 years) is of particular interest in this study. Younger athletes (e.g., adolescents) may be at greater risk for difficulties as compared to adults, for several reasons: 1) the brain is still maturing and developing during childhood and adolescence and thus an injury during this developmental period can interfere with this development; second, the differences in how intense and how long symptoms last in adolescents compared to adults suggests that the adolescent brain is different to that of the adult brain.

One sport in which concussion is frequently reported is that of rugby. Although many people play rugby, little research has been done to investigate the long-term outcomes of concussive injuries in an adolescent rugby-playing sample.

In order to investigate this you are invited to allow your child to take part in a research study at your son's school with the University of Cape Town. This form provides you with information about the study and seeks your permission for the collection, use and disclosure of your child's neuropsychological and behavioural performance data, as well as other information necessary for the study. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also describe this study to you and answer all of your questions. Your child's participation is entirely voluntary. Before you decide whether or not your child may take part, read the information below and ask questions about anything you do not understand. Whether you do or do not allow your child to participate in this study you will not be penalized or lose any benefits to which you would otherwise be entitled.

This study will be conducted in a manner that adheres to the ethical guidelines and principles of the International Declaration of Helsinki (Fortaleza, Brazil, 2013).

1. Title of Research Study

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players.

2. Principal Investigator(s) and Telephone Number(s)

Dr. Leigh Schrieff

3.11 Department of Psychology

University of Cape Town

Rondebosch

7701

Tel: 021 650 3708

Email: leigh.schrieff-elson@uct.ac.za / leigh.schrieff@gmail.com

Research assistant

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Department of Psychology

University of Cape Town

Rondebosch

7701

Email: sarah.mcfie@gmail.com

3. Source of Funding or Other Material Support

Medical Research Council

4. What is a concussion?

A concussion is a traumatic brain injury that results in the changing of brain functioning. A concussion is typically caused by a direct impact to the head, but it can also occur when a force is applied to the body that results in the rapid rotation of the head. The most common symptoms of a concussion include headaches, dizziness, memory deficits, and balance disturbances.

5. What is the purpose of this research study?

The purpose of this research study is to investigate whether or not, and how instances of concussions contribute to brain functioning in adolescents, whose brains are still developing. More specifically the research intends to find out how these injuries may affect the way that an individual thinks, feels and behaves, and whether/how it impacts on the brain. Also, the purpose is to observe how individuals who sustain concussions compare to people who have had no such injuries.

6. Who is taking part in this study?

Because we would like to compare individuals who sustain concussions to individuals who have had no such injuries, there will be two groups of participants in this study: a rugby group and a non-contact sports playing matched control group. In this study, the matched control group includes non-rugby sports players who are similar (matched) in terms of age, sex, baseline test scores and sport involvement to the players in the rugby group so that we can compare rugby players in our study to similar aged non-rugby players.

Rugby is a sport that involves a lot of impacts to the head, neck, and shoulder areas. These forces can at times lead to a concussion. The rugby group will be analyzed to see the effect of these concussions on tests of behavior and cognitive (thinking) functioning, as well as the structure of the brain (using a

brain scan). The non-contact sports group, the control group, will be included so that we can compare the outcomes of the rugby group to matched individuals who are not exposed to rugby and the associated injuries.

7. How many people are expected to participate in the research?

Your son will be one of 120 school-aged rugby and 120 school-aged non-contact sport players in this study. The maximum number of participants who will be screened at the baseline testing will be 120 for each group. Your son may be one of 16 control participants invited to take part in the testing and brain scan component of the study at the end of the season (explained below).

8. What will be done if you allow your child to take part in this research study?

The reason that we are including non-rugby playing participants is so that we can compare the performances of high school learners who play rugby (and who may or may not have sustained a concussion) to the performances of those who do not play rugby and have not sustained concussions.

At the start of this study, your son will be asked to complete a number of questionnaires and tests to obtain individual demographic information, personal characteristics, an estimate of his ability to think, as well as the different ways in which he acts and feels.

At the end of the rugby season, we are going to do a similar set of tests to the baseline tests with rugby players that were concussed during the rugby season. Those players will also undergo a brain scan. At that point, we will also select and invite players from the matched control group who match the rugby players that were concussed during the season, on age, baseline testing, and sport involvement, to undergo the same tests and a brain scan so that we can have comparative data.

Therefore, following initial testing, the results of the baseline testing will be evaluated. Your son may be contacted to participate in another session of the same tests in September/October, 2019, where he may also be asked to undergo a brain scan, if he happens to match (in terms of age, baseline testing and activity levels) a rugby-playing participant at that time.

These testing procedures will be conducted in a private room at the Cape Universities Body Imaging Centre (CUBIC), Groote Schuur Hospital. We will ask for your son's assent again if he is asked to participate in the second set of assessments.

Tests and questionnaires that will be given to your son at the initial testing session and if your son if invited to participate in further testing at the end of the season:

Demographic and medical history questionnaire – This questionnaire asks for information about your son's age, height, weight, language ability, learning difficulties (if any), any current or previous concussions, any previous or current psychiatric disorder, and what (if any) medication your son is currently taking.

Alcohol Use Disorders Identification Test – This questionnaire measures your son's current and/or lifetime alcohol use. The researchers do not suspect your son of consuming alcohol, however previous research has shown a strong relationship between concussions and substance use.

Barratt Impulsiveness Scale – This questionnaire looks at how impulsive your son's behavior is, and how this may relate to concussion.

Beck Depression Inventory – This questionnaire looks at symptoms of depression. Concussion has been shown to be associated with depressive symptoms, and this questionnaire will be used to assess such symptoms.

General Health Questionnaire – This questionnaire is used to look at the overall psychological health in an individual. It will be used with the other psychological questionnaires to understand your son's general health.

Profile of Mood States (short form) – The profile of mood states is a measure of overall mood. Mood is different to psychological health because it is more variable. This will also be used to compliment the other psychological questionnaires.

State-trait Anger Expression Inventory – This questionnaire looks at the amount of anger expressed by your son.

State-trait Anxiety Inventory – This questionnaire looks at the levels of anxiety your son has, and how it is expressed.

The IMPACT – The IMPACT is a computerized test used to measure concussion symptoms. It has two parts to it. The first part measures the concussion symptoms of your son, such as nausea, sleep and headaches. The second part measures your son's cognitive performance.

Pocket Concussion Recognition Tool (PCRT). The PCRT, is a side-line evaluation which can be administered by medical or non-medical professionals to detect a probable concussion. A conclusion of a probable concussion should be made if one or more symptoms is present in the following categories; visible cues of suspected concussion (loss of consciousness, balance problems, dazed gaze), symptoms of a concussion (headache, dizziness, confusion), and memory function.

Brain Scan – Brain scans are computerized images of the brain generated by placing the participant on a padded plastic bed that slides into the scanner. The scan is non-invasive (does not enter or

penetrate the body) and painless. These images are used to examine the brain for any possible abnormalities in the brain that may be causing some discomfort. The standard brain imaging techniques do not reveal any gross structural abnormalities associated with concussions. However, recent research indicates that there may be small changes following a concussion. If your son is in the control group, the scan will be done in order to compare your son's brain structure to the rugby group participants'. If any abnormalities are discovered, a pediatric neurosurgeon will review the scans and advise you and your family on the best course of action.

9. What are the exclusion criteria for this study?

The exclusion criteria for the study include: (a) being of the female sex, (b) being older than 19 years or younger than 16 years at time of recruitment, (c) scoring 21 or more on the Beck Depression Inventory-Second Edition (BDI-II), (d) prior or current diagnosed psychiatric illnesses, learning disabilities, or neurological disease, (e) any history of, or current drug and/or alcohol abuse, (f) control participants with a history of a previous concussion.

Should your son meet any of these criteria, he will not be contacted to partake in the second phase of the study.

10. If you choose to participate in this study, how long will your child be expected to participate in the research?

Your son will be asked to be available for the initial scheduled testing session – this session will take approximately 2 hours. The study will run over the course of 6 months. Your son will however only participate in the baseline testing session unless he is selected as a matched control to participate in the end of season assessment and brain scan.

11. What are the possible discomforts and risks for your child?

There is minimal risk associated with this study. You***r*** child may be required to return for a repeated assessment in September/October at CUBIC. You will be contacted by the Principal Investigator if this is the case. The testing procedures take approximately 1½ - 2 hours per person. Due to it being a lengthy process, your child may feel fatigued or irritable during testing. However, your child will be given breaks where necessary, as well as refreshments. The follow-up session is not as time consuming.

Some participants in the research study may feel anxious or claustrophobic with regards to the brain scan. To counter this, an assistant will explain the scanning procedure to your child. The research assistant will also allow your child to have a "mock scan" where they will experience what it is like to have a scan, before undergoing the actual scan. The scan will not hurt your son and it will not be dangerous in any way. Your son will however need to take the following precautions.

During the MRI neuroimaging assessment, certain metal objects, such as watches, credit cards, hairpins, and writing pens, may be damaged by the MRI scanner or pulled away from the body by the magnet. For these reasons, your son will be asked to remove these objects before entering the scanner. When the scanner takes the images, the bed may vibrate, and your son will hear loud banging noises. He will be given earplugs or earphones to protect his ears. Also, some people feel nervous in a small-enclosed space such as that of the scanner. Your son will be able to see out of the scanner at all times, and the radiographer will not start the procedure until your son is comfortable. Your son will be able to stop the procedure at any time by squeezing a ball and can talk to the radiographers using an intercom that is built into the scanner. There are no known harmful long-term effects of the scanner used in this study. Scans will take no longer than 1 hour.

In the process of testing and scanning, researchers may come across incidental findings. Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. For example, these may relate to findings on brain scan, where, in the process of completing the scan at the end of the season for this research study (if you son is selected to participate in that component), researchers may come across other findings on the scan that may be of concern. (Below we include referral information in the event of such incidental findings).

If you wish to discuss the information above or any discomforts you may experience, you may ask questions now or call the Principal Investigators listed on this form.

12. Referrals

Given that we are administering tests of thinking and behavior and brain scans as part of the study, there may be outcomes following those tests, for which further follow-up by health professionals may be advisable. We will not impose these referrals but we provide the necessary information for parents as these follow-up consultations in the best interests of the child. We outline these referrals below.

Referrals related to baseline testing and exclusion criteria

We noted under point 8 above that there are certain exclusion criteria for this study and we outlined those points there. Two of these exclusion criteria related to participants' scores on a test of depression symptoms and a test related to alcohol usage. If participants score within certain ranges on these tests, they will be referred to a Sports Psychologist at the Sports Science Institute of South

Africa. In the event that your son scores 21 or more on the Beck Depression Inventory and/or reports any history of, or current drug and/or alcohol abuse, as reported on the AUDIT (see exclusion criteria), he will be referred to Clinton Gahwiler (see details below) by the Principal Investigator.

Psychological management:

Clinton Gahwiler (BA hons MA)

Sport Psychologist at the Sport Science Institute of South Africa

Tel: 021 659 5655

Fax: 086 624 7988

Email: sportpsych@xsinet.co.za

Website: www.performingmind.co.za

Referrals related to incidental findings on MRI scans

Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. A radiologist on the CUBIC staff and linked to this study, is going to review all the participants' brain scans for such incidental findings. In an unfortunate case of an incidental finding your son will be referred for further evaluation to Professor Anthony Figaji. Professor Figaji is a pediatric neurosurgeon, and he will undertake to consult, examine and counsel you and your son where necessary, as well as determine any further course of management that may be needed.

13. What if something goes wrong?

This research study is covered by an insurance policy taken out by the University of Cape Town if your son suffers a bodily injury because he is taking part in the study.

The insurer will pay for all reasonable medical costs required to treat your son's bodily injury, according to the SA Good Clinic§al Practice Guidelines 2006, which are based on the Association of the British Pharmaceutical Industry Guidelines. The insurer will pay without you having to prove that the research was responsible for your son's bodily injury. You may ask the study doctor for a copy of these guidelines.

The insurer will *not* pay for harm if, during the study, your son:

- Uses medicines or other substances that are not allowed

- Does not follow the study doctor's instructions
- Does not tell the study doctor that he has a bad side effect from the study medicine
- Does not take reasonable care of himself and his study medicine

If your son is harmed and the insurer pays for the necessary medical costs, usually you will be asked to accept that insurance payment as full settlement of the claim for medical costs. However, accepting this offer of insurance cover does not mean you give up your right to make a separate claim for other losses based on negligence, in a South African court. It is important to follow the study doctor's instructions and to report straightaway if your son has a side effect from the study medicine.

14. What are the possible benefits of this study to your child, and others?

There is no potential for direct individual benefit by your son taking part in this study.

After the completion of each testing session, participants will be given a restaurant voucher as compensation for their time.

Overall, this research aims to contribute to practical information regarding return-to-play decisions, thresholds of concussion injuries, and diagnostic guides of concussion that are important for player safety. It will provide those involved with contact sport, including medical teams, information regarding the cognitive, behavioural and brain scan findings associated with concussion

15. If you choose to let your child participate in this research study, will it cost you anything?

Participating in this research study will not cost you anything. However, the cost of any referrals for further management will be for the personal account of parents/legal guardians and the participants.

16. Can your child withdraw from this research study?

You and your child may withdraw your consent and assent and stop participating in this research study at any time, without any penalty to you or your child. At the beginning of each testing session your son will be asked if he wants to continue with the study. Should he say no, there will be no punishment or penalty placed on your son.

If you have a complaint or complaints about your son's rights and wellbeing as a research participant, please contact the Human Research Ethics Committee.

Tel: 021 406 6492

E-mail: sumaya.ariefdien@uct.ac.za

17. If your child withdraws, can information about you and your child still be used and/or collected?

Information that has already been collected will be removed from the data set. Should your son withdraw from the study, his data will be removed from the data set.

18. Once personal and performance information is collected, how will it be kept secret (confidential) in order to protect your privacy?

If you agree for your child to participate in this research study, it is possible that some of the information collected might be copied into a "limited data set" to be used for other research purposes. If so, the limited data set will only include information that does not directly identify your son – his identity will remain confidential. Data will be labeled using participant numbers rather than names, so that they cannot be used to directly identify any particular individual. A separate and private log will be used simply to relate participant names to numbers in the event that a participant needs to be contacted or contacts the Principal Investigator. This log will only be accessible to the Principle Investigator.

All hard copy data collected will be stored in a locked filing cabinet in the access-controlled ACSENT Laboratory located in the Department of Psychology UCT. All electronic data will be stored on a password protected hard drive. Only the primary researcher and select individuals involved in the collection and analysis of the data will have access to these files. Your son's research records will not be released without your permission unless required by law or a court order. These measures do not however guarantee complete privacy. It may therefore not be possible to guarantee individual privacy. However, published data will not contain any identifiable information other than participant numbers.

19. How will the researcher benefit from your child participating in this study?

The researcher may choose to present this research at a conference or in a scientific journal.

20. Dissemination of research findings

You and your son's school will be provided with a report on the analysis of the data collected in this study. It is the aim that this report be published in an academic journal in order to widen the knowledge base of concussion in rugby. The report is based on the overall statistical findings, and will not reveal any personal details specific to your son.

Signatures

You have been informed about this study's purpose, procedures, possible benefits, and risks; and how your son's responses and performance and other data will be collected, used and shared with others. You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree for your child to participate in this study. You hereby authorize the collection, use and sharing of your son's performance and other data. By signing this form, you are not waiving any of your legal rights.

Signature of Person Consenting and Authorizing Date

_____ _____

Relationship to child participating in the study: parent / legal guardian

_____

Name of Participant ("Study Participant" – the child)

_____

Authorization for _____ to participate in the study.

Parent / legal guardian cellphone number: _____

Parent / legal guardian email address: _____

Appendix B

Informed Consent Form for Rugby Player Participants

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players

Informed consent for your child to participate in research and authorization for collection, use, and disclosure of protected health information

The neuropsychological (relationship between the brain and behavior) effects of traumatic brain injuries (TBIs) are considered a public health concern, both in South Africa and around the world. A common form of TBI is concussion, which is known to be associated with neuropsychological (thinking and behavioural) difficulties. Some of the outcomes associated with concussion often include difficulties with attention and concentrating, higher order thinking skills (e.g., working with information in one's head), remembering information and the speed at which one thinks or processes information.

Some research suggests that exposure to concussive head injuries over a long period of time, especially when this starts at a young age like in the adolescent years, may result in permanent neuropsychological (thinking and behavioural) and emotional problems in the adult years. There have been some cases for which research has suggested that such long-term exposure to multiple concussions may also be associated with neurodegenerative (loss of structure and function of neurons (brain cells) over time) processes in later life.

Added to this, adolescent athletes seem to show more difficulties and longer recovery times compared to adults following concussion, suggesting that the injury and recovery process may be different between adolescents and adults. Therefore, investigating the effects of concussion among a young adolescent population (aged 16 to 19 years) is of particular interest in this study. Younger athletes (e.g., adolescents) may be at greater risk for difficulties as compared to adults, for several reasons: 1) the brain is still maturing and developing during childhood and adolescence and thus an injury during this developmental period can interfere with this development; second, the differences in how intense

and how long symptoms last in adolescents compared to adults suggests that the adolescent brain is different to that of the adult brain.

One sport in which concussion is frequently reported is that of rugby. Although many people play rugby, little research has been done to investigate the long-term outcomes of concussive injuries in an adolescent rugby-playing sample.

In order to investigate this you are invited to allow your child to take part in a research study at your son's school with the University of Cape Town. This form provides you with information about the study and seeks your permission for the collection, use and disclosure of your child's neuropsychological and behavioural performance data, as well as other information necessary for the study. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also describe this study to you and answer all of your questions. Your child's participation is entirely voluntary. Before you decide whether or not your child may take part, read the information below and ask questions about anything you do not understand. Whether you do or do not allow your child to participate in this study you will not be penalized or lose any benefits to which you would otherwise be entitled.

This study will be conducted in a manner that adheres to the ethical guidelines and principles of the International Declaration of Helsinki (Fortaleza, Brazil, 2013).

21. Title of Research Study

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players.

22. Principal Investigator(s) and Telephone Number(s)

Dr. Leigh Schrieff

3.11 Department of Psychology

University of Cape Town

Rondebosch

7701

Tel: 021 650 3708

Email: leigh.schrieff-elson@uct.ac.za / leigh.schrieff@gmail.com

Research assistant

Dr Sarah McFie

Department of Psychology

University of Cape Town

Rondebosch

7701

Email: sarah.mcfie@gmail.com

23. Source of Funding or Other Material Support

National Research Foundation

Medical Research Council

24. What is a concussion?

A concussion is a traumatic brain injury that results in the changing of brain functioning. A concussion is typically caused by a direct impact to the head, but it can also occur when a force is applied to the body that results in the rapid rotation of the head. The most common symptoms of a concussion include headaches, dizziness, memory deficits, and balance disturbances.

25. What is the purpose of this research study?

The purpose of this research study is to investigate whether or not, and how, instances of concussions contribute to brain functioning in adolescents, whose brains are still developing. More specifically the research intends to find out how these injuries may affect the way that an individual thinks, feels and behaves, and whether/how it impacts on the brain. Also, the purpose is to observe how individuals who sustain concussions compare to people who have had no such injuries.

26. Who is taking part in this study?

Because we would like to compare to individuals who sustain concussions to individuals who have had no such injuries, there will be two groups of participants in this study: a rugby group and a non-contact sports playing matched control group.

Rugby is a sport that involves a lot of impacts to the head, neck, and shoulder areas. These forces can at times lead to a concussion. The rugby group will be analyzed to see the effect of these concussions on tests of behavior and cognitive (thinking) functioning, as well as the structure of the brain (using a

brain scan). The non-contact sports group (the control group) will be included so that we can compare the outcomes of the rugby group to matched individuals who are not exposed to rugby and the associated injuries. By matched participants we mean that participants in the control group who are similar to participants in the rugby group based on their age, sex, baseline test scores and sport involvement.

27. How many people are expected to participate in the research?

Your son will be one of 120 school-aged rugby and 120 school-aged non-contact sport players in this study. The maximum number of participants who will be screened at the baseline testing will be 120 for each group; but only 16 participants per group will be requested to complete the full study procedures.

28. What will be done if you allow your child to take part in this research study?

During this study, your son will be asked to complete a number of questionnaires and tests to obtain individual demographic information, personal characteristics, an estimate of his ability to think, as well as the different ways in which he acts and feels. Following the start of the season, should your son sustain a concussion, he will then be contacted for repeated testing in the 24-72 hours following the injury, where he will be asked to undergo a brain scan. Following the conclusion of the rugby season, your child may be contacted for repeated testing in September/October, 2019, where he may be asked to undergo another brain scan. These testing procedures will be conducted in a private room at the Cape Universities Body Imaging Centre (CUBIC), Groote Schuur Hospital. By signing the consent form, you are consenting to your child's participation in the possible follow-up assessments as well. Your child will also be asked to give their assent at the start of all testing sessions.

Tests and questionnaires that will be given to your son:

Demographic and medical history questionnaire – This questionnaire asks for information about your son's age, height, weight, language ability, learning difficulties (if any), any current or previous concussions, any previous or current psychiatric disorder, and what (if any) medication your son is currently taking.

Alcohol Use Disorders Identification Test – This questionnaire measures your son's current and/or lifetime alcohol use. The researchers do not suspect your son of consuming alcohol, however previous research has shown a strong relationship between concussions and substance use.

Barratt Impulsiveness Scale – This questionnaire looks at how impulsive your son's behavior is, and how this may relate to concussion.

Beck Depression Inventory – This questionnaire looks at symptoms of depression. Concussion has been shown to be associated with depressive symptoms, and this questionnaire will be used to assess for any such symptoms.

General Health Questionnaire – This questionnaire is used to look at the overall psychological health in an individual. It will be used with the other psychological questionnaires to understand your son's general health.

Profile of Mood States (short form) – The profile of mood states is a measure of overall mood. Mood is different to psychological health because it is more variable. This will also be used to compliment the other psychological questionnaires.

State-trait Anger Expression Inventory – This questionnaire looks at the amount of anger expressed by your son.

State-trait Anxiety Inventory – This questionnaire looks at the levels of anxiety your son has, and how it is expressed.

The IMPACT – The IMPACT is a computerized test used to measure concussion symptoms. It has two parts to it. The first part measures the concussion symptoms of your son, such as nausea, sleep and headaches. The second part measures your son's cognitive performance.

Pocket Concussion Recognition Tool (PCRT). The PCRT, is a side-line evaluation which can be administered by medical or non-medical professionals to detect a probable concussion. A conclusion of a probable concussion should be made if one or more symptoms is present in the following categories: visible cues of suspected concussion (loss of consciousness, balance problems, dazed gaze), symptoms of a concussion (headache, dizziness, confusion), and poor memory function.

Brain Scan – Brain scans are computerized images of the brain generated by placing the participant on a padded plastic bed that slides into the scanner. The scan is non-invasive (does not enter or penetrate the body) and painless. These images are used to examine the brain for any possible abnormalities that may be causing some discomfort. The standard brain imaging techniques do not reveal any obvious big negative changes in the structure of the brain associated with concussions. However, recent research indicates that there may be smaller changes following a concussion. The brain scans will be conducted in order to see if there are any small changes to your son's brain structure as a result of the concussion. Any small structural changes after concussion will be recorded, and reports will be forwarded on to the medical teams employed by you and/or your son's school. If any abnormalities are discovered, a pediatric neurosurgeon will review the scans and advise you and your family on the best course of action. It is important to note that as with the other assessment measures, the brain scan is part of the research assessment and not part of clinical management of the concussion injury.

29. What are the exclusion criteria for this study?

The exclusion criteria for the study include: (a) being of the female sex, (b) being older than 19 years or younger than 16 years at time of recruitment, (c) scoring 21 or more on the Beck Depression Inventory-Second Edition (BDI-II), (d) prior or current diagnosed psychiatric illnesses, learning disabilities, or neurological disease, (e) any history of or current drug and/or alcohol abuse, (f) participants who do not have a clear referral process to an adequately qualified clinician following a concussive episode, for a formal diagnosis of concussion. Should your son meets any of these criteria, he will not be contacted to partake in the second phase of the study.

Discharge points

We have also included what we refer to as 'discharge' or exit points in the study. In their Concussion Guidance document, World Rugby (2017) note the following about multiple concussions: "Players with a history of two or more concussions within the past year are at greater risk of further brain injury and slower recovery and should seek medical attention from practitioners experienced in concussion management before return to play". Given the potential risk of a participant sustaining multiple concussions and the possibility that they may be returning to play prematurely following a concussion, and in an effort to adhere to the World Rugby guidelines which are in the player's best interest (i.e., for their protection), we will include the following discharge points in the study:

1) If an individual has previously been concussed in the year leading up to the study and is concussed again during the course of the study, and those two concussion points fall within a one-year period, then they will need to be discharged from the study in accordance with the World Rugby guidelines, mentioned before.

2) If an individual is concussed twice within the course of the study, then they will be discharged from the study thereafter, again, in accordance with the World Rugby guidelines, mentioned before.

3) If standard return to play guidelines, as put forward by World Rugby (as outlined in the information sheets distributed on return-to-play guidelines) (Gomez and Hergenroeder 2012, Kutcher and Giza 2014) are not followed before a player returns to play following a concussion, then they will also be discharged from the study. We will ask your son's attending doctor, managing the concussion, to oversee a return-to-play protocol checklist used in this study.

Again, these discharge points are included as a measure of precaution, with participants' best interest in mind.

30. If you choose to participate in this study, how long will your child be expected to participate in the research?

Your son will be asked to be available for each of the scheduled testing sessions – each session will take approximately 2 hours. The study will run over the course of 6 months. There will be only one testing session around the start of the season if your son does not sustain a concussion. Should your son sustain a concussion during the course of the rugby season, he will be asked to participate in the post-concussion and end-of-season assessments and brain scans.

31. What are the possible discomforts and risks for your child?

There is minimal risk associated with this study. Your son may be required to return for a repeated assessment in September/October 2018 at CUBIC, should he sustain a concussion during the season. You will be contacted by the Principal Investigator if this is the case. The testing procedures take approximately 1½ - 2 hours per person. Due to it being a lengthy process, your son may feel fatigued or irritable during testing. However, he will be given breaks where necessary, as well as refreshments. The follow-up session is not as time consuming.

All return-to-school and play decisions will be made by the medical team employed by your son's school, and not the researchers. Your son's testing results will be made available to the medical team, as well as comparisons between his baseline scores and his injury scores. Findings from the study are not primarily intended to determine whether your son returns to play or not - that is the goal of the clinical assessors. Clinical assessors might however use the data we collect to inform return-to-play decisions.

Some participants in the research study may feel anxious or claustrophobic with regards to the brain scan. To counter this, an assistant will explain the scanning procedure to your son. The research assistant will also allow your son to have a "mock scan" where he will experience what it is like to have a scan, before undergoing the actual scan. The scan will not hurt your son and it will not be dangerous in any way. Your son will however need to take the following precautions.

During the MRI neuroimaging assessment, certain metal objects, such as watches, credit cards, hairpins, and writing pens, may be damaged by the MRI scanner or pulled away from the body by the magnet. For these reasons, your son will be asked to remove these objects before entering the scanner. When the scanner takes the images, the bed may vibrate, and your son will hear loud banging noises. He will be given earplugs or earphones to protect his ears. Also, some people feel nervous in a small-enclosed space such as that of the scanner. Your son will be able to see out of the scanner at all times, and the radiographer will not start the procedure until he is comfortable. Your son will be able to stop the procedure at any time by squeezing a ball and he can talk to the radiographers using an intercom

that is built into the scanner. There are no known harmful long-term effects of the scanner used in this study. Scans will take no longer than 1 hour.

In the process of testing and scanning, researchers may come across incidental findings. Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. For example, these may relate to findings on brain scan, where, in the process of investigating the outcomes of concussion, researchers may come across other findings on the scan that may be of concern. (Below we include referral information in the event of such incidental findings).

If you wish to discuss the information above or any discomforts your son may experience, you may ask questions now or call the Principal Investigators listed on this form an any point in the study.

Because this study involves on-going brain scans and cognitive testing related to concussion, this may give you the incorrect impression or misconception that we are providing care for, or clinical management of, your son's concussion injury. It is important to note that this is however not the case as this is a research study and it is therefore not providing any clinical care or management of the concussion injury. We are not replacing any existing medical/care structures that the schools and/or you may have in place, but rather working in conjunction with them. All decisions on whether to return to school and play will be made by the medical structures already employed by the schools and/or you. Your son's test and brain scan results will be made available to the medical professionals employed by the you and/or your son's school should it be required, as well as comparisons between their baseline scores and their scores from any testing after a concussion. Before we collect any data, we will hold an information session with parents and participants to talk about this potential misconception.

It is important to note that if your child does suffer a concussion injury, findings from tests conducted as part of this research study might impact on your child's ability to continue playing rugby or other contact sports in the future. The implications of the test findings for thinking and behaviour and brain scan findings should be discussed with health professionals as part of the referral process (described below).

32. Referrals

Given that return-to-play decisions are the domain of the clinical assessors, we, as researchers, cannot and should not make any such decisions on the basis of our data. However, clinical assessors might however use the data we collect to inform return-to-play decisions. However, given that we are administering tests of thinking and behavior, post-concussion tests, and brain scans as part of the study, there may be outcomes following those tests, for which further follow-up by health professionals may be advisable. We will not impose these referrals but we provide the necessary

information for parents as these follow-up consultations in the best interests of the child. We outline these referrals below.

Referrals related to baseline testing and exclusion criteria

We noted under point 8 above that there are certain exclusion criteria for this study and we outlined those points there. Two of these exclusion criteria related to participants' scores on a test of depression symptoms and a test related to alcohol usage. If participants score within certain ranges on these tests, they will be referred to a Sports Psychologist at the Sports Science Institute of South Africa. In the event that your son scores 21 or more on the Beck Depression Inventory and/or reports any history of, or current drug and/or alcohol abuse, as reported on the AUDIT (see exclusion criteria), he will be referred to Clinton Gahwiler (see details below) by the Principal Investigator.

Psychological management:

Clinton Gahwiler (BA hons MA)

Sport Psychologist at Sport Science Institute of South Africa

Tel: 021 659 5655

Fax: 086 624 7988

Email: sportpsych@xsinet.co.za

Website: www.performingmind.co.za

Referrals related to concussion diagnoses and post-concussion testing

It is important to note that a suspected concussion requires a clinical assessment by a doctor skilled in the management of concussion. We include the details of doctors below, who specialize in concussion diagnoses and management, should your son or the school not currently have such a management system in place.

As noted, we will share your son's performances on the behavior and cognitive tests administered, and on the brain scan, with the health professional managing your son's concussion. That health professional will decide whether your son may need further medical management, either by the school's medical team or another medical team, should the school not have one.

Please note that the costs of referrals for further management will be for the personal account of parents/legal guardians and the participants.

In the event that your son's school does not have a medical team in place to assist in your son's care, please see the details below, which can be passed on to the health professional attending to your son.

Concussion management:

Sports Medicine department at the Sports Science Institute of South Africa

Tel: 021 659 5644

Email: info@cape-sportsmed.com

Neurosurgery Clinic (with Prof Anthony Figaji)

Red Cross War Memorial Children's Hospital

021 658 5434

Referrals related to incidental findings on MRI scans

Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. A radiologist on the CUBIC staff and linked to this study, is going to review all the participants' brain scans for such incidental findings. In an unfortunate case of an incidental finding your son will be referred for further evaluation to Professor Anthony Figaji. Professor Figaji is a pediatric neurosurgeon, and he will undertake to consult, examine and counsel you and your son where necessary, as well as determine any further course of management that may be needed.

33. What if something goes wrong?

This research study is covered by an insurance policy taken out by the University of Cape Town if your son suffers a bodily injury because you are taking part in the study. The insurer will pay for all reasonable medical costs required to treat your son's bodily injury, according to the SA Good Clinical Practice Guidelines 2006, which are based on the Association of the British Pharmaceutical Industry Guidelines. The insurer will pay without your son having to prove that the research was responsible for your bodily injury. You may ask the study doctor for a copy of these guidelines.

The insurer will *not* pay for harm if, during the study, your son:

- Uses medicines or other substances that are not allowed
- Does not follow the study doctor's instructions
- Does not tell the study doctor that he had a bad side effect from the study medicine
- Does not take reasonable care of himself and his study medicine

If your son is harmed and the insurer pays for the necessary medical costs, usually you will be asked to accept that insurance payment as full settlement of the claim for medical costs. However, accepting

this offer of insurance cover does not mean you give up your right to make a separate claim for other losses based on negligence, in a South African court. It is important to follow the study doctor's instructions and to report straightaway if your son has a side effect from the study medicine.

34. What are the possible benefits of this study to your child, and others?

After the completion of each testing session, participants will be given a restaurant voucher as compensation for their time. In the event that your son sustains a concussion, the individual brain scans and test results will be sent to the medical team at your son's school following testing and imaging.

Overall, this research aims to contribute to practical information regarding return-to-play decisions, thresholds of concussion injuries, and diagnostic guides of concussion that are important for player safety. It will provide those involved with contact sport, including medical teams, information regarding the cognitive, behavioural and brain scan findings associated with concussion.

35. If you choose to let your child participate in this research study, will it cost you anything?

Participating in this research study will not cost you anything. However, the cost of any care arising from a concussion injury (over and above what is done in the study), i.e., the clinical management of a concussion, or the costs of referrals for further management, will be for the personal account of parents/legal guardians and the participants.

36. Can your child withdraw from this research study?

You and your child may withdraw your consent and assent and stop participating in this research study at any time, without any penalty to you or your child. At the beginning of each testing session your son will be asked if he wants to continue with the study. Should he say no, there will be no punishment or penalty placed on your son.

If you have a complaint or complaints about your son's rights and wellbeing as a research participant, please contact the Human Research Ethics Committee.

Tel: 021 406 6492

E-mail: sumaya.ariefdien@uct.ac.za

37. If your child withdraws, can information about you and your child still be used and/or collected?

Information that has already been collected will be removed from the data set. Should your son withdraw from the study, his data will be removed from the data set.

38. Once personal and performance information is collected, how will it be kept secret (confidential) in order to protect your privacy?

If you agree for your child to participate in this research study, it is possible that some of the information collected might be copied into a "limited data set" to be used for other research purposes. If so, the limited data set will only include information that does not directly identify your son – his identity will remain confidential. Data will be labeled using participant numbers rather than names, so that they cannot be used to directly identify any particular individual. A separate and private log will be used simply to relate participant names to numbers in the event that a participant needs to be contacted or contacts the Principal Investigator. This log will only be accessible to the Principle Investigator.

All hard copy data collected will be stored in a locked filing cabinet in the access-controlled ACSENT Laboratory located in the Department of Psychology UCT. All electronic data will be stored on a password protected hard drive. Only the primary researcher and select individuals involved in the collection and analysis of the data will have access to these files. Your son's research records will not be released without your permission unless required by law or a court order. These measures do not however guarantee complete privacy, given the small cohort of rugby-playing participants, that players may be inherently identifiable. It may therefore not be possible to guarantee individual privacy. However, published data will not contain any identifiable information other than participant numbers.

39. How will the researcher benefit from your child participating in this study?

The researcher may choose to present this research at a conference or in a scientific journal.

40. Dissemination of research findings

You and your son's school will be provided with a report on the analysis of the data collected in this study. It is the aim that this report be published in an academic journal in order to widen the knowledge base of concussion in rugby. The report is based on the overall statistical findings, and will not reveal any personal details specific to your son.

41. Signatures

You have been informed about this study's purpose, procedures, possible benefits, and risks; and how your son's responses and performance and other data will be collected, used and shared with others. You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree for your child to participate in this study. You hereby authorize the collection, use and sharing of your son's performance and other data. By signing this form, you are not waiving any of your legal rights.

Signature of Person Consenting and Authorizing Date

_____ _____

Relationship to child participating in the study: parent / legal guardian

_____

Name of Participant ("Study Participant" – the child)

_____

Authorization for _____ to participate in the study.

Parent / legal guardian cellphone number: _____

Parent / legal guardian email address: _____

Appendix C

Informed Assent form for Control (non-rugby) Participants

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players

Informed consent for you to participate in research and authorisation for collection, use, and disclosure of protected health information

The neuropsychological (relationship between the brain and behavior) effects of traumatic brain injuries (TBIs) are considered a public health concern, both in South Africa and around the world. A common form of TBI is concussion, which is known to be associated with neuropsychological (thinking and behavioural) difficulties. Some of the outcomes associated with concussion often include difficulties with attention and concentrating, higher order thinking skills (e.g., working with information in one's head), remembering information and the speed at which one thinks or processes information.

Some research suggests that exposure to concussive head injuries over a long period of time, especially when this starts at a young age like in the adolescent years, may result in permanent neuropsychological (thinking and behavioural) and emotional problems in the adult years. There have been some cases for which research has suggested that such long-term exposure to multiple concussions may also be associated with neurodegenerative (loss of structure and function of neurons (brain cells) over time) processes in later life.

Added to this, adolescent athletes seem to show more difficulties and longer recovery times compared to adults following concussion, suggesting that the injury and recovery process may be different between adolescents and adults. Therefore, investigating the effects of concussion among a young adolescent population (aged 16 to 19 years) is of particular interest in this study. Younger athletes (e.g., adolescents) may be at greater risk for difficulties as compared to adults, for several reasons: 1) the brain is still maturing and developing during childhood and adolescence and thus an injury during this developmental period can interfere with this development; second, the differences in how intense

and how long symptoms last in adolescents compared to adults suggests that the adolescent brain is different to that of the adult brain.

One sport in which concussion is frequently reported is that of rugby. Although many people play rugby, little research has been done to investigate the long-term outcomes of concussive injuries in an adolescent rugby-playing sample.

In order to investigate this you are invited to take part in a research study at your school with the University of Cape Town. This form provides you with information about the study and seeks your permission for the collection, use and disclosure of your neuropsychological and behavioural performance data, as well as other information necessary for the study. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also describe this study to you and answer all of your questions. Your participation is entirely voluntary. Before you decide whether or not to take part, read the information below and ask questions about anything you do not understand. Whether you do or do not decide to participate in this study you will not be penalized or lose any benefits to which you would otherwise be entitled.

This study will be conducted in a manner that adheres to the ethical guidelines and principles of the International Declaration of Helsinki (Fortaleza, Brazil, 2013).

42. Title of Research Study

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players.

43. Principal Investigator(s) and Telephone Number(s)

Dr. Leigh Schrieff

3.11 Department of Psychology

University of Cape Town

Rondebosch

7701

Tel: 021 650 3708

Email: leigh.schrieff-elson@uct.ac.za / leigh.schrieff@gmail.com

Research assistant

Dr Sarah McFie

Department of Psychology

University of Cape Town

Rondebosch

7701

Email: sarah.mcfie@gmail.com

44. Source of Funding or Other Material Support

National Research Foundation

Medical Research Council

45. What is a concussion?

A concussion is a traumatic brain injury that results in the changing of brain functioning. A concussion is typically caused by a direct impact to the head, but it can also occur when a force is applied to the body that results in the rapid rotation of the head. The most common symptoms of a concussion include headaches, dizziness, memory deficits, and balance disturbances.

46. What is the purpose of this research study?

The purpose of this research study is to investigate whether or not, and how instances of concussions contribute to brain functioning in adolescents, whose brains are still developing. More specifically the research intends to find out how these injuries may affect the way that an individual thinks, feels and behaves, and whether/how it impacts on the brain. Also, the purpose is to observe how individuals who sustain concussions compare to people who have had no such injuries.

47. Who is taking part in this study?

Because we would like to compare to individuals who sustain concussions to individuals who have had no such injuries, there will be two groups of participants in this study: a rugby group and a non-contact sports playing matched control group. In this study, the matched control group includes non-rugby sports players who are similar (matched) in terms of age, sex, baseline test scores and sport

involvement to the players in the rugby group so that we can compare rugby players in our study to similar aged non-rugby players.

Rugby is a sport that involves a lot of impacts to the head, neck, and shoulder areas. These forces can at times lead to a concussion. The rugby group will be analyzed to see the effect of these concussions on tests of behavior and cognitive (thinking) functioning, as well as the structure of the brain (using a brain scan). The non-contact sports group, the control group, will be included so that we can compare the outcomes of the rugby group to matched individuals who are not exposed to rugby and the associated injuries.

48. How many people are expected to participate in the research?

You will be one of 120 school-aged rugby and 120 non-contact sport players in this study. The maximum number of participants who will be screened at the baseline testing will be 120 for each group. You may be one of 16 control participants invited to take part in the testing and brain scan component of the study at the end of the season (explained below).

49. What will be done if you take part in this research study?

The reason that we are including non-rugby playing participants is so that we can compare the performances of high school learners who play rugby (and who may or may not have sustained a concussion) to the performances of those who do not play rugby and have not sustained concussions.

At the start of this study, you will be asked to complete a number of questionnaires and tests to obtain individual demographic information, personal characteristics, an estimate of your ability to think, as well as the different ways in which you act and feel.

At the end of the rugby season, we are going to do a similar set of tests to the baseline tests with rugby players that were concussed during the rugby season. Those players will also undergo a brain scan. At that point, we will also select and invite players from the matched control group, who match the rugby players that were concussed during the season, on age baseline testing, and sport involvement, to undergo the same tests and a brain scan so that we can have comparative data.

Therefore, following initial testing, the results of the baseline testing will be evaluated. You may be contacted to participate in another session of the same tests in September/October, 2019, where you may also be asked to undergo a brain scan, if you happen to match (in terms of age, baseline testing and activity levels) a rugby-playing participant at that time.

These testing procedures will be conducted in a private room at the Cape Universities Body Imaging Centre (CUBIC), Groote Schuur Hospital. We will ask for your assent again if you are asked to participate in the second set of assessments.

Tests and questionnaires that will be given to you:

Demographic and medical history questionnaire – This questionnaire asks for information about your age, height, weight, language ability, learning difficulties (if any), any current or previous concussions, any previous or current psychiatric disorder, and what (if any) medication your son is currently taking.

Alcohol Use Disorders Identification Test – This questionnaire measures your current and/or lifetime alcohol use. The researchers do not suspect you of consuming alcohol, however previous research has shown a strong relationship between concussions and substance use.

Barratt Impulsiveness Scale – This questionnaire looks at how impulsive your behavior is, and how this may relate to concussion.

Beck Depression Inventory – This questionnaire looks at symptoms of depression. Concussion has been shown to be associated with depressive symptoms, and this questionnaire will be used to assess such symptoms.

General Health Questionnaire – This questionnaire is used to look at the overall psychological health in an individual. It will be used with the other psychological questionnaires to understand your general health.

Profile of Mood States (short form) – The profile of mood states is a measure of overall mood. Mood is different to psychological health because it is more variable. This will also be used to compliment the other psychological questionnaires.

State-trait Anger Expression Inventory – This questionnaire looks at the amount of anger expressed by you.

State-trait Anxiety Inventory – This questionnaire looks at the levels of anxiety you have, and how it is expressed.

The IMPACT – The IMPACT is a computerized test used to measure concussion symptoms. It has two parts to it. The first part measures the concussion symptoms of your son, such as nausea, sleep and headaches. The second part measures your son's cognitive performance.

Pocket Concussion Recognition Tool (PCRT). The PCRT, is a side-line evaluation which can be administered by medical or non-medical professionals to detect a probable concussion. A conclusion of a probable concussion should be made if one or more symptoms is present in the following

categories; visible cues of suspected concussion (loss of consciousness, balance problems, dazed gaze), symptoms of a concussion (headache, dizziness, confusion), and memory function.

Brain Scan – Brain scans are computerized images of the brain generated by placing the participant on a padded plastic bed that slides into the scanner. The scan is non-invasive (does not enter or penetrate the body) and painless. These images are used to examine the brain for any possible abnormalities in the brain that may be causing some discomfort. The standard brain imaging techniques do not reveal any gross structural abnormalities associated with concussions. However, recent research indicates that there may be small changes following a concussion. If you are in the control group, the scan will be done in order to compare your brain structure to the rugby group participants'. If any abnormalities are discovered, a pediatric neurosurgeon will review the scans and advise you and your family on the best course of action.

50. What are the exclusion criteria for this study?

The exclusion criteria for the study include: (a) being of the female sex, (b) being older than 19 years and younger than 16 years at time of recruitment, (c) scoring 21 or more on the Beck Depression Inventory-Second Edition (BDI-II), (d) prior or current diagnosed psychiatric illnesses, learning disabilities, or neurological disease, (e) any history of, or current drug and/or alcohol abuse, (f) control participants with a history of a previous concussion.

Should you meet any of these criteria, you will not be contacted to partake in the second phase of the study.

51. If you choose to participate in this study, how long will you be expected to participate in the research?

You will be asked to be available for the initial scheduled testing session – this session will take approximately 2 hours. The study will run over the course of 6 months. You will however only participate in the baseline testing session unless you are selected as a matched control to participate in the end of season assessment and brain scan.

52. What are the possible discomforts and risks for your child?

There is minimal risk associated with this study. You may be required to return for a repeated assessment in September/October at CUBIC. You will be contacted by the Principal Investigator if this is the case. The testing procedures take approximately 1½ - 2 hours per person. Due to it being a lengthy process, you may feel fatigued or irritable during testing. However, you will be given breaks where necessary, as well as refreshments. The follow-up session is not as time consuming.

Some participants in the research study may feel anxious or claustrophobic with regards to the brain scan. To counter this, an assistant will explain the scanning procedure to you. The research assistant will also allow you to have a "mock scan" where you will experience what it is like to have a scan, before undergoing the actual scan. The scan will not hurt you and it will not be dangerous in any way. You will however need to take the following precautions.

During the MRI neuroimaging assessment, certain metal objects, such as watches, credit cards, hairpins, and writing pens, may be damaged by the MRI scanner or pulled away from the body by the magnet. For these reasons, you will be asked to remove these objects before entering the scanner. When the scanner takes the images, the bed may vibrate, and you will hear loud banging noises. You will be given earplugs or earphones to protect your ears. Also, some people feel nervous in a small-enclosed space such as that of the scanner. You will be able to see out of the scanner at all times, and the radiographer will not start the procedure until you are comfortable. You will be able to stop the procedure at any time by squeezing a ball and can talk to the radiographers using an intercom that is built into the scanner. There are no known harmful long-term effects of the scanner used in this study. Scans will take no longer than 1 hour.

In the process of testing and scanning, researchers may come across incidental findings. Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. For example, these may relate to findings on brain scan, where, in the process of completing the scan at the end of the season for this research study (if you are selected to participate in that component), researchers may come across other findings on the scan that may be of concern. (Below we include referral information in the event of such incidental findings).

If you wish to discuss the information above or any discomforts you may experience, you may ask questions now or call the Principal Investigators listed on this form.

53. Referrals

Given that we are administering tests of thinking and behavior and brain scans as part of the study, there may be outcomes following those tests, for which further follow-up by health professionals may be advisable. We will not impose these referrals but we provide the necessary information for you and your parents in your best interest. We outline these referrals below.

Referrals related to baseline testing and exclusion criteria

We noted under point 8 above that there are certain exclusion criteria for this study and we outlined those points there. Two of these exclusion criteria related to your scores on a test of depression symptoms and a test related to alcohol usage. If participants score within certain ranges on these tests, they will be referred to a Sports Psychologist at the Sports Science Institute of South Africa. In the event that you score 21 or more on the Beck Depression Inventory and/or report any history of, or current drug and/or alcohol abuse, as reported on the AUDIT (see exclusion criteria), you will be referred to Clinton Gahwiler (see details below) by the Principal Investigator.

Psychological management:

Clinton Gahwiler (BA hons MA)

Sport Psychologist at the Sport Science Institute of South Africa

Tel: 021 659 5655

Fax: 086 624 7988

Email: sportpsych@xsinet.co.za

Website: www.performingmind.co.za

Referrals related to incidental findings on MRI scans

Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. A radiologist on the CUBIC staff and linked to this study, is going to review all the participants' brain scans for such incidental findings. In an unfortunate case of an incidental finding you will be referred for further evaluation to Professor Anthony Figaji. Professor Figaji is a pediatric neurosurgeon, and he will undertake to consult, examine and counsel you where necessary, as well as determine any further course of management that may be needed.

54. What if something goes wrong?

This research study is covered by an insurance policy taken out by the University of Cape Town if you suffer a bodily injury because you are taking part in the study.

The insurer will pay for all reasonable medical costs required to treat your bodily injury, according to the SA Good Clinical Practice Guidelines 2006, which are based on the Association of the British Pharmaceutical Industry Guidelines. The insurer will pay without you having to prove that the

research was responsible for your bodily injury. You may ask the study doctor for a copy of these guidelines.

The insurer will *not* pay for harm if, during the study, you:

- Use medicines or other substances that are not allowed
- Do not follow the study doctor's instructions
- Do not tell the study doctor that you have a bad side effect from the study medicine
- Do not take reasonable care of yourself and your study medicine

If you are harmed and the insurer pays for the necessary medical costs, usually you will be asked to accept that insurance payment as full settlement of the claim for medical costs. However, accepting this offer of insurance cover does not mean you give up your right to make a separate claim for other losses based on negligence, in a South African court.

It is important to follow the study doctor's instructions and to report straightaway if you have a side effect from the study medicine.

55. What are the possible benefits of this study to you, and others?

There is no potential for direct individual benefit by you taking part in this study.

After the completion of each testing session, participants will be given a restaurant voucher as compensation for their time.

Overall, this research aims to contribute to practical information regarding return-to-play decisions, thresholds of concussion injuries, and diagnostic guides of concussion that are important for player safety. It will provide all those involved with contact sport, including medical teams, information regarding the cognitive, behavioural and brain scan findings associated with concussion.

56. If you choose to participate in this research study, will it cost you anything?

Participating in this research study will not cost you anything. However, the cost of any referrals for further management will be for the personal account of parents/legal guardians and the participants.

57. Can you withdraw from this research study?

You may withdraw your consent and assent and stop participating in this research study at any time, without any penalty to you. At the beginning of each testing session you will be asked if you want to continue with the study. Should you say no, there will be no punishment or penalty placed on you.

If you have a complaint or complaints about your rights and wellbeing as a research participant, please contact the Human Research Ethics Committee.

Tel: 021 406 6492

E-mail: sumaya.ariefdien@uct.ac.za

58. If you withdraw, can information about you still be used and/or collected?

Information that has already been collected will be removed from the data set. Should you withdraw from the study, your data will be removed from the data set.

59. Once personal and performance information is collected, how will it be kept secret (confidential) in order to protect your privacy?

If you agree to participate in this research study, it is possible that some of the information collected might be copied into a "limited data set" to be used for other research purposes. If so, the limited data set will only include information that does not directly identify you – your identity will remain confidential. Data will be labeled using participant numbers rather than names, so that they cannot be used to directly identify any particular individual. A separate and private log will be used simply to relate participant names to numbers in the event that a participant needs to be contacted or contacts the Principal Investigator. This log will only be accessible to the Principle Investigator.

All hard copy data collected will be stored in a locked filing cabinet in the ACSENT Laboratory located in the Department of Psychology UCT. All electronic data will be stored on a password protected hard drive. Only the primary researcher and select individuals involved in the collection and analysis of the data will have access to these files. Your research records will not be released without your permission unless required by law or a court order. These measures do not however guarantee complete privacy, given the small cohort of participant. It may therefore not be possible to guarantee individual privacy. However, published data will not contain any identifiable information other than participant numbers.

60. How will the researcher benefit from you participating in this study?

The researcher may choose to present this research at a conference or in a scientific journal.

61. Dissemination of research findings

You and your school will be provided with a report on the analysis of the data collected in this study.

It is the aim that this report be published in an academic journal in order to widen the knowledge base of concussion in rugby. The report is based on the overall statistical findings, and will not reveal any personal details.

Signatures

You have been informed about this study's purpose, procedures, possible benefits, and risks; and how your responses and performance and other data will be collected, used and shared with others. You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree to participate in this study. You hereby authorize the collection, use and sharing of your performance and other data. By signing this form, you are not waiving any of your legal rights.

Signature of Person Assenting and Authorizing Date

_____ _____

Name of Participant ("Study Participant" – the child)

_____

Participant cellphone number: _____

Participant email address: _____

Appendix D

Informed Assent Form for Rugby player Participants

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players

Informed consent for you to participate in research and authorisation for collection, use, and disclosure of protected health information

The neuropsychological (relationship between the brain and behavior) effects of traumatic brain injuries (TBIs) are considered a public health concern, both in South Africa and around the world. A common form of TBI is concussion, which is known to be associated with neuropsychological (thinking and behavioural) difficulties. Some of the outcomes associated with concussion often include difficulties with attention and concentrating, higher order thinking skills (e.g., working with information in one's head), remembering information and the speed at which one thinks or processes information.

Some research suggests that exposure to concussive head injuries over a long period of time, especially when this starts at a young age like in the adolescent years, may result in permanent neuropsychological (thinking and behavioural) and emotional problems in the adult years. There have been some cases for which research has suggested that such long-term exposure to multiple concussions may also be associated with neurodegenerative (loss of structure and function of neurons (brain cells) over time) processes in later life.

Added to this, adolescent athletes seem to show more difficulties and longer recovery times compared to adults following concussion, suggesting that the injury and recovery process may be different between adolescents and adults. Therefore, investigating the effects of concussion among a young adolescent population (aged 16 to 19 years) is of particular interest in this study. Younger athletes (e.g., adolescents) may be at greater risk for difficulties as compared to adults, for several reasons: 1) the brain is still maturing and developing during childhood and adolescence and thus an injury during this developmental period can interfere with this development; second, the differences in how intense and how long symptoms last in adolescents compared to adults suggests that the adolescent brain is different to that of the adult brain.

One sport in which concussion is frequently reported is that of rugby. Although many people play rugby, little research has been done to investigate the long-term outcomes of concussive injuries in an adolescent rugby-playing sample.

In order to investigate this you are invited to take part in a research study at your school with the University of Cape Town. This form provides you with information about the study and seeks your permission for the collection, use and disclosure of your neuropsychological and behavioural performance data, as well as other information necessary for the study. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also describe this study to you and answer all of your questions. Your participation is entirely voluntary. Before you decide whether or not to take part, read the information below and ask questions about anything you do not understand. Whether you do or do not decide to participate in this study you will not be penalized or lose any benefits to which you would otherwise be entitled.

This study will be conducted in a manner that adheres to the ethical guidelines and principles of the International Declaration of Helsinki (Fortaleza, Brazil, 2013).

62. Title of Research Study

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players.

63. Principal Investigator(s) and Telephone Number(s)

Dr. Leigh Schrieff

3.11 Department of Psychology

University of Cape Town

Rondebosch

7701

Tel: 021 650 3708

Email: leigh.schrieff-elson@uct.ac.za / leigh.schrieff@gmail.com

Research assistant

Dr Sarah McFie

Department of Psychology

University of Cape Town

Rondebosch

7701

Email: sarah.mcfie@gmail.com

64. Source of Funding or Other Material Support

Medical Research Council

65. What is a concussion?

A concussion is a traumatic brain injury that results in the changing of brain functioning. A concussion is typically caused by a direct impact to the head, but it can also occur when a force is applied to the body that results in the rapid rotation of the head. The most common symptoms of a concussion include headaches, dizziness, memory deficits, and balance disturbances.

66. What is the purpose of this research study?

The purpose of this research study is to investigate whether or not, and how, instances of concussions contribute to brain functioning in adolescents, whose brains are still developing. More specifically the research intends to find out how these injuries may affect the way that an individual thinks, feels and behaves, and whether/how it impacts on the brain. Also, the purpose is to observe how individuals who sustain concussions compare to people who have had no such injuries.

67. Who is taking part in this study?

Because we would like to compare to individuals who sustain concussions to individuals who have had no such injuries, there will be two groups of participants in this study: a rugby group and a non-contact sports playing matched control group.

Rugby is a sport that involves a lot of impacts to the head, neck, and shoulder areas. These forces can at times lead to a concussion. The rugby group will be analyzed to see the effect of these concussions on tests of behavior and cognitive (thinking) functioning, as well as the structure of the brain (using a

brain scan). The non-contact sports group (the control group), will be included so that we can compare the outcomes of the rugby group to matched individuals who are not exposed to rugby and the associated injuries. By matched participants we mean that participants in the control group who are similar to participants in the rugby group based on their age, sex, baseline test scores and sport involvement.

68. How many people are expected to participate in the research?

You will be one of 120 school-aged rugby and 120 school-aged non-contact sport players in this study. The maximum number of participants who will be screened at the baseline testing will be 120 for each group; but only 16 participants per group will be requested to complete the full study procedures.

69. What will be done if you take part in this research study?

During this study, you will be asked to complete a number of questionnaires and tests to obtain individual demographic information, personal characteristics, an estimate of your ability to think, as well as the different ways in which you act and feel. Following the start of the season, should you sustain a concussion, you will then be contacted for repeated testing in the 24-72 hours following the injury, and you will also be asked to undergo a brain scan. Following the conclusion of the rugby season, you may be contacted for repeated testing in September/October, 2019, where you may be asked to undergo another brain scan. These testing procedures will be conducted in a private room at the Cape Universities Body Imaging Centre (CUBIC), Groote Schuur Hospital.

Tests and questionnaires that will be given to you:

Demographic and medical history questionnaire – This questionnaire asks for information about your age, height, weight, language ability, learning difficulties (if any), any current or previous concussions, any previous or current psychiatric disorder, and what (if any) medication you are currently taking.

Alcohol Use Disorders Identification Test – This questionnaire measures your current and/or lifetime alcohol use. The researchers do not suspect you of consuming alcohol, however previous research has shown a strong relationship between concussions and substance use.

Barratt Impulsiveness Scale – This questionnaire looks at how impulsive your behavior is, and how this may relate to concussion.

Beck Depression Inventory – This questionnaire looks at symptoms of depression. Concussion has been shown to be associated with depressive symptoms, and this questionnaire will be used to assess for the possible presence of any such symptoms.

General Health Questionnaire – This questionnaire is used to look at the overall psychological health in an individual. It will be used with the other psychological questionnaires to understand your general health.

Profile of Mood States (short form) – The profile of mood states is a measure of overall mood. Mood is different to psychological health because it is more variable. This will also be used to compliment the other psychological questionnaires.

State-trait Anger Expression Inventory – This questionnaire looks at the amount of anger expressed by you.

State-trait Anxiety Inventory – This questionnaire looks at the levels of anxiety you have, and how it is expressed.

The IMPACT – The IMPACT is a computerized test used to measure concussion symptoms. It has two parts to it: the first part measures any concussion symptoms, such as nausea, sleep and headaches; the second part measures your cognitive performance.

Pocket Concussion Recognition Tool (PCRT). The PCRT, is a side-line evaluation which can be administered by medical or non-medical professionals to detect a probable concussion. A conclusion of a probable concussion should be made if one or more symptoms is present in the following categories: visible cues of suspected concussion (loss of consciousness, balance problems, dazed gaze), symptoms of a concussion (headache, dizziness, confusion), and poor memory function.

Brain Scan – Brain scans are computerized images of the brain generated by having you lie on a padded plastic bed that slides into the scanner. The scan process is non-invasive (does not enter or penetrate the body) and painless. These images are used to examine the brain for any possible abnormalities that may be causing some discomfort. The standard brain imaging techniques do not reveal any obvious big negative changes in the structure of the brain associated with concussions. However, recent research indicates that there may be smaller changes following a concussion. The brain scans will be conducted in order to see if there are any small changes to your brain structure as a result of the concussion. Any small structural changes after concussion will be recorded, and reports will be forwarded on to the medical teams employed by your parents and/or your school. If any abnormalities are discovered, a pediatric neurosurgeon will review the scans and advise you and your family on the best course of action. It is important to note that as with the other assessment measures, the brain scan is part of the research assessment and not part of clinical management of the concussion injury.

70. What are the exclusion criteria for this study?

The exclusion criteria for the study include: (a) being of the female sex, (b) being older than 19 years or younger than 16 years at time of recruitment, (c) scoring 21 or more on the Beck Depression Inventory-Second Edition (BDI-II), (d) prior or current diagnosed psychiatric illnesses, learning disabilities, or neurological disease, (e) any history of, or current drug and/or alcohol abuse, (f) Participants who do not have a clear referral process to an adequately qualified clinician following a concussive episode, for a formal diagnosis of concussion.

Should you meet any of these criteria, you will not be contacted to partake in the second phase of the study.

Discharge points

We have also included what we refer to as 'discharge' or exit points in the study. In their Concussion Guidance document, World Rugby (2017) note the following about multiple concussions: "Players with a history of two or more concussions within the past year are at greater risk of further brain injury and slower recovery and should seek medical attention from practitioners experienced in concussion management before return to play". Given the potential risk of a participant sustaining multiple concussions and the possibility that they may be returning to play prematurely following a concussion, and in an effort to adhere to the World Rugby guidelines which are in the player's best interest (i.e., for their protection), we will include the following discharge points in the study:

1) If an individual has previously been concussed in the year leading up to the study and is concussed again during the course of the study, and those two concussion points fall within a one-year period, then they will need to be discharged from the study in accordance with the World Rugby guidelines, mentioned before.

2) If an individual is concussed twice within the course of the study, then they will be discharged from the study thereafter, again, in accordance with the World Rugby guidelines, mentioned before.

3) If standard return to play guidelines, as put forward by World Rugby (as outlined in the information sheets distributed on return-to-play guidelines) (Gomez and Hergenroeder 2012, Kutcher and Giza 2014) are not followed before a player returns to play following a concussion, then they will also be discharged from the study. We will ask your attending doctor, managing the concussion, to oversee a return-to-play protocol checklist used in this study.

Again, these discharge points are included as a measure of precaution, with participants' best interest in mind.

71. If you choose to participate in this study, how long will you be expected to participate in the research?

You will be asked to be available for each scheduled of the testing sessions – each session will take approximately 2 hours. The study will run over the course of 6 months. There will be only one testing session around the start of the season if you do not sustain a concussion. Should you sustain a concussion during the course of the rugby season, you will be asked to participate in the post-concussion and end of season assessments and brain scans.

72. What are the possible discomforts and risks for you?

There is minimal risk associated with this study. You may be required to return for a repeated assessment in September/October 2018 at CUBIC, should you sustain a concussion during the season. You will be contacted by the Principal Investigator if this is the case. The testing procedures take approximately 1½ - 2 hours per person. Due to it being a lengthy process, you may feel fatigued or irritable during testing. However, you will be given breaks where necessary, as well as refreshments. The follow-up session is not as time consuming.

All return-to-school and play decisions will be made by the medical team employed by your school, and not the researchers. Your testing results will be made available to the medical team, as well as comparisons between your baseline scores and your injury scores. Findings from the study are not primarily intended to determine whether you return to play or not - that is the goal of the clinical assessors. Clinical assessors might however use the data we collect to inform return-to-play decisions.

Some participants in the research study may feel anxious or claustrophobic with regards to the brain scan. To counter this, an assistant will explain the scanning procedure to you. The research assistant will also allow you to have a "mock scan" where you will experience what it is like to have a scan, before undergoing the actual scan. The scan will not hurt you and it will not be dangerous in any way. You will however need to take the following precautions.

During the MRI neuroimaging assessment, certain metal objects, such as watches, credit cards, hairpins, and writing pens, may be damaged by the MRI scanner or pulled away from the body by the magnet. For these reasons, you will be asked to remove these objects before entering the scanner. When the scanner takes the images, the bed may vibrate, and you will hear loud banging noises. You will be given earplugs or earphones to protect your ears. Also, some people feel nervous in a small-enclosed space such as that of the scanner. You will be able to see out of the scanner at all times, and

the radiographer will not start the procedure until you are comfortable. You will be able to stop the procedure at any time by squeezing a ball and can talk to the radiographers using an intercom that is built into the scanner. There are no known harmful long-term effects of the scanner used in this study. Scans will take no longer than 1 hour.

In the process of testing and scanning, researchers may come across incidental findings. Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. For example, these may relate to findings on brain scan, where, in the process of investigating the outcomes of concussion, researchers may come across other findings on the scan that may be of concern. (Below we include referral information in the event of such incidental findings).

If you wish to discuss the information above or any discomforts you may experience, you may ask questions now or call the Principal Investigators listed on this form at any point during the study.

Because this study involves on-going brain scans and cognitive testing related to concussion, this may give you the incorrect impression or misconception that we are providing care for, or clinical management of, your concussion injury. It is important to note that this is however not the case as this is a research study and it is therefore not providing any clinical care or management of the concussion injury. We are not replacing any existing medical/care structures that the schools and/or you may have in place, but rather working in conjunction with them. All decisions on whether to return to school and play will be made by the medical structures already employed by the schools and/or you. Your test and brain scan results will be made available to the medical professionals employed by the you and/or your school should it be required, as well as comparisons between your baseline scores and your scores from any testing after a concussion. Before we collect any data, we will hold an information session with you and your parents to talk about this potential misconception.

It is important to note that if you do suffer a concussion injury, findings from tests conducted as part of this research study might impact on your ability to continue playing rugby or other contact sports in the future. The implications of the test findings for thinking and behaviour and brain scan findings should be discussed with health professionals as part of the referral process (described below).

73. Referrals

Given that return-to-play decisions are part of the job of the clinical assessors, we, as researchers, cannot and should not make any such decisions on the basis of our data. However, clinical assessors might however use the data we collect to inform return-to-play decisions. However, given that we are administering tests of thinking and behavior, post-concussion tests, and brain scans as part of the study, there may be outcomes following those tests, for which further follow-up by health professionals may be advisable. We will not impose these referrals but we provide the necessary information for you and your parents in your best interest. We outline these referrals below.

Referrals related to baseline testing and exclusion criteria

We noted under point 8 above that there are certain exclusion criteria for this study and we outlined those points there. Two of these exclusion criteria related to your scores on a test of depression symptoms and a test related to alcohol usage. If participants score within certain ranges on these tests, they will be referred to a Sports Psychologist at the Sports Science Institute of South Africa. In the event that you score 21 or more on the Beck Depression Inventory and/or report any history of, or current drug and/or alcohol abuse, as reported on the AUDIT (see exclusion criteria), you will be referred to Clinton Gahwiler (see details below) by the Principal Investigator.

Psychological management:

Clinton Gahwiler (BA hons MA)

Sport Psychologist at the Sport Science Institute of South Africa

Tel: 021 659 5655

Fax: 086 624 7988

Email: sportpsych@xsinet.co.za

Website: www.performingmind.co.za

Referrals related to concussion diagnoses and post-concussion testing

It is important to note that a suspected concussion requires a clinical assessment by a doctor skilled in the management of concussion. We include the details of doctors below, who specialize in concussion diagnoses and management, should you or the school not currently have such a management system in place.

As noted, we will share your performances on the behavior and cognitive tests administered , and on the brain scan, with the health professional managing your concussion. That health professional will decide whether you may need further medical management, either by the school's medical team or another medical team, should the school not have one.

Please note that the costs of referrals for further management will be for the personal account of your parents/legal guardians and the participants.

In the event that your school does not have a medical team in place to assist in your care, please see the details below, which can be passed on to the health professional attending to you.

Concussion management:

Sports Medicine department at the Sports Science Institute of South Africa

Tel: 021 659 5644

Email: info@cape-sportsmed.com

Neurosurgery Clinic (with Prof Anthony Figaji)

Red Cross War Memorial Children's Hospital

021 658 5434

Referrals related to incidental findings on MRI scans

Incidental findings are discoveries that are made that do not relate to the research study, and may be potentially harmful. A radiologist on the CUBIC staff and linked to this study, is going to review all the participants' brain scans for such incidental findings. In an unfortunate case of an incidental finding you will be referred for further evaluation to Professor Anthony Figaji. Professor Figaji is a pediatric neurosurgeon, and he will undertake to consult, examine and counsel you where necessary, as well as determine any further course of management that may be needed.

74. What if something goes wrong?

This research study is covered by an insurance policy taken out by the University of Cape Town if you suffer a bodily injury because you are taking part in the study. The insurer will pay for all reasonable medical costs required to treat your bodily injury, according to the SA Good Clinical Practice Guidelines 2006, which are based on the Association of the British Pharmaceutical Industry Guidelines. The insurer will pay without you having to prove that the research was responsible for your bodily injury. You may ask the study doctor for a copy of these guidelines.

The insurer will *not* pay for harm if, during the study, you:

- Use medicines or other substances that are not allowed
- Do not follow the study doctor's instructions
- Do not tell the study doctor that you have a bad side effect from the study medicine
- Do not take reasonable care of yourself and your study medicine

If you are harmed and the insurer pays for the necessary medical costs, usually you will be asked to accept that insurance payment as full settlement of the claim for medical costs. However, accepting this offer of insurance cover does not mean you give up your right to make a separate claim for other

losses based on negligence, in a South African court. It is important to follow the study doctor's instructions and to report straightaway if you have a side effect from the study medicine.

75. What are the possible benefits of this study to you, and others?

After the completion of each testing session, participants will be given a restaurant voucher as compensation for their time. In the event that you sustain a concussion, your individual brain scans and test results will be sent to the medical team at your school following testing and imaging.

Overall, this research aims to contribute to practical information regarding return-to-play decisions, thresholds of concussion injuries, and diagnostic guides of concussion that are important for player safety. It will provide all those involved with contact sport, including medical teams, information regarding the cognitive, behavioural and brain scan findings associated with concussion.

76. If you choose to participate in this research study, will it cost you anything?

Participating in this research study will not cost you anything. However, the cost of any care arising from a concussion injury (over and above what is done in the study), i.e., the clinical management of a concussion, or the costs of referrals for further management, will be for the personal account of parents/legal guardians and the participants.

77. Can you withdraw from this research study?

You may withdraw your consent and assent and stop participating in this research study at any time, without any penalty to you. At the beginning of each testing session you will be asked if you want to continue with the study. Should you say no, there will be no punishment or penalty placed on you.

If you have a complaint or complaints about your rights and wellbeing as a research participant, please contact the Human Research Ethics Committee.

Tel: 021 406 6492

E-mail: sumaya.ariefdien@uct.ac.za

78. If you withdraw from the study, can information about you still be used and/or collected?

Information that has already been collected will be removed from the data set. Should you withdraw from the study, your data will be removed from the data set.

79. Once personal and performance information is collected, how will it be kept secret (confidential) in order to protect your privacy?

If you agree to participate in this research study, it is possible that some of the information collected might be copied into a "limited data set" to be used for other research purposes. If so, the limited data set will only include information that does not directly identify you – your identity will remain confidential. Data will be labeled using participant numbers rather than names, so that they cannot be used to directly identify any particular individual. A separate and private log will be used simply to relate participant names to numbers in the event that a participant needs to be contacted or contacts the Principal Investigator. This log will only be accessible to the Principle Investigator.

All hard copy data collected will be stored in a locked filing cabinet in the access-controlled ACSENT Laboratory located in the Department of Psychology UCT. All electronic data will be stored on a password protected hard drive. Only the primary researcher and select individuals involved in the collection and analysis of the data will have access to these files. Your research records will not be released without your permission unless required by law or a court order. These measures do not however guarantee complete privacy, given the small cohort of rugby-playing participants, as players may be inherently identifiable. It may therefore not be possible to guarantee individual privacy. However, published data will not contain any identifiable information other than participant numbers.

80. How will the researcher benefit from you participating in this study?

The researcher may choose to present this research at a conference or in a scientific journal.

81. Dissemination of research findings

You and your school will be provided with a report on the analysis of the data collected in this study. It is the aim that this report be published in an academic journal in order to widen the knowledge base of concussion in rugby. The report is based on the overall statistical findings, and will not reveal any personal details

Signatures

You have been informed about this study's purpose, procedures, possible benefits, and risks; and how your responses and performance and other data will be collected, used and shared with others. You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree to participate in this study. You hereby authorize the collection, use and sharing of your performance data and other data. By signing this form, you are not waiving any of your legal rights.

Signature of Person Assenting and Authorizing Date

_____ _____

Name of Participant ("Study Participant" – the child)

Participant cellphone number: _____

Participant email address: _____

Appendix E

Letter of Ethical Approval from the Western Cape Education Department

Directorate: Research

Audrey.Wyngaard@westerncape.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20170320 –9296
ENQUIRIES: Dr A T Wyngaard

Dr Leigh Schrieff-Elson
3.11 Department of Psychology, UCT
Woolsack Drive
Rondebosch
7700

Dear Dr Leigh Schrieff-Elson

RESEARCH PROPOSAL: INVESTIGATING THE NEUROPSYCHOLOGICAL EFFECT AND LONG TERM OUTCOMES OF MULTIPLE CONCUSSIONS AMONG HIGH SCHOOL RUGBY PLAYERS

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **04 February 2019 till 27 September 2019**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

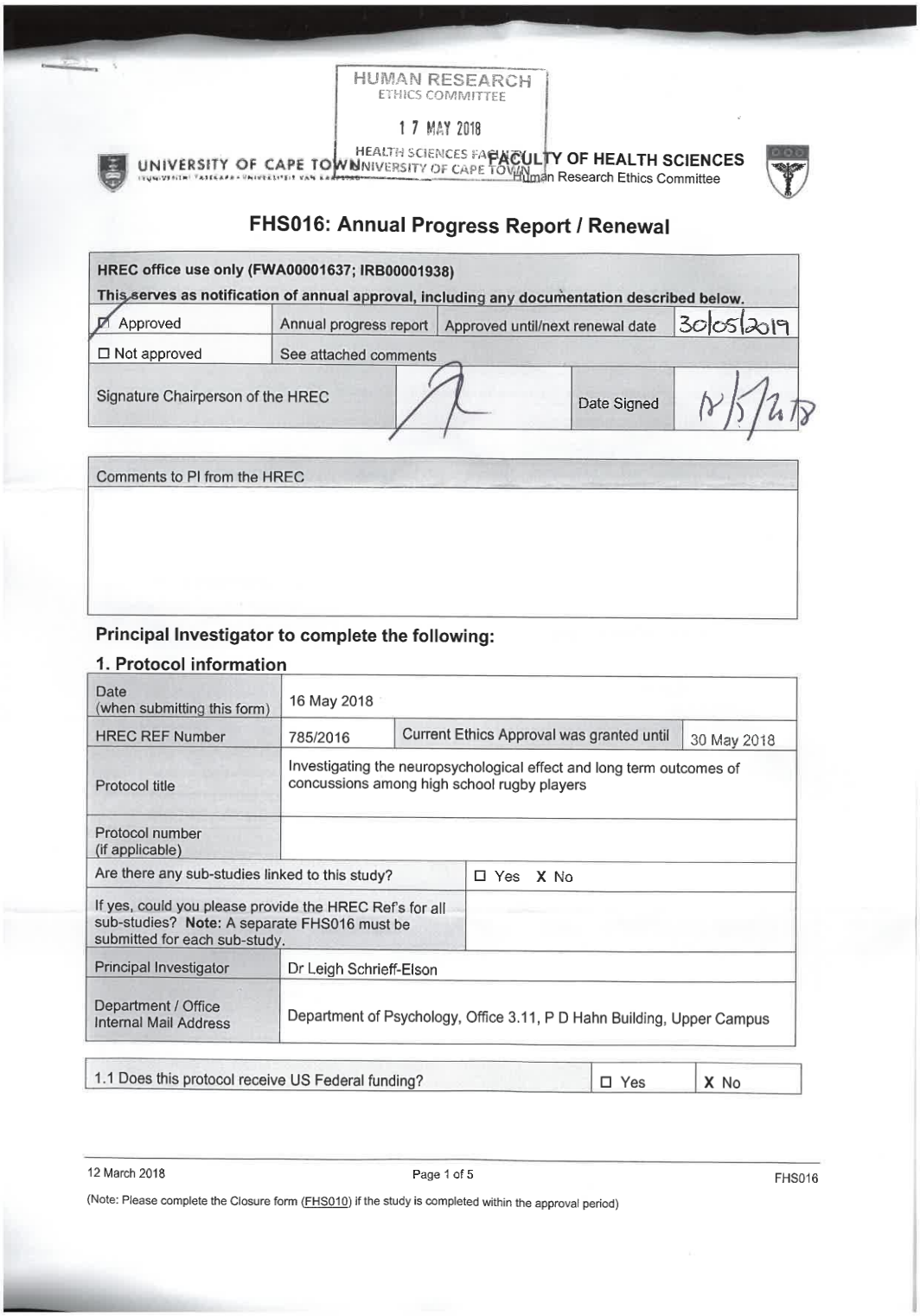
    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 31 January 2019

Appendix F

Letter of Ethical Approval from the Faculty of Health Sciences Human Research Ethics Committee



HUMAN RESEARCH ETHICS COMMITTEE
17 MAY 2018
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

UNIVERSITY OF CAPE TOWN
FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938) **This serves as notification of annual approval, including any documentation described below.**			
☑ Approved	Annual progress report	Approved until/next renewal date	30/05/2019
☐ Not approved	See attached comments		
Signature Chairperson of the HREC		Date Signed	18/5/2018

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol information

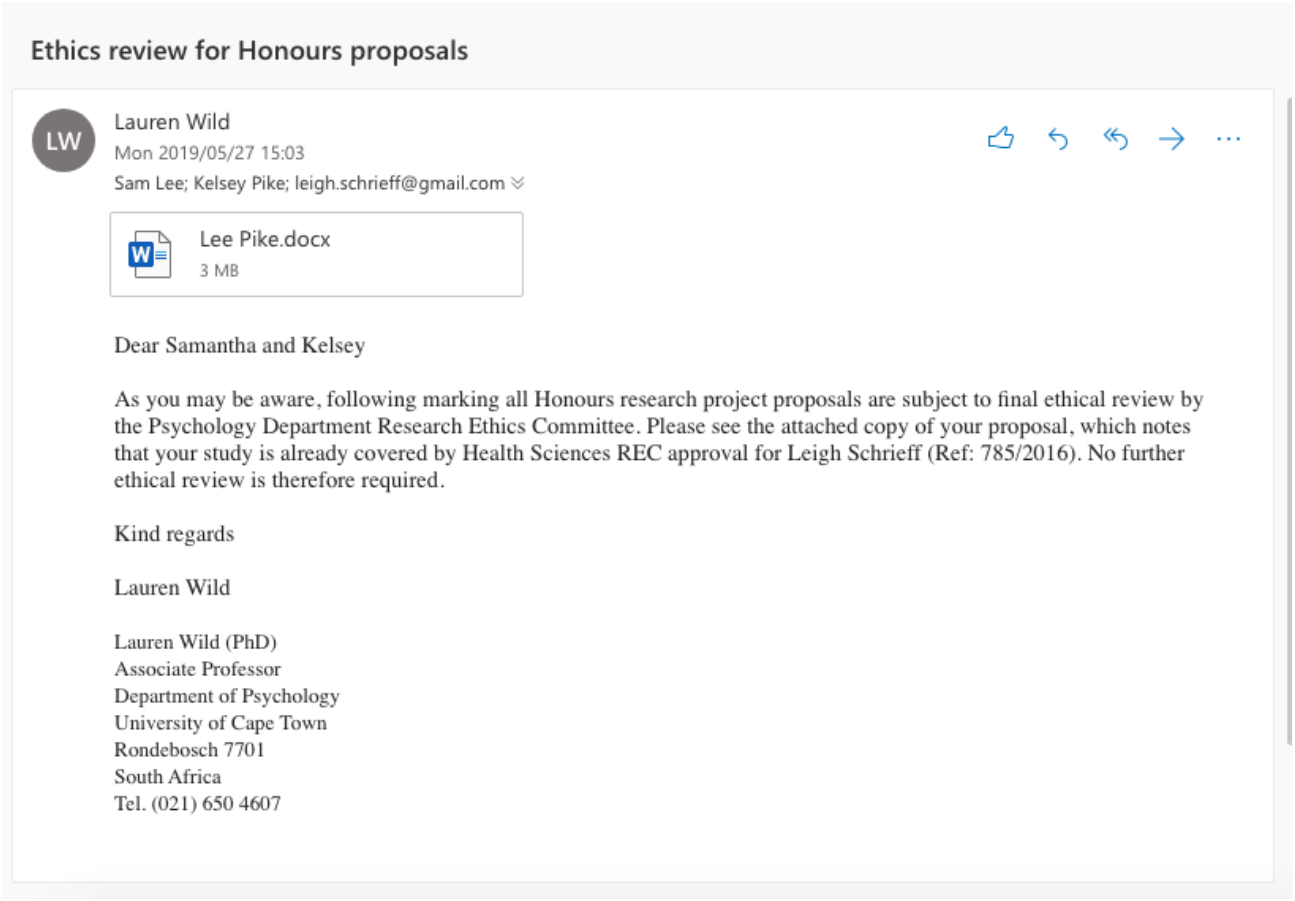
Date (when submitting this form)	16 May 2018		
HREC REF Number	785/2016	Current Ethics Approval was granted until	30 May 2018
Protocol title	Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?	☐ Yes X No		
If yes, could you please provide the HREC Ref's for all sub-studies? **Note:** A separate FHS016 must be submitted for each sub-study.			
Principal Investigator	Dr Leigh Schrieff-Elson		
Department / Office Internal Mail Address	Department of Psychology, Office 3.11, P D Hahn Building, Upper Campus		

1.1 Does this protocol receive US Federal funding?	☐ Yes	X No

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

Appendix G

Letter of Ethical Approval from the University of Cape Town's Psychology Department



Ethics review for Honours proposals

LW

Lauren Wild
Mon 2019/05/27 15:03
Sam Lee; Kelsey Pike; leigh.schrieff@gmail.com

Lee Pike.docx
3 MB

Dear Samantha and Kelsey

As you may be aware, following marking all Honours research project proposals are subject to final ethical review by the Psychology Department Research Ethics Committee. Please see the attached copy of your proposal, which notes that your study is already covered by Health Sciences REC approval for Leigh Schrieff (Ref: 785/2016). No further ethical review is therefore required.

Kind regards

Lauren Wild

Lauren Wild (PhD)
Associate Professor
Department of Psychology
University of Cape Town
Rondebosch 7701
South Africa
Tel. (021) 650 4607

Appendix H

Data Usage Informed Consent

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players

Informed Consent for your child's data collected in the study "Investigating the neuropsychological effect and long term outcomes of concussion among high school rugby players" to be used in future research.

As you have agreed to have your child take part in the study titled "Investigating the neuropsychological effect and long term outcomes of concussion among high school rugby players", it is possible that some of the information collected might be copied into a "limited data set" to be used for future research purposes. If so, the limited data set will only include

information that does not directly identify your son – his identity will remain confidential. Data will be labelled using participant numbers rather than names, so that they cannot be used to directly identify any particular individual. A separate and private log will be used simply to relate participant names to numbers in the event that a participant needs to be contacted or contacts the Principle Investigator. This contact will only be with the Principle Investigator.

The data collected as part of the titled study may be used to compliment further research in the field of concussion and head injuries in the future, and it provides researchers at UCT with a very specific and unique data set. Data from this current study may, for example, be

compared to, or collated with, data collected in future related research projects. Research ethics approval will be obtained before any future use of data.

However, the researchers involved in this study will only keep the data for a maximum of 5 years. Once this time has elapsed, all data pertaining to individual participants stored on the computers will be permanently deleted, and all hard copies of this data will be shredded.

All information collected will be stored in locked filing cabinets and on computers with security passwords, in a secure computer lab at the University of Cape Town. Only certain people - the researchers for this study and certain University of Cape Town officials -have the legal right to review these research records. Your son's research records will not be released without your permission unless required by law or a court order.

Please note that the future storage of data is optional, and that your son can take part in the main study without your consenting to future storage of data.

Can you withdraw your child's data from future use?

You may withdraw your consent to your child's participation and the intended future storage periods of five years after the data have been collected at any stage during the course of the study, without any penalty to you or your child.

If you have a complaint or complaints about your son's rights and welfare as a research participant, please contact the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee.

Tel: 021 406 6492

E-mail: sumaya.ariefdien@uct.ac.za

Dissemination of research findings

Your son's school will be provided with a report on any future analysis of the data collected in this study. It is the aim that these future reports be published in an academic journal in order to widen the knowledge base of concussion in rugby.

Signatures

As a representative of this study, I have explained to the participant's (child's) parents how the participant's performance and other data will be collected, stored for possible use in future studies.

Signature of Person Obtaining Consent and Authorization Date

_____ _____

You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree for your child's data to be stored for future use. You hereby authorize the collection, use and sharing of your performance and other data. By signing this form, you are not waiving any of your legal rights.

Signature of Person Consenting and Authorizing Date

_____ _____

Relationship to child participating in the study: parent/legal guardian

_____

Name of the Participant ("Study Participant" – the child)

_____

Authorization for _____ data to be stored for future use.

Parent / legal guardian cellphone number: _____

Parent / legal guardian email address: _____

Appendix I

Data Usage Informed Assent

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players

Informed Consent for your data collected in the study "Investigating the neuropsychological effect and long term outcomes of concussion among high school rugby players" to be used in future research.

As you have agreed to take part in the study titled "Investigating the neuropsychological effect and long term outcomes of concussion among high school rugby players", it is possible that some of the information collected might be copied into a "limited data set" to be used for future research purposes. If so, the limited data set will only include information that does not directly identify you – your identity will remain confidential. Data will be labeled using participant numbers rather than names, so that they cannot be used to directly identify any particular individual. A separate and private log will be used simply to relate participant names to numbers in the event that a participant needs to be contacted or contacts the Principle Investigator. This contact will only be with the Principle Investigator.

The data collected as part of the titled study may be used to compliment further research in the field of concussion and head injuries in the future, and it provides researchers at UCT with a very specific and unique data set. Data from this current study may, for example, be compared to, or collated with, data collected in future related research projects. Research ethics approval will be obtained before any future use of data.

However, the researchers involved in this study will only keep the data for a maximum of 5 years. Once this time has elapsed, all data pertaining to individual participants stored on the computers will be permanently deleted, and all hard copies of this data will be shredded.

All information collected will be stored in locked filing cabinets and on computers with security passwords, in a secure computer lab at the University of Cape Town. Only certain people - the researchers for this study and certain University of Cape Town officials -have the legal right to review these research records. Your research records will not be released without your permission unless required by law or a court order.

Please note that the future storage of data is optional, and that you can take part in

the main study without assenting to future storage of data.

Can you and you withdraw your data from future use?

You may withdraw your assent to your participation and the intended future storage periods of five years after the data have been collected at any stage during the course of the study, without any penalty.

If you have a complaint or complaints about your rights and welfare as a research

participant, please contact the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee.

Tel: 021 406 6492

E-mail: sumaya.ariefdien@uct.ac.za

Dissemination of research findings

You and your school will be provided with a report on any future analysis of the data

collected in this study. It is the aim that these future reports be published in an academic journal in order to widen the knowledge base of concussion in rugby.

Signatures

As a representative of this study, I have explained to the participant's (child's) parents how the participant's performance and other data will be collected, stored for possible use in future studies.

Signature of Person Obtaining Consent and Authorization Date

_____ _____

You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree for your data to be stored for future use. You hereby authorize the collection, use and sharing of your performance and other data. By signing this form, you are not waiving any of your legal rights.

Signature of Person Assenting and Authorizing Date

_____ _____

Name of Participant ("Study Participant" – the child)

_____

Authorization for _____ data to be stored for future use.

Participant cellphone number: _____

Participant email address: _____

Appendix J

Debriefing Form

University of Cape Town
Psychology Department
Telephone: +27 21 650-3430
Fax: +27 21 650-4104

Formal Study Debriefing Form

Thank you for participating in the research study.

This form provides you with information about the study in which you have just participated. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also explain this study to you in full and answer all of your questions.

1. **Name of Participant ("-Study Subject")**

_____

2. **Title of Research Study**

Investigating the neuropsychological effect and long term outcomes of concussions among high school rugby players, and their associated predictors.

3. **What is the purpose of this research study?**

The purpose of this research study was to investigate whether or not, and how, instances of concussions contribute to brain functioning in adolescents. More specifically the research intends to find out how these injuries may affect the way that an individual thinks, feels and behaves, and whether/how it impacts on the brain. Also, the purpose is to observe how individuals who sustain concussions compare to people who have had no such injuries.

4. **What was done during this research study?**

During this study, you were required to participate in one study, completing numerous questionnaires and scales to obtain individual demographic information, personal characteristics, an approximation of your ability to think, as well as the different ways in which you act and feel. Following initial testing and if there was a diagnosis of a concussion, you underwent similar testing procedures as the baseline phase, as well as undergoing additional brain scans. Following the completion of the rugby season, if you sustained a concussion, you underwent an additional testing and scanning session.

5. **Was any deception used in this research study?**

No.

6. **Is anything further required of you?**

There is nothing further required of you. If you do however have any questions or concerns regarding my research you may contact the Principle Investigator involved: either Nicholas Reid (Nicholas.reid@alumni.uct.ac.za) or Dr. Leigh Schrieff-Elson (leigh.e.elson@gmail.com).

7. **Confidentiality**

All data collected for the study will be kept confidential – this is not to be confused with the results of the study which will be made available. Data will be labelled using participant numbers rather than names, so that they cannot be used to directly identify any particular individual. Furthermore, all data will be stored in a locked filing cabinets in the department. Data will also be stored on a password-protected computer. Only certain people – the researchers for this study and certain University of Cape Town officials – are afforded the legal right to review these research records.

8. **Signatures**

As a representative of this study, I have explained to the participant, in detail, the purpose, the procedures, and any deception used in this research study.

_____ _____

Signature of Person Obtaining Consent/Assent Date

I have been informed, in detail, about this study's purpose, procedures, and deceptions. I have been given the opportunity to ask questions before I sign. By signing this form, I am not waiving any of my legal rights.

_____ _____

Signature of Person Assenting Date

Appendix K

Table of Descriptive Statistics for Rugby/Control groups

Table of Descriptive Statistics for the Control/Rugby group

		Age	BIS Total	BIS Self-Control	STAXI Angry Temperament	STAXI Angry Reaction	STAXI Anger Expression Out	ImPACT Impulse Control	GHQ Somatic Symptoms	GHQ Anxiety/ Insomnia	GHQ Social Dysfunction	BDI Total	T-STAI Total	AUDIT Total
Control	Mean	16.45	63.09	14.27	5.55	9.00	17.27	4.90	12.09	11.18	14.00	10.64	47.27	1.73
	N	11	11	11	11	11	11	10	11	11	11	11	11	11
	Stdev	.52	6.69	3.38	1.51	2.53	3.47	2.51	3.62	3.76	2.49	5.75	5.04	3.47
	Min	16	48	8	4	5	12	1	7	7	9	1	40	0
	Max	17	73	19	8	12	21	9	18	19	18	19	59	10
Rugby	Mean	16.48	65.30	14.70	6.35	7.61	18.87	6.00	12.00	10.13	12.91	7.35	47.00	3.43
	N	23	23	23	23	23	23	21	23	23	23	23	23	23
	Stdev	.59	11.24	2.98	3.10	2.66	4.02	3.32	2.47	2.42	1.81	5.78	4.92	4.07
	Min	16	46	9	4	4	10	2	8	7	9	0	40	0
	Max	18	92	20	16	16	31	17	18	17	15	20	58	11

Note. BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.

Appendix L

Sample Characteristics for Rugby/Control

Table 3
Sample Characteristics for Rugby/Control

Measure	*df*	*F*	*p*
Age	1,32	.01	.911
BIS Total	1,32	.36	.552
BIS Self-control	1,32	.14	.713
STAXI Angry Temperament	1,32	.66	.424
STAXI Angry Reaction	1,32	2.10	.157
STAXI: ANGER Expression Out	1,32	1.28	.267
ImPACT Impulse Control	1,29	.86	.362
GHQ Somatic Symptoms	1,32	.01	.932
GHQ Anxiety/Insomnia	1,32	.97	.331
GHQ Social Dysfunction	1,32	2.10	.157
BDI Total	1,32	2.42	.130
T-STAI Total	1,32	.02	.882
AUDIT Total	1,32	.144	.240

Note. df = degrees of freedom; BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.
All listed *p*-values are two-tailed.

Appendix M

Table of Effect Sizes for each of the Grouping Variables

Cohen's d for Between Group Differences

Measure	Rugby/Control	Diagnosed Concussion/ No Diagnosed Concussion	Diagnosed and Suspected Concussion/ No Concussion
Age	0.06	0.69	0.43
BIS Total	0.24	0.03	0.49
BIS Self-control	0.14	0.18	0.29
STAXI Angry Temperament	0.33	0.33	0.15
STAXI Angry Reaction	0.54	0.16	0.13
STAXI Angry Expression Out	0.43	0.55	0.03
ImPACT Impulse Control	0.37	0.83	0.30
GHQ Somatic Symptoms	0.03	0.27	0.31
GHQ Anxiety/Insomnia	0.33	0.52	0.20
GHQ Social Dysfunction	0.50	0.16	0.14
BDI Total	0.57	0.36	0.00
T-STAI Total	0.05	0.11	0.43
AUDIT Total	0.45	0.19	0.30

Note. BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.

Appendix N

Table of Descriptive Statistics for Diagnosed Concussion/No Diagnosed Concussion

Table of Descriptive Statistics for Diagnosed Concussion/No Diagnosed Concussion groups

		Age	BIS Total	BIS Self-Control	STAXI Angry Temperament	STAXI Angry Reaction	STAXI Anger Expression Out	ImPACT Impulse Control	GHQ Somatic Symptoms	GHQ Anxiety / Insomnia	GHQ Social Dysfunction	BDI Total	T-STAI Total	AUDIT Total
No Diagnosed	Mean	16.39	64.54	14.46	5.93	7.96	18.71	5.00	12.14	10.71	13.32	8.79	47.18	2.75
Concussion	N	28	28	28	28	28	28	25	28	28	28	28	28	28
	Stdev	.50	10.33	3.18	2.71	2.37	3.91	1.94	3.05	3.00	2.14	5.93	5.13	3.97
	Min	16	46	8	4	4	12	1	7	7	9	0	40	0
	Max	17	92	20	16	12	31	9	18	19	18	20	59	11
Diagnosed	Mean	16.83	64.83	15.00	6.83	8.50	16.67	8.33	11.50	9.33	13.00	6.67	46.67	3.50
Concussion	N	6	6	6	6	6	6	6	6	6	6	6	6	6
	Stdev	.75	8.70	2.68	2.71	4.04	3.50	5.32	1.52	2.25	1.90	5.92	3.88	3.94
	Min	16	51	10	4	5	10	2	9	7	11	0	42	0
	Max	18	74	18	11	16	19	17	13	13	15	14	51	10

Note. BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.

Appendix O

Table of Results Predicting Externalizing Behaviors using Diagnosed Concussion/No Diagnosed Concussion

Results of Multiple Hierarchical Regression, Predicting Externalising Behaviours using Diagnosed Concussion/No Diagnosed Concussion as the Third Predictor Variable (N = 34)

						Change Statistics				
Measure	Model	R	R^2	Adjusted R^2	SES	R^2 Change	F Change	*df*1	*df*2	*p*
BIS Total	1	.11	.01	-.02	10.03	.01	.40	1	32	.531
	2	.15	.02	-.04	10.14	.01	.34	1	31	.564
	3	.16	.03	-.07	10.29	.00	.11	1	30	.738
BIS Self-control	1	.07	.01	-.03	3.11	.01	.15	1	32	.698
	2	.10	.01	-.06	3.15	.00	.14	1	31	.711
	3	.12	.02	-.08	3.19	.01	.17	1	30	.682
STAXI Angry Temperament	1	.01	.00	-.03	2.73	.00	.00	1	32	.947
	2	.14	.02	-.04	2.75	.02	.63	1	31	.432
	3	.17	.03	-.07	2.78	.01	.26	1	30	.616
STAXI Angry Reaction	1	.16	.03	-.00	2.67	.03	.87	1	32	.357
	2	.30	.10	.03	2.62	.06	2.15	1	31	.152
	3	.32	.10	.01	2.64	.01	.48	1	30	.494
STAXI Anger Expression	1	.08	.01	-.03	3.92	.01	.20	1	32	.659
Out	2	.21	.05	-.02	3.90	.04	1.27	1	31	.269
	3	.34	.19	.03	3.81	.07	2.48	1	30	.125
ImPACT Impulse Control	1	.11	.01	-.02	3.12	.01	.34	1	29	.565
	2	.20	.04	-.03	3.13	.03	.82	1	28	.374
	3	.44	.19	.10	2.92	.15	5.02	1	27	.034*

Model 1. Predictors: (Constant), Age
Model 2. Predictors: (Constant), Age, Rugby/Control
Model 3. Predictors: (Constant), Age, Rugby/Control, Diagnosed Concussion/No Diagnosed Concussion

Note. R = correlation coefficient; SES = standard error of estimate; df = degrees of freedom; BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.
*$p < .05$. All listed *p*-values are two-tailed.

Appendix P

Table of Descriptive Statistics for Diagnosed and Suspected Concussion/No Concussion

Table of Descriptive Statistics for Diagnosed and Suspected Concussion/No Concussion

		Age	BIS Total	BIS Self-Control	STAXI Angry Temperament	STAXI Angry Reaction	STAXI Anger Expression Out	ImPACT Impulse Control	GHQ Somatic Symptoms	GHQ Anxiety/ Insomnia	GHQ Social Dysfunction	BDI Total	T-STAI Total	AUDIT Total
No Concussion	Mean	16.35	67.00	15.00	6.29	7.88	18.29	5.19	11.59	10.76	13.12	8.41	46.06	2.29
	N	17	17	17	17	17	17	16	17	17	17	17	17	17
	Stdev	.49	10.94	3.28	3.29	2.42	4.82	2.11	3.26	2.99	2.42	5.40	4.55	3.26
	Min	16	48	8	4	4	12	1	7	7	9	1	40	0
	Max	17	92	20	16	12	31	9	18	19	18	19	58	10
Diagnosed and Suspected Concussion	Mean	16.59	62.18	14.12	5.88	8.24	18.41	6.13	12.47	10.18	13.41	8.41	48.12	3.47
	N	17	17	17	17	17	17	15	17	17	17	17	17	17
	Stdev	.62	8.47	2.87	2.00	2.95	2.76	3.89	2.35	2.88	1.73	6.52	5.12	4.50
	Min	16	46	9	4	5	10	2	9	7	11	0	41	0
	Max	18	74	18	11	16	21	17	18	17	17	20	59	11

Note. BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification

Appendix Q

Table of Results Predicting Externalizing Behaviors using Diagnosed and Suspected Concussion/No Concussion

Results of Multiple Hierarchical Regression, Predicting Externalising Behaviours using Diagnosed and Suspected Concussion/No Concussion as the Third Predictor Variable (N = 34)

						Change Statistics				
Measure	Model	R	R^2	Adjusted R^2	SES	R^2 Change	F Change	df1	df2	p
BIS Total	1	.11	.01	-.02	10.03	.01	.40	1	32	.531
	2	.15	.02	-.04	10.14	.01	.34	1	31	.564
	3	.36	.13	.04	9.73	.11	3.66	1	30	.065
BIS Self-control	1	.07	.01	-.03	3.11	.01	.15	1	32	.698
	2	.10	.01	-.06	3.15	.00	.14	1	31	.711
	3	.19	.04	-.06	3.16	.03	.84	1	30	.367
STAXI Angry Temperament	1	.01	.00	-.03	2.73	.00	.00	1	32	.947
	2	.14	.02	-.04	2.75	.02	.63	1	31	.432
	3	.20	.04	-.06	2.77	.02	.56	1	30	.461
STAXI Angry Reaction	1	.16	.03	-.00	2.67	.03	.87	1	32	.357
	2	.30	.10	.03	2.62	.06	2.15	1	31	.152
	3	.32	.10	.01	2.64	.01	.48	1	30	.495
STAXI Anger Expression	1	.08	.01	-.03	3.92	.01	.20	1	32	.659
Out	2	.21	.05	-.02	3.90	.04	1.27	1	31	.269
	3	.22	.05	-.05	3.96	.00	.03	1	30	.861
ImPACT Impulse Control	1	.11	.01	-.02	3.12	.01	.34	1	29	.565
	2	.20	.04	-.03	3.13	.03	.82	1	28	.374
	3	.22	.05	-.06	3.17	.01	.22	1	27	.645

Model 1. Predictors: (Constant), Age
Model 2. Predictors: (Constant), Age, Rugby/Control
Model 3. Predictors: (Constant), Age, Rugby/Control, Diagnosed and Suspected Concussion/No Concussion

Note. R = correlation coefficient; SES = standard error of estimate; df = degrees of freedom; BIS = Barratt Impulsiveness Scale; STAXI = State-Trait Anger Expression Inventory; ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing; GHQ = General Health Questionnaire; BDI = Beck Depression Inventory; T-STAI = Trait measures of the State-Trait Anxiety Inventory; AUDIT = Alcohol Use Disorder Identification Test.
All listed *p*-values are two-tailed.