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The neuropsychological outcomes of concussions among field-hockey players

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Abstract

Concussions in sport have been a popular, yet controversial topic in recent years. In collision sports such as boxing and American football, ex-players have been displaying concerning neuropsychological sequelae which have been associated with multiple concussions sustained throughout their sporting careers. In sports such as field-hockey, the likelihood of concussions might be lower, but it is still prevalent. Literature has shown that field-hockey players have shown similar emotional, behavioural and cognitive symptoms following a concussion to those in collision sports. However, the research dedicated to neuropsychological effects of concussions among field-hockey players is extremely limited. Therefore, this study aimed to explore the neuropsychological effects of concussions solely focusing on field-hockey players. By employing emotional/behavioural measures and a neuropsychological test battery (ImPACT) the differences across these outcomes were used to explore whether sex, age and history of concussions were predictors of neuropsychological outcomes. The study is cross-sectional and retrospective in nature, within a quantitative paradigm. The participants (N= 50) were recruited from Central Hockey Club, included both males and females, aged between 18 and 42. Using hierarchical regression, I found that sex significantly predicted alcohol usage and associated behaviour, age significantly predicted state and trait anxiety as well as anger expression and impulse control, and history of a prior concussion significantly predicted poor visual memory. Given the increasing participation in field-hockey across the world, more research of this nature focusing on this sport specifically, is needed.

Keywords: *Concussion, neuropsychological, emotional, behavioural, cognitive, field-hockey*

Research shows that sport-related concussions (SRC) result in long-term adverse neuropsychological effects (McCrory et al., 2017a). Dave Duerson, an American footballer, had taken his own life after years of cognitive and emotional adversity (Roehr, 2012; Shen, 2015). McKee, the neurologist who studied Duerson's brain, reported that these adverse neuropsychological effects were likely the result of repeated mild traumatic brain injuries (TBIs) he sustained throughout his footballing career (Roehr, 2012; Shen, 2015). Apparent in Duerson's case are the cumulative, long term cognitive, emotional and behavioural outcomes of sports-related concussions.

There are numerous studies dedicated to investigating the effects of concussions in collision sports such as rugby, American football, and boxing (Guskiewicz, Weaver, Padua, & Garrett, 2000; Karr, Areshenkoff, & Garcia-Barrera, 2014; Rodrigues, Lasmar, & Caramelli, 2016). Consequently, the neuropsychological effects of these popular sports dominate the literature. However, SRCs can be just as damaging in sports where the literature is not as vast. A study by Collin et al. (2003) found concussions to be a common injury in field-hockey, which highlights the need for more literature directed at field-hockey. There is a dearth of research on SRCs and its neuropsychological effects in field-hockey.

Field-hockey

Field-hockey is played in over 132 countries (Jeroen, 2016; Orooj, Nuhmani, & Muaidi, 2016; Theilen, Mueller-Eising, Bettink, & Rolle, 2016). One can assume its popularity in South Africa, as South Africa hosted the World Hockey League Semi-final in 2017 ("HOCKEY WORLD LEAGUE", n.d.). In addition, the South African field-hockey teams took part in the Hockey African Cup of Nations and the Hockey Junior World Cup ("HERO HOCKEY JUNIOR

WORLD CUP MEN 2013", 2013; "South Africa teams blast into Africa Cup for Nations finals", 2013).

Field-hockey is a fast-paced, aggressive game due to the high speed at which the hockey ball travels; therefore, can be extremely dangerous leading to concussions, as a result of blows to the head with either the stick or ball (Murtaugh, 2009; Orooj et al., 2016; Rose, 1981; Rossiter & Challis, 2017; Theilen et al., 2016). Murtaugh (2009), however, points out that studies included in their analyses used elite hockey players, and therefore generalizability is limited. In turn, the literature regarding neuropsychological effects of concussions in South African field-hockey is limited.

Concussions

Concussions are a form of traumatic brain injury (Daneshvar, Nowinski, McKee, & Cantu, 2011; "Concussion", 2006). Concussions that occur in sports settings are usually blows to the head or body causing the head to jerk and snap back and forth as a result of the force transmitted from low-velocity impact (Aubry, Cantu, Dvorak, Graf-Baumann, Johnston, Kelly, Lovell, McCrory, Meeuwisse, & Schamasch, 2002; Erlanger, Kutner, Barth, & Barnes, 1999; "Concussion", 2006; Meehan & Bachur, 2009; Upshaw, Gosserand, Williams, & Edwards, 2012). The frontal and temporal lobes are affected most by the acceleration and deceleration forces common in sports-related injuries to the head (Belanger & Vanderploeg, 2005; Lovell et al., 2006).

SRC's are usually diagnosed by the professionals who are available in the sport setting, such as coaches, physiotherapists and sports physicians (Belanger & Vanderploeg, 2005). Diagnosing and assessing an SRC poses a challenge, as they occur with no loss of consciousness or obvious neurological signs; and there are no diagnostic test/marker in the sport setting that

provides a quick diagnosis (McCrory et al., 2017a). In the field of sports research, concussions are referred to as a "traumatic brain injury that is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces" (McCrory et al., 2017b, p. 5).

Concussions in field-hockey. A study conducted in England found concussions to be the most common injury in field-hockey between 1988 and 2003 (Rossiter & Challis, 2017). Collins et al. (2003), conducted similar studies in America and Australia, and found that 50% of all injuries in field-hockey involved the head and face. Cassell (2002) found that 17.3% of reported field-hockey injuries required follow-up care, and that 3.4% of these reported injuries were attributed to cerebral concussions, which were of a serious nature (. Data pertaining to injuries in 16 international field-hockey tournaments that took place in Europe, Asia and Australia, found that the most frequent injuries were blows to the head and face (Theilen et al., 2016). Thus, the chances of sustaining concussions in field-hockey appear to be high.

In England, female field-hockey players in the under-21 age category were found to have a higher concussion incidence rate compared to their male counterparts (Rossiter & Challis, 2017). These statistics were lower in the under-16 and under-18 age groups (Rossiter & Challis, 2017). These finding suggest that age is a factor with regards to concussions in fueld hockey. Further, Dick et al. (2007) notes the importance of implementing prevention strategies early, as this may prevent long-term effects of injuries to the head in field-hockey, such as memory deficits, for example.

Neuropsychological effects of concussions in sport

Concussed athletes have reported emotional and cognitive symptoms, which typically appear following a concussion and usually dissipate independently (Aubry et al., 2002; Collins, Grindel, & Lovell, 1999). Differences in the structure and functioning of the brain have been

positively correlated with head injuries in sport; and evident in neuroimaging studies (McCrory et al., 2017a).

Cognitive symptoms/impairments of SRC include slower reaction times, feeling as if one is in a fog, impairments in memory, attention and processing speed (Daneshvar et al., 2011; McCrory et al., 2009; Scott, Atkinson, & Gother, 2017). Thus, cognitive functioning can be significantly affected following a SRC (Collins et al., 1999). This was evident as deficits in attentional processes, memory (delayed and acquisition), global functioning and neurocognitive speed were found in soccer and American-football players following a concussion (Belanger & Vanderploeg, 2005; Lovell et al., 2006). In addition, behavioural and emotional symptoms such as irritability and adverse emotional symptoms also occur. Disturbances in sleep patterns, too, have occurred following a concussion, as well as physical symptoms such as loss of consciousness and headaches (Daneshvar et al., 2011; Emery et al., 2016; McCrory et al., 2009). In terms of the cumulative effects of SRC's, Iverson, Gaetz, Lovell and Collins (2004) found in their study that young athletes who experienced multiple concussions exhibited more symptoms and poorer memory performance than athletes that have not.

Neuropsychological effects of concussions in field-hockey. Of the limited research focusing on field-hockey, a study by Shuttleworth-Edwards, Morder, Reid and Radloff (2004), South African high-school field-hockey players were used as controls to investigate the effects of concussions among school rugby players. It was found that, consistent with the rugby players, the field-hockey players also reported clumsiness in speech, a short temper, emotional worry, sleep difficulties, headaches, sensitivity to noise, and weakness in limbs following a concussion. Neurocognitive symptoms were also found among field-hockey players, which included attention and concentration impairments (Shuttleworth-Edwards et al., 2004). These outcomes

reported in the field-hockey players are in line with the symptoms found in players of more collision sports such as American football, boxing, rugby and soccer (Conder & Conder, 2015; Rossiter & Challis, 2017; Shen, 2015). In a study by Rossiter and Challis, conducted in England, gender differences were noted across emotional and behavioural symptoms: female field-hockey players reported feeling emotional and irritable with sadness and depressive symptoms more often than men; who, on the contrary, reported more physical symptoms such as neck pain and dizziness. In addition, fatigue and difficulty concentrating were also reported by the field-hockey players (Rossiter & Challis, 2017).

Literature on the neuropsychological effects of concussions in field-hockey players are limited (Murtaugh, 2009; Rossiter & Challis, 2017). Hence, further studies need to be conducted in this area. The wellbeing and safety of sports players needs to be duly considered, especially as participation increases and the sport becomes more popular.

Aims, Rationale, and Hypotheses

There is little to no research which solely focuses on the neuropsychological and emotional effects of SRCs among field-hockey players, despite the sport being played at an extremely high intensity and therefore presents a risk for sustaining concussions (Murtaugh, 2009; Orooj et al., 2016; Rossiter & Challis, 2017; Theilen et al., 2016).

The current study therefore aimed to investigate the neuropsychological outcomes of sports-related concussions among field-hockey players; by specifically exploring the predictive value of age, sex and history of concussions. In terms of age and sex, no predictions were made. However, with regards to history of concussion, it was predicted that players with a history of concussion will perform more poorly than the field-hockey players who experienced no prior concussion on the neuropsychological measures.

Methods

Design and Setting

The study is cross-sectional and retrospective in nature, within a quantitative paradigm. In order to investigate whether age, sex and concussion history predicted neuropsychological outcomes among field-hockey players a computerized battery (which tested verbal memory, visual memory, visual motor, reaction time and impulse control) and eight different measures of emotion and behavioural outcomes was used. Data collection took place at Central Hockey Club, in Athlone. The emotion and behavioural measures and the composite scores of the ImPACT are the dependent variables of the study. The predictors of age, sex and history of concussion are the independent variables.

Participants

Convenience sampling was used in recruiting the field-hockey players, as Central Hockey Club was easily accessible and was willing to provide participants. A total of fifty field-hockey players aged 18 to 42 took part in the study (N=50). The fifty players included male and female players. All the field-hockey players were fluent in English.

Power analysis. Using G Power, a priori power analysis indicated that a sample size of 56 was needed for the proposed study to have 95% power for detecting a medium effect at α = .05. I managed to recruit 50 players within the time frame for the research project, however.

Exclusion criteria. Players were excluded from participation in the study if they were: (a) below the age of 18 and above the age of 45, (b) non-English-speaking players, and (c) players with a diagnosed neurological disorder.

Materials

Emotional and behavioural measures.

Alcohol Use Disorders Identification Test. The Alcohol Use Disorders Identification Test (AUDIT) is a 10-item questionnaire which measures hazardous and harmful alcohol use. It covers the following domains: (a) alcohol consumption, (b) drinking behaviour, and (c) alcohol-related problems (Saunders, Aasland, Babor, De La Fuente, & Grant, 1993). See Appendix A. Questions take the form of a frequency rating format, scored from 0 (never) to 4 (daily); and a bimodal response format, 0 representing "no" and 1 representing "yes" (Saunders et al., 1993, p. 794). A score of 8 or more on the AUDIT indicates higher chance of harmful alcohol assumption (Allen & Columbus, 1995). Validity and reliability of the AUDIT measure for use in self-administration and general health-risk screenings is satisfactory overall (Daeppen, Yersin, Landry, Pecoud & Decrey, 2000). Internal consistency for AUDIT was found to be high, with a Cronbach α coefficient of .083 (Hays, Merz, & Nicholas, 1995; Daeppen et al., 2000).

Barratt Impulsiveness Scale (BIS-11). The BIS-11 contains 30 items that assesses impulsiveness (BIS-11; Stanford et al., 2009). See Appendix B. The BIS-11 measures impulsivity based on its three sub traits: Attentional Impulsiveness, Motor Impulsiveness, and Non-planning Impulsiveness. The questions are aligned on 4-point scale: 1 being "rarely/never" and 4 being "almost always/always". Higher scores represent higher levels of impulsivity (BIS-11). The BIS-11 was shown to have good concurrent validity. Reliability for the BIS-11 is satisfactory, .84 (Stanford et al., 2009; Whiteside & Lynam, 2000). Internal consistency is high for the three sub traits are also satisfactory, ranging between .58 and .78 (Whiteside & Lynam, 2000).

Beck Depression Inventory – Second Edition (BDI-II). The BDI-II is a self-report scale consisting of 21 items which measures depressive symptoms during the past week (Storch,

Roberti, & Roth, 2004). See Appendix C. The items take the form of a 4-point scale format, from 0 to 3, and participants are expected to state the degree to which they agree with each statement. The scores are summed up, and a higher total represents more severe depression levels, with a score of 14-19 indicating mild depression, 20-28 indicates moderate and 29-63 indicates severe depression (Steer, Kumar, Ranieri, & Beck, 1998). The BDI-II has high reliability and internal consistency for the BDI-II is .90 (Storch, Roberti, & Roth, 2004). Validity is also satisfactory for the BDI-II (Beck, Steer, & Garbin, 1988).

General Health Questionnaire (GHQ-28). The GHQ-28 is a 28-item questionnaire to detect minor psychiatric disorders (Goldberg et al., 1997). See Appendix D. It measures four areas: (a) somatic symptoms, (b) anxiety and worry, (c) social dysfunction, and (d) observed depressed mood (Goldberg & Hillier, 1979). Items are scored on a four-point Likert scale. Internal consistency and the coefficients of reliability for the GHQ-28 are high and fall within an acceptable range (Nagyova et al., 2000).

State-Trait Anger Expression Inventory (STAXI). The STAXI is a 44-item self-report measure which takes the form of a 4-point Likert scale, ranging from *almost never to almost always*. The STAXI assesses intensity and frequency of anger. Reliability and internal consistency, and validity are high for the STAXI (De Azevedo, Wang, Goulart, Lotufo, & Bensenor, 2010). The subscales S-Ang and T-Ang will be used in addition to the AX Index. S-Ang measures state anger, T-Ang measures trait anger and the AX Index indicates total anger expression (Spielberger, 1999).

State-Trait Anxiety Inventory (STAI). The STAI measures state and trait anxiety. State anxiety refers to anxiety that comes about as a result of a specific situation; and trait anxiety refers to the "general tendency to perceive situations as threatening" (McDowell, 2006, p. 1).

The STAI is divided into form 1 and form 2. Form 1 refers to *State Anxiety* (STAI-1) and form 2 consists of items relating to *Trait Anxiety* (STAI-2). Both state and trait anxiety scores are utilized in the study. Internal consistency is high for the STAI (McDowell, 2006).

Cognitive and symptom measures.

Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT). ImPACT is a copyrighted computerized test battery (ImPACT Applications Inc., 2018). It consists of three sections: demographic data, current symptoms and condition data, and the neuropsychological testing. The demographic section deals with sport-, medical- and concussion- history information. The current symptoms and condition section is a 21-item checklist rated on a 6-point Likert scale which asks participants to rate their current physiological and psychological symptoms and conditions during the testing session. The neuropsychological section looks at cognitive functioning, such as: verbal memory, visual memory, visual motor speed, reaction time and impulse control (See Appendix E; Iverson, Lovell, & Collins, 2005). Concussed athletes tend to score low on the cognitive functions listed above, and report more severe symptoms on the symptoms checklist compared to non-concussed athletes (Schatz, Pardini, Lovell, Collins, & Podell, 2006). ImPACT was previously found to have good construct and divergent validity (Schatz et al., 2006).

Procedure

Ethical clearance was granted by the Department of Psychology Research Ethics Committee; reference number PSY2018-037 (see Appendix F). Before data collection commenced, different teams at Central Hockey Club were approached, and participants who met the inclusion criteria were contacted by the head coach. A schedule was set up allocating the times and days in which each team would be tested. Data collection took place during the

practice sessions of the respective teams chosen. Testing was conducted at the clubhouse, where five laptops were set up. I explained the details of the study and what the process would be if they agreed to participate. Once participants signed the consent form (see Appendix G), they began the ImPACT test. The computer testing lasted between forty minutes to an hour. Given time constraints, participants who consented to participation, only completed the ImPACT testing on site. They were allowed to take the pen-and-pencil emotional and behavioural measures home to complete and return it at the next practice session. All the participants completed the ImPACT test and the pen-and-pencil emotional and behavioural measures. The data were recorded and then analysed.

Statistical Analyses

The statistics software Statistics Package for Social Sciences version 25(IBM SPSS, 2018) was used to record and analyse the data with a significance threshold set at $\alpha = .05$.

Hierarchical regression analysis. The dummy variables "With Formal Diagnosis" and "Without Formal Diagnosis" were created for the predictor variable "history of concussion". A further variable "Number of Concussions" was created for this predictor.

Descriptive statistics and frequency data were generated in SPSS. The outcome variables were: the AUDIT, which measures alcohol dependency behaviour; the BIS-2, measuring impulsiveness; BDI-2, which measures depressive symptoms; GHQ-28, which measures psychological disturbance; the STAI-1(State) and STAI-2(Trait), which measures state and trait anxiety; the S-Ang (State) and T-Ang (Trait), which measures state and trait anger as well the AX Index, which measures anger expression as well as the Symptom Score, which measured current physiological and psychological symptoms during the testing session symptoms, Verbal Memory, Visual Memory, Visual Motor Processing Speed, Reaction Time and Impulse Control**.**

SPSS then generated correlation- and regression- statistics for every outcome variable across the three predictors.

Ethical considerations

Ethical approval was received by the Department of Psychology Research Ethics Committee.

Informed Consent. Consent forms (Appendix G) were distributed to the participants before every testing session. The consent forms informed participants what the process would be if they agreed to participate and that their participation was voluntary, and that they were able to withdraw from the study at any time without penalty.

Privacy and confidentiality. Participants were assigned a number. Thus, their identity was kept private. All data collected from the participants was kept confidential.

Potential risks and discomforts, and minimizing risk. The time taken to complete both the ImPACT test and the pen-and-paper emotional/behavioural measures in one practice session was a potential risk as participants might become fatigued and irritable, develop discomfort or have difficulty concentrating for that length of time. However, participants were allowed to complete the emotional/behavioural forms at home which minimised this risk.

Participants were given a debriefing form once they completed both the ImPACT and pen-and-pencil emotional/behavioural measures. Therewith, all the contact details of the researchers of the current study were listed, if they had further questions. In addition, participants with mild to severe Beck Depression scores were contacted with a list of options and contact details for appropriate services if they intended to seek help.

Potential benefits of the current study. The study benefits the participants as it provides a range of information regarding their emotion and behavioural state as well as their cognitive abilities which they might not have known prior to their participation in the study.

Results

Descriptive Statistics. Table 1 represents the descriptive statistics for age and number of concussions across the sample (*N*= 50). There was a fairly wide range in terms of age and some players reported having sustained up to 4 concussions.

Table 1
Descriptive Statistics for Age and Number of Concussions for Sample (*N*= 50)

	M	*SD*	*Min*	*Max*
Age	26.96	6.74	18	42
Number of Concussions	0.4	0.93	0	4

In Table 2, the number of participants per age bracket is noted as well as the number of formally diagnosed vs not formally diagnosed concussions across the sample. Of the fifty participants, 38 participants (76%) did not report any concussions, and 12 (24%) did. The number of concussions across sex was equal, as both male and females reported 6 concussions respectively (See Appendix H).The age brackets *20-24*, *25-29 and 30-34* contained the highest number of participants reporting concussions (*n* = 11 in each case). Eight concussions were diagnosed formally by a doctor and four were not formally diagnosed. The age brackets *20-24* and *25-29* reported the most concussions.

Table 2
Frequency for Number of Concussions Across Age

Age Intervals	Number of Concussions									Total Concussions	Total
	No	Yes									
		With Formal Diagnosis				Without Formal Diagnosis					
		One	Two	Three	Four	One	Two	Three	Four		
15 – 19	9	0	0	0	1	0	0	0	0	1	10
20 – 24	7	2	0	0	1	1	0	0	0	4	11
25 – 29	7	1	0	0	0	3	0	0	0	4	11
30 – 34	9	1	0	1	0	0	0	0	0	2	11
35 – 39	4	0	0	0	0	0	0	0	0	0	4
40 - 44	2	1	0	0	0	0	0	0	0	1	3
Total	**38**									**12**	**50**

Age differences among the field-hockey players were one of the areas the study intended to explore. In Table 3, the age bracket *35-39* obtained the highest average of *AUDIT* scores, which measured alcohol dependency behaviour, and the *15-19*, the lowest. *BIS-2* scores seemed to decrease from ages 30-44. The oldest age bracket obtained the lowest average scores whereas the 20-24-year age bracket scored the highest. *BDI-2* scores, which measured depressive symptoms, decreased as age increased at least from 20 years. The two youngest age brackets *15-19* and *20-24* obtained the highest and second highest scores respectively, with the oldest age bracket obtaining the lowest mean score. With regards to the *GHQ-28*, which measured psychological disturbance, scores varied across the age brackets with the biggest difference in scores being between the two oldest age groups. *STAI-1 (State)* scores, which measured state anxiety, decreased as age increased. The oldest age bracket, *40-44*, scored the lowest, in comparison to the two youngest age brackets, *15-19* and *20-24*, who obtained the highest. *STAI-2 (Trait)* scores, which measures trait anxiety, were more stable across the younger and older age groups. *Anger State* and *Anger Trait* scores varied across age, with a major difference in scores for the youngest (15-19) and second oldest (35-39) age groups on the Anger Trait measure. In comparison, *AX Index* scores, which measured anger expression, largely decreased as age increased. The youngest age bracket obtained the highest scores and the oldest age bracket the lowest.

Table 3

Descriptive Statistics for Outcome Variables (Emotional and Behavioural Measures) Across Age

Age		AUDIT	BIS - 2	BDI - 2	GHQ - 28	STAI - 1	STAI -2	Anger (State)	Anger (Trait)	AX Index
15-19	M	2.05	57.83	9.83	18.30	36.20	41.13	53.88	48.65	56.13
	SD	2.60	9.93	8.72	11.26	11.44	12.36	19.70	37.64	31.37
20-24	M	4.35	58.35	11.95	19.65	37.20	41.40	50.25	18.80	46.75
	SD	4.36	10.19	9.64	17.14	10.11	9.49	12.69	15.40	20.75
25-29	M	4.50	55.95	8.50	15.55	33.10	35.30	45.00	38.25	46.50
	SD	5.07	10.27	4.95	10.51	7.90	7.02	18.19	24.24	13.02
30-34	M	4.20	57.50	8.50	14.77	29.20	31.67	53.50	31.30	30.73
	SD	3.80	15.77	8.26	7.98	9.31	9.53	22.32	27.17	24.64
35-39	M	7.50	54.50	7.00	20.17	27.83	32.83	55.00	14.83	35.83
	SD	4.95	3.54	9.90	16.26	9.19	7.78	7.07	10.61	10.61
40-44	M	3.00	50.33	5.00	13.67	24.33	32.33	40.00	45.00	20.00
	SD	.	.	.	.	.	.	.	.	.

Note. AUDIT is abbreviated for Alcohol Use Disorders Identification Test, *BIS-2* is abbreviated for Barratt Impulsiveness Scale, *BDI-2* is abbreviated for Beck Depression Inventory-Second Edition, *GHQ-28* is abbreviated for General Health Questionnaire, *STAI-1* is abbreviated for State Anxiety, *STAI-2* is abbreviated for Trait Anxiety, *Anger (State)* and *Anger (Trait)* represents the S-Ang and T-Ang subscales from the STAXI, as well as *AX Index* which measures anger expression. Lowest and highest scores for each respective measure are highlighted in red.

In Table 4, *Symptom Score* (which measured current physiological and psychological symptoms during the testing session), *Verbal Memory* and *Visual Motor Processing Speed* scores varied across the age brackets. *Visual Memory* scores decreased as age increased. The three youngest age brackets (*15-19*, *20-24*, *25-29*) obtained higher scores than the older three age brackets (*30-34*, *35-39*, *40-44*), collectively. With regards to *Reaction Time*, second youngest age group (20-24) obtained the quickest reaction time scores, whereas the oldest age group (40-44) obtained the slowest scores. With regards to *Impulse Control*, the three youngest age brackets (*15-19*, *20-24*, *25-29*) obtained higher scores than the three older age brackets (*30-34*, *35-39*, *40-44*).

Table 4

Descriptive statistics for outcome variables (ImPACT composite scores) across Age

Age		Symptom Score	Verbal Memory	Visual Memory	Visual Motor Processing Speed	Reaction Time	Impulse Control
15-19	M	12.88	84.18	69.35	32.97	0.65	6.70
	SD	13.50	11.71	21.22	4.41	0.11	2.52
20-24	M	22.55	82.70	72.45	34.36	0.62	4.30
	SD	23.60	10.57	16.69	10.54	0.06	2.70
25-29	M	6.45	82.65	70.05	40.43	0.66	5.35
	SD	5.77	11.10	18.15	8.56	0.10	4.68
30-34	M	11.57	79.47	61.43	36.42	0.68	2.33
	SD	8.27	9.42	20.77	5.77	0.10	1.99
35-39	M	14.50	91.83	64.50	32.63	0.65	1.50
	SD	26.16	6.36	31.82	4.63	0.05	2.12
40-44	M	12.00	84.67	66.67	35.58	0.72	2.33
	SD	.	.	.	.	.	.

Sex differences among the field-hockey players were one of the areas the study intended to explore. Thus, Table 5 represents the scores between the female and male participants across the outcome variables. Scores for the *BIS (*which measured impulsiveness), *BDI* (which measured depressive symptoms), *GHQ-28* (which measured psychological disturbance), Anger *State*, *Anger Trait*, *Visual Memory*, *Visual Motor Processing Speed*, *Reaction Time* and *Impulse Control* did not vary much between males and females in the study. *Males* scored higher on the *AUDIT* (which measures alcohol dependency) than *Females*. Female field-hockey players scored higher than the male players for: the *STAI-2* that measures trait anxiety, *AX Index* which measures anger expression, *Symptom Score*, which measured current physiological and psychological symptoms during the testing session, and *Verbal Memory*. Thus, Figure 2 shows these results where the female field-hockey players scored higher than the males.

Table 5

Descriptive Statistics for Outcome variables across Sex

Sex		AUDIT	BIS - 2	BDI - 2	GHQ - 28	STAI - 1	STAI -2	Anger (State)	Anger (Trait)	AX Index	Symptom Score	Verbal Memory	Visual Memory	Visual Motor Processing Speed	Reaction Time	Impulse Control
Male	M	6.15	55.73	8.15	16.23	31.85	34.77	52.31	32.15	36.96	9.92	80.65	70.77	37.68	.63	4.38
	SD	5.86	10.06	4.70	8.79	8.48	7.73	15.89	28.36	22.92	9.99	10.06	17.47	7.07	.09	4.05
Female	M	2.67	58.17	11.54	19.96	34.46	40.46	51.25	35.42	46.04	17.87	85.38	66.12	34.50	.69	4.17
	SD	3.25	10.23	10.43	13.55	11.46	12.40	16.96	27.25	25.58	21.50	10.32	15.76	9.67	.14	2.82

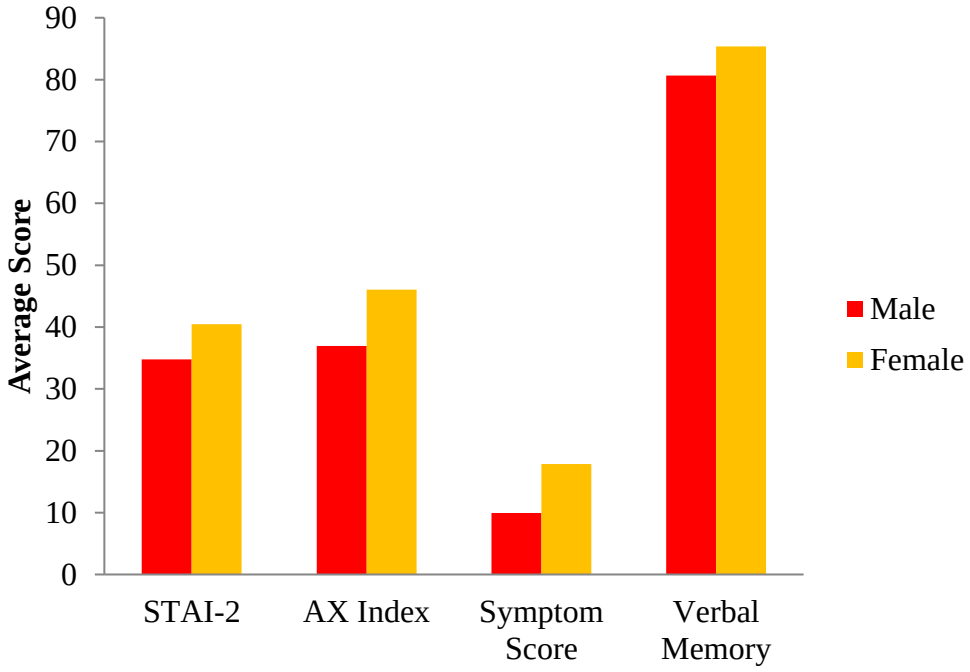

Figure 1. Average scores of *STAI-2*, *AX Index*, *Symptom Score* and *Verbal Memory* between male and female field-hockey players.

Another area the study aimed to investigate was whether the number of concussions affected outcome variables. In Table 6, scores for the *AUDIT*, *BIS*, *BDI*, *GHQ-28*, *Anger (State)*,

Anger (Trait), *AX Index*, *Symptom Score*, *Verbal Memory*, *Visual Motor Processing Speed* and *Reaction Time* across the *Number of Concussions* varied. For *STAI-1* and *STAI-2*, those who reported no concussion and one concussion collectively scored lower than those who reported three and four concussions collectively. This suggests that those who reported three or more concussions exhibit higher levels of state and trait anxiety. *Visual Memory* performances were lower for the players who reported three and four concussions collectively than those who reported none and one concussion. This indicates that players who reported three or four concussion experienced performed more poorly on visual memory than those who reported none or one concussion. Those who experienced three or four concussions scored lower on *Verbal Memory* than those who experienced no concussion and one concussion. For *Impulse Control* scores, those who experienced four concussions obtained higher *Impulse Control* score than those who reported no concussions.

Table 6

Descriptive Statistics for Outcome variables across Number of Concussions

Number of Concussions		AUDIT	BIS-2	BDI-2	GHQ-28	STAI-1	STAI-2	Anger (State)	Anger (Trait)	AX Index	Symptom Score	Verbal Memory	Visual Memory	Visual Motor Processing Speed	Reaction Time	Impulse Control
None	M	4.42	57.53	10.08	17.97	32.42	37.13	51.97	32.37	41.74	14.50	82.61	71.55	35.93	.66	3.63
	SD	5.18	10.66	8.77	11.97	10.47	11.71	16.34	27.75	25.43	18.660	9.797	15.19	9.11	0.13	2.86
Two	M	3.89	52.67	7.89	17.00	33.00	36.78	43.33	32.22	36.11	7.78	85.33	65.78	38.28	.68	6.00
	SD	4.23	7.35	5.75	7.91	8.43	4.92	10.00	18.89	21.47	5.47	13.41	14.90	5.54	0.11	4.272
Three	M	14.00	70.00	16.00	29.00	43.00	41.00	75.00	65.00	30.00	34.00	87.00	30.00	31.75	.67	2.00
	SD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Four	M	3.50	57.50	9.50	18.00	41.50	46.00	75.00	50.50	62.50	16.00	76.00	43.00	32.98	.63	10.00
	SD	4.95	4.95	3.57	19.80	4.95	1.41	0.00	65.76	17.68	5.66	9.90	9.90	11.14	0.05	5.657

Note. No standard deviations for players who reported three concussions as there was only one player.

Correlations. Correlational relationships between the outcome variables and the predictors were analysed.

Age. From Table 7, *Age* shows a small and positive correlation with the *AUDIT*. This suggests that there is a definite, but very small, relationship between age and alcohol misuse and that as age increases so does AUDIT scores. *Age* correlates significantly with *STAI-1* and *STAI-2*, and shares a low but negative relationship suggesting that as *Age* increases these scores on the respective outcome variables decreases. *Age* also shares a moderately negative relationship with *Impulse Control*. Thus, as age increases *Impulse Control* scores decreases.

Sex. *Sex* has a small, but significant positive correlation with *STAI-T, Symptom Score, Verbal Memory, BDI* and *Reaction Time.* This suggests that these scores increased as sex changed from male to female. In comparison, sex has a significant and small but negative correlation with *AUDIT* which suggests that that AUDIT scores increased as sex changed from female to male.

History of Concussion. *History of Concussion* has a significant, small and positive correlation with *Visual Memory.* Thus, as *History of Concussion* changed from no formal diagnosis to a formal diagnosis of concussion and no concussion, visual memory scores increased. Further, there is a small, but significant, negative correlation between having a formal concussion diagnosis and *Visual Memory*. *Number of Concussions* correlated significantly and moderately with *Visual Memory* indicating that as the number of concussions increases it is more likely participants' visual memory scores will be poorer. In addition, *Anger (State)* scores increased as *Number of Concussions* increased, as they share a significantly positive relationship. *Impulse Control* and *History of Concussion* share a significant, low but negative correlation which

suggests that impulse control decreased as *History of Concussion* changed from no formal to a formal concussion diagnosis to no concussion.

Table 7

Correlations between Outcome Variables and Predictor Variables

	Sex	Age	History of concussion	With Formal Diagnosis	Without Formal Diagnosis	Number of Concussions	AUDIT	BIS-2	BDI-2	GHQ-28	STAI - 1 (State)	STAI -2 (Trait)	Anger (State)	Anger (Trait)	AX Index	Symptom Score	Verbal Memory	Visual Memory	Visual Motor Proce	Reaction Time	Impulse Control
Sex	1	-.01	-.02	.017	.09	-.16	-.35**	.12	.21	.17	.13	**.27***	-.03	.06	.19	**.24***	.23	-.14	-.19	**.24***	-.03
Age		1	-.01	.01	-.02	-.07	.22	-.11	-.17	-.11	**-.32***	**-.32***	-.04	-.05	-.36**	-.08	.03	-.16	.05	.11	**-.40****
History of concussion			1	**-.93****	-0.20	**-.82****	-0.02	0.11	0.08	0.00	-0.12	-0.07	-0.6	-0.08	0.02	0.04	-0.01	**.34****	0.02	-0.05	**-.27***
With Formal Diagnosis				1	-0.11	**.76****	0.02	-0.09	-0.1	-0.0	0.10	0.07	0.14	0.05	-0.02	0.010	-0.04	**-.31***	-0.10	0.05	0.17
Without Formal Diagnosis					1	0.16	-0.01	-0.07	0.01	0.04	0.05	0.00	-0.19	0.01	0.04	-0.11	0.14	-0.01	0.14	-0.06	0.03
Number of Concussions						1	0.07	0.01	-0.0	0.05	0.21	0.15	**.24***	0.17	0.08	0.03	-0.05	**-.46****	-0.05	-0.02	**.34****
AUDIT							1	**.29***	0.11	0.23	0.21	0.03	0.18	0.19	0.12	0.15	-0.07	-0.03	0.04	-0.23	-0.0
BIS-2								1	**.59****	**.50****	**.44****	**.53****	**.26***	**.24***	**.53****	**.33****	-0.04	-0.09	-0.10	-0.02	0.1
BDI-2									1	**.78****	**.73****	**.84****	**.43****	**.40****	**.52****	**.75****	-0.12	-0.16	**-.25***	0.02	0.03
GHQ-28										1	**.69****	**.73****	**.31***	**.29***	**.44****	**.67****	-0.00	-0.08	-0.01	-0.02	0.06

Table 7 cont.
Correlations between Outcome Variables and Predictor Variables

STAI - 1 (State)	1	**.82****	**.54****	**.43****	**.68****	**.60****	-0.13	-0.19	-0.19	-0.08	0.07
STAI-2 (Trait)		1	**.45****	**.38****	**.64****	**.66****	-0.04	-0.10	-0.13	-0.04	0.12
Anger (State)			1	**.27***	**.37****	**.43****	-0.21	-0.20	**-.32***	-0.02	-0.04
Anger (Trait)				1	**.41****	**.34****	-0.12	-0.20	**-.28***	0.09	0.04
AX Index					1	**.358****	-0.12	-0.2	**-.25***	-0.14	0.09
Symptom Score						1	-0.0	-0.1	**-.30***	0.01	-0.1
Verbal Memory							1	**.36****	**.25***	-0.08	-0.02
Visual Memory								1	**.45****	**-.35****	-0.22
Visual Motor Processing Speed									1	**-.42****	0.07
Reaction Time										1	-0.03
Impulse Control											1

Note. *. Correlation is significant at the .05 level (1-tailed). **. Correlation is significant at the .001 level (2-tailed).

Regression Analysis. A series of hierarchical regressions were conducted for each outcome variable (Appendix I). Table 8 represents the significant model summaries of the outcome variables. See Appendix J for outcome variables that were not significantly affected by the predictor variables. Results showed that the model in which only *Sex* was entered as a predictor significantly predicted the outcome variable *AUDIT,* which measured alcohol dependency behaviour. A model including Sex and Age significantly predicted the outcome variable *STAI-1 (State)* and *STAI-2 (Trait)*which measured state and trait anxiety, as well as *Impulse Control*, which measured the amount of error made during the completion of ImPACT, and *AX Index*, which measured anger expression. No model that included sex, age, with a concussion diagnosis (formal or not) significantly predicted any of the outcome variables. On further analysis, regression coefficients were analysed. Results showed that *Sex* only significantly predicted *AUDIT* scores, which measured alcohol dependency behaviour. The change in AUDIT scores decreases as sex changes from male to female, β = -3.46, t(46)= -2.53, p=.015 (95% CI: -6.22- -.35). Thus, the male field-hockey players, as mentioned before, exhibit more alcohol dependency behaviour than female field-hockey players. *Age* had a significant effect on *STAI – 1 (State)* ¸which measured state anxiety, β = -.47, t (46) = -2.27, p= .028, (95% CI: -.89- -.05). The change in STAI –1 scores decreased as age increased, which indicates that the older field-hockey exhibited higher levels of state anxiety than the younger field-hockey players. *Age*, too, significantly predicted *STAI-2(Trait)* (β = -.49, t (46) = -2.29, p=.027 [95% CI: 6.91- -.06]), *AX Index* (β = -.128, t (46) = -2.58, p= .013[95% CI: -2.27- -.28]) and *Impulse Control* scores (β = -.21, t (46) = -2.96, p= .005[95% CI: -.35- -.07]), respectively. These significant findings suggest that older players have higher trait anxiety levels (*STAI-2*), express their anger more often (*AX Index*) and have poorer response inhibition (*Impulse Control*) than the

younger field-hockey players. Further, a *With Formal Diagnosis* of a concussion had a significant effect on *Visual Memory, β* = -13.71, *t* (46) = -2.19, *p*= .034[95% CI: -26.34- -1.09]. Thus, indicating that field-hockey players with a formal diagnosis of a prior concussion performed more poorly than those who reported a concussion without formal diagnosis and no prior concussion.

Table 8.

Model Summary for Significant Outcome Variables

Model						Change Statistics				
		R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
AUDIT										
	1	.35[a]	.12	.10	4.79	.12	6.61	1	48	**.013**
	2	.41[b]	.17	.13	4.72	.05	2.55	1	47	.117
	3	.41[c]	.17	.09	4.82	.00	.05	2	45	.951
STAI-1 (State)										
	1	.13[a]	.02	-.00	10.02	.02	.85	1	48	.362
	2	.34[b]	.12	.08	9.60	.10	5.30	1	47	**.026**
	3	.36[c]	.13	.05	9.74	.01	.31	2	45	.735
STAI-2 (Trait)										
	1	.27[a]	.08	.06	10.24	.07	3.85	1	48	.055
	2	.41[b]	.17	.14	9.80	.10	5.42	1	47	**.024**
	3	.42[c]	.18	.10	9.98	.01	.13	2	45	.875
AX Index										
	1	.19[a]	.04	.02	24.23	.04	1.75	1	48	.192
	2	.40[b]	.16	.12	22.86	.12	6.95	1	47	**.011**
	3	.40[c]	.16	.09	23.35	.00	.02	2	45	.983
Impulse Control										
	1	.032[a]	.001	-.020	3.516	.001	.048	1	48	.828
	2	.40[b]	.16	.12	3.26	.16	8.76	1	47	**.005**
	3	.44[c]	.19	.12	3.27	.03	.91	2	45	.411

Note. *AUDIT* is abbreviated for Alcohol Use Disorders Identification Test, *STAI-1* is abbreviated for State Anxiety, *STAI-2* is abbreviated for Trait Anxiety, *AX Index* is subscales from the STAXI which measures anger expression, and Impulse control measures errors made during the ImPACT test

Discussion

The aim of the study was to explore the neuropsychological, behavioural and emotional outcomes of concussions among field-hockey players with age, sex and history of concussions as predictors. This was achieved by using a range of emotional and behavioural measures as well as the neuropsychological test battery, ImPACT, to investigate the differences across age, sex and history of concussion among the field-hockey players.

Summary of Results

Results showed that the younger field hockey players aged 18 to 29; seem to score higher on most measures, than the older players aged 30 to 42, indicating poorer results. Further, female players tended to score higher than male players on most of the measures. In terms of concussions, those who reported prior concussions scored more poorly than those who reported no prior concussion. Age significantly predicted measures of anxiety, anger expression and impulse control; sex significantly predicted alcohol dependency behaviour; and a history of concussion with a formal diagnosis significantly predicted visual memory scores.

Age. The younger field hockey players (aged 18-29) reported more concussions than the older players (aged 30-42). Research pertaining to the emotional and behavioural outcomes in terms of age in field- hockey players is limited. Age significantly predicted scores for state and trait anxiety (STAI-1 and STAI-2) as well as anger expression (AX Index) and Impulse Control. These findings indicate that the older field-hockey players exhibited less state- and trait- anxiety than the younger players. This finding is consistent with previous research. Brenes (2006) found that “worry” plays less of a prominent role in older people, and thus they also experience anxiety differently. The younger players were more likely to experience intense angry feelings, which

are either more suppressed or expressed than the older players. This finding is in line with past research by Philips et al. (2006) who found that older adults have lower levels of trait-anger and anger expression which might be due to the fact that they were found to experience less emotion in this regard than the younger participants. The current study also found that the older players made less response inhibition errors than the younger players. Past literature regarding the differences in impulse control between older and younger people are limited.

Sex. In terms of significance, Sex only significantly predicted alcohol dependency behaviour scores. The male players only scored higher than the female players on the measure of alcohol dependency. Thus, the male players tend to exhibit more alcohol dependency behaviour than the female players. This finding is consistent with previous literature which found men to consume more alcohol than females (Wilsnack et al., 2009). These patterns of alcohol behaviour between male and females might be due to cultural factors such as the gender roles and stereotypes surrounding alcohol consumption, as well as biological factors (Bobrova et al., 2010; Wilsnack et al., 2009).

History of Concussion. A *Formal Diagnosis* of a concussion was the only factor to significantly predict Visual Memory performance and also only significantly predicted this neuropsychological outcome variable. Covassin et al. (2017) found inconsistent results to that of the current study, finding that only verbal memory and reaction time impairments were present in athletes with two or more prior concussions. However, a range of previous research found similar results to the current study, concluding that previously concussed sports players display poorer memory ability than non-concussed players (Iverson, Gaetz, Lovell and Collins, 2004; Killam, Cautin, & Santucci, 2005).

Limitations and Implications for Future Research

The current study is not without limitations. First, the study utilised self-report measures for collecting emotional/behavioural data as well as the data regarding history of concussion and number of concussions. This poses as a limitation as self-report measures can be unreliable due to the possibility of inaccuracy in recall and participants wanting to report socially desirable responses (Washington et al., 2012). A second limitation of the study is the type of sampling method used. With convenience sampling, there is a possibility of selection bias. Thus, the results drawn from the sample in the study should not be generalized or seen to represent the greater population (Etikan, Musa, & Alkassim, 2016). A third limitation is that the study is retrospective in nature. Retrospective studies are known prone to generate a lot of missed information (Anthonisen, 2009).

Conclusion

The significant findings indicated that age, sex and history of concussion predicted different outcome variables. The finding that a prior formal diagnosis of concussion significantly predicted poorer performance on visual memory tasks suggests that concussions among field-hockey players may result in adverse neuropsychological memory effects. However, sex and age of participants were also significant predictors of important behavioural and emotional outcomes among participants, highlighting the need to consider such demographic factors in determining outcomes. The findings of the current study also raise awareness to the occurrence and effects of concussion in field-hockey and to the importance of concussion management in non-popular sports such as field-hockey. In addition, the findings of the study introduce many avenues for future research including further research of concussions and associated behavioural and emotional outcomes in field-hockey. and associated behavioural and emotional outcomes

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Appendix A

The Alcohol Use Disorders Identification Test: Self-Report Version

Administer if participant has used alcohol within the last year.

PATIENT: Because alcohol use can affect your health and can interfere with certain medications and treatments, it is important that we ask some questions about your use of alcohol. Your answers will remain confidential so please be honest.

Place an X in one box that best describes your answer to each question.

Questions	0	1	2	3	4
1. How often during the last year have you had a drink containing alcohol?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
2. During the last year, how many drinks containing alcohol have you had on a typical day when you are drinking?	1 or 2	3 or 4	5 or 6	7 to 9	10 or more
3. During the last year, how often do you have six or more drinks on one occasion?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
4. How often during the last year have you found that you were not able to stop drinking once you had started?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
5. How often during the last year have you failed to do what was normally expected of you because of drinking?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
6. How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
7. How often during the last year have you had a feeling of guilt or remorse after drinking?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
8. How often during the last year have you been unable to remember what happened the night before because of your drinking?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
9. Have you or someone else been injured because of your drinking?	No		Yes, but not in the last year		Yes, during the last year
10. Has a relative, friend, doctor, or other health care worker been concerned about your drinking or suggested you cut down?	No		Yes, but not in the last year		Yes, during the last year
Total					

Appendix B

DIRECTIONS: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and put an X on the appropriate circle on the right side of this page. Do not spend too much time on any statement. Answer quickly and honestly.

	① Rarely/Never	② Occasionally	③ Often	④ Almost Always/Always
1	I plan tasks carefully.			① ② ③ ④
2	I do things without thinking.			① ② ③ ④
3	I make-up my mind quickly.			① ② ③ ④
4	I am happy-go-lucky.			① ② ③ ④
5	I don't "pay attention."			① ② ③ ④
6	I have "racing" thoughts.			① ② ③ ④
7	I plan trips well ahead of time.			① ② ③ ④
8	I am self controlled.			① ② ③ ④
9	I concentrate easily.			① ② ③ ④
10	I save regularly.			① ② ③ ④
11	I "squirm" at plays or lectures.			① ② ③ ④
12	I am a careful thinker.			① ② ③ ④
13	I plan for job security.			① ② ③ ④
14	I say things without thinking.			① ② ③ ④
15	I like to think about complex problems.			① ② ③ ④
16	I change jobs.			① ② ③ ④
17	I act "on impulse."			① ② ③ ④
18	I get easily bored when solving thought problems.			① ② ③ ④
19	I act on the spur of the moment.			① ② ③ ④
20	I am a steady thinker.			① ② ③ ④
21	I change residences.			① ② ③ ④
22	I buy things on impulse.			① ② ③ ④
23	I can only think about one thing at a time.			① ② ③ ④
24	I change hobbies.			① ② ③ ④
25	I spend or charge more than I earn.			① ② ③ ④
26	I often have extraneous thoughts when thinking.			① ② ③ ④
27	I am more interested in the present than the future.			① ② ③ ④
28	I am restless at the theater or lectures.			① ② ③ ④
29	I like puzzles.			① ② ③ ④
30	I am future oriented.			① ② ③ ④

Appendix C

Roche

V 0477

Beck Depression Inventory

CRTN: _____ CRF number: _____

Page 14 patient inits: _____

Baseline

BDI-II

Date:

Name: _____ Marital Status: _____ Age: _____ Sex: _____

Occupation: _____ Education: _____

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past two weeks, including today**. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness

0 I do not feel sad.
1 I feel sad much of the time.
2 I am sad all the time.
3 I am so sad or unhappy that I can't stand it.

2. Pessimism

0 I am not discouraged about my future.
1 I feel more discouraged about my future than I used to be.
2 I do not expect things to work out for me.
3 I feel my future is hopeless and will only get worse.

3. Past Failure

0 I do not feel like a failure.
1 I have failed more than I should have.
2 As I look back, I see a lot of failures.
3 I feel I am a total failure as a person.

4. Loss of Pleasure

0 I get as much pleasure as I ever did from the things I enjoy.
1 I don't enjoy things as much as I used to.
2 I get very little pleasure from the things I used to enjoy.
3 I can't get any pleasure from the things I used to enjoy.

5. Guilty Feelings

0 I don't feel particularly guilty.
1 I feel guilty over many things I have done or should have done.
2 I feel quite guilty most of the time.
3 I feel guilty all of the time.

6. Punishment Feelings

0 I don't feel I am being punished.
1 I feel I may be punished.
2 I expect to be punished.
3 I feel I am being punished.

7. Self-Dislike

0 I feel the same about myself as ever.
1 I have lost confidence in myself.
2 I am disappointed in myself.
3 I dislike myself.

8. Self-Criticalness

0 I don't criticize or blame myself more than usual.
1 I am more critical of myself than I used to be.
2 I criticize myself for all of my faults.
3 I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes

0 I don't have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.

10. Crying

0 I don't cry anymore than I used to.
1 I cry more than I used to.
2 I cry over every little thing.
3 I feel like crying, but I can't.

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Subtotal Page 1

Continued on Back

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NR15645

11. Agitation

0 I am no more restless or wound up than usual.

1 I feel more restless or wound up than usual.

2 I am so restless or agitated that it's hard to stay still.

3 I am so restless or agitated that I have to keep moving or doing something.

12. Loss of Interest

0 I have not lost interest in other people or activities.

1 I am less interested in other people or things than before.

2 I have lost most of my interest in other people or things.

3 It's hard to get interested in anything.

13. Indecisiveness

0 I make decisions about as well as ever.

1 I find it more difficult to make decisions than usual.

2 I have much greater difficulty in making decisions than I used to.

3 I have trouble making any decisions.

14. Worthlessness

0 I do not feel I am worthless.

1 I don't consider myself as worthwhile and useful as I used to.

2 I feel more worthless as compared to other people.

3 I feel utterly worthless.

15. Loss of Energy

0 I have as much energy as ever.

1 I have less energy than I used to have.

2 I don't have enough energy to do very much.

3 I don't have enough energy to do anything.

16. Changes in Sleeping Pattern

0 I have not experienced any change in my sleeping pattern.

1a I sleep somewhat more than usual.

1b I sleep somewhat less than usual.

2a I sleep a lot more than usual.

2b I sleep a lot less than usual.

3a I sleep most of the day.

3b I wake up 1–2 hours early and can't get back to sleep.

17. Irritability

0 I am no more irritable than usual.

1 I am more irritable than usual.

2 I am much more irritable than usual.

3 I am irritable all the time.

18. Changes in Appetite

0 I have not experienced any change in my appetite.

1a My appetite is somewhat less than usual.

1b My appetite is somewhat greater than usual.

2a My appetite is much less than before.

2b My appetite is much greater than usual.

3a I have no appetite at all.

3b I crave food all the time.

19. Concentration Difficulty

0 I can concentrate as well as ever.

1 I can't concentrate as well as usual.

2 It's hard to keep my mind on anything for very long.

3 I find I can't concentrate on anything.

20. Tiredness or Fatigue

0 I am no more tired or fatigued than usual.

1 I get more tired or fatigued more easily than usual.

2 I am too tired or fatigued to do a lot of the things I used to do.

3 I am too tired or fatigued to do most of the things I used to do.

21. Loss of Interest in Sex

0 I have not noticed any recent change in my interest in sex.

1 I am less interested in sex than I used to be.

2 I am much less interested in sex now.

3 I have lost interest in sex completely.

3456789011 12 ABCDE

_____ Subtotal Page 2

_____ Subtotal Page 1

_____ Total Score

Appendix D

The scaled GHQ

GENERAL HEALTH QUESTIONNAIRE

Please read this carefully:

We should like to know if you have had any medical complaints, and how your health has been in general, *over the past few weeks*. Please answer ALL the questions on the following pages simply by underlining the answer which you think most nearly applies to you. Remember that we want to know about present and recent complaints, not those that you had in the past.
It is important that you try to answer ALL the questions.
Thank you very much for your cooperation.

HAVE YOU RECENTLY:

A1.	Been feeling perfectly well and in good health?	Better than usual	Same as usual	Worse than usual	Much worse than usual
A2.	Been feeling in need of a good tonic?	Not at all	No more than usual	Rather more than usual	Much more than usual
A3.	Been feeling run down and out of sorts?	Not at all	No more than usual	Rather more than usual	Much more than usual
A4.	Felt that you are ill?	Not at all	No more than usual	Rather more than usual	Much more than usual
A5.	Been getting any pains in your head?	Not at all	No more than usual	Rather more than usual	Much more than usual
A6.	Been getting a feeling of tightness or pressure in your head?	Not at all	No more than usual	Rather more than usual	Much more than usual
A7.	Been having hot or cold spells?	Not at all	No more than usual	Rather more than usual	Much more than usual
B1.	Lost much sleep over worry?	Not at all	No more than usual	Rather more than usual	Much more than usual
B2.	Had difficulty in staying asleep once you are off?	Not at all	No more than usual	Rather more than usual	Much more than usual
B3.	Felt constantly under strain?	Not at all	No more than usual	Rather more than usual	Much more than usual
B4.	Been getting edgy and bad-tempered?	Not at all	No more than usual	Rather more than usual	Much more than usual
B5.	Been getting scared or panicky for no good reason?	Not at all	No more than usual	Rather more than usual	Much more than usual
B6.	Found everything getting on top of you?	Not at all	No more than usual	Rather more than usual	Much more than usual
B7.	Been feeling nervous and strung-up all the time?	Not at all	No more than usual	Rather more than usual	Much more than usual
C1.	Been managing to keep yourself busy and occupied?	More so than usual	Same as usual	Rather less than usual	Much less than usual
C2.	Been taking longer over the things you do?	Quicker than usual	Same as usual	Longer than usual	Much longer than usual
C3.	Felt on the whole you were doing things well?	Better than usual	About the same	Less well than usual	Much less well
C4.	Been satisfied with the way you've carried out your task?	More satisfied	About same as usual	Less satisfied than usual	Much less satisfied
C5.	Felt that you are playing a useful part in things?	More so than usual	Same as usual	Less useful than usual	Much less useful
C6.	Felt capable of making decisions about things?	More so than usual	Same as usual	Less so than usual	Much less capable
C7.	Been able to enjoy your normal day-to-day activities?	More so than usual	Same as usual	Less so than usual	Much less than usual
D1.	Been thinking of yourself as a worthless person?	Not at all	No more than usual	Rather more than usual	Much more than usual
D2.	Felt that life is entirely hopeless?	Not at all	No more than usual	Rather more than usual	Much more than usual
D3.	Felt that life isn't worth living?	Not at all	No more than usual	Rather more than usual	Much more than usual
D4.	Thought of the possibility that you might make away with yourself?	Definitely not	I don't think so	Has crossed my mind	Definitely have
D5.	Found at times you couldn't do anything because your nerves were too bad?	Not at all	No more than usual	Rather more than usual	Much more than usual
D6.	Found yourself wishing you were dead and away from it all?	Not at all	No more than usual	Rather more than usual	Much more than usual
D7.	Found that the idea of taking your own life kept coming into your mind?	Definitely not	I don't think so	Has crossed my mind	Definitely has

A ☐ B ☐ C ☐ D ☐ TOTAL ☐

Appendix E

Appendix E: Composite Scores of the ImPACT (Schatz et al., 2006)

Composite Score	Contributing scores
Verbal Memory	Word Memory (learning and delayed), Symbol Match memory score Three Letters Memory score
Visual Memory	Design Memory (learning and delayed) X's and O's percent correct
Reaction Time	X's and O's (average counted correct reaction time), Symbol Match (average weighted reaction time for correct responses), Colour Match (average reaction time for correct response)
Visual Motor Processing Speed	X's and O's (average correct distracters), Symbol Match (average correct responses) Three letters (number of correct numbers correctly counted)
Impulse Control	X's and O's (number of incorrect distracters) Colour Match (number of errors)

Appendix F

UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone (021) 650 3417
Fax No. (021) 650 4104

11 June 2018

Zahra Dollie
Department of Psychology
University of Cape Town
Rondebosch 7701

Dear Zahra

I am pleased to inform you that ethical clearance has been given by an Ethics Review Committee of the Faculty of Humanities for your study, *The neuropsychological effects of concussions among field hockey players*. The reference number is PSY2018-037.

I wish you all the best for your study.

Yours sincerely

University of Cape Town
PSYCHOLOGY DEPARTMENT
Upper Campus
Rondebosch

Lauren Wild (PhD)
Associate Professor
Chair: Ethics Review Committee

Appendix G

Department of Psychology

Consent Form

Neuropsychological effects of concussions among field-hockey players

Literature has shown that sports-related concussions may produce adverse neuropsychological outcomes, especially in high-intensity sports. The prevalence and severity of neuropsychological outcomes have also been shown to differ significantly between male and female hockey players.

You are invited to participate in this research regarding neuropsychological outcomes of sports-related concussions in field-hockey.

Sample:

56 field-hockey players from Central Hockey Club.

Exclusion Criteria: Players below the age of 18 and players above 40, non-English Speaking players, and players with a previous or present neurological disorder

Procedure:

You will be completing 7 assessment tools, listed below by name, which measures: alcohol behaviour, impulsiveness, depression, health, mood states, anger, anxiety and cognition. Six of the measures are hand-outs, which will be distributed to all players taking part; and thus, needs to be returned. One assessment is a computerized test, and needs to be done using a computer.

The testing will be done at Central Hockey Club, during a practice session, and at the UCT ACSENT Lab, on an allocated day which is convenient for most players.

Benefits and Risks:

There are minimal risks associated with this research. The only concern is the length of the testing session (60-90 minutes), but refreshments will be provided during the break.

Participation:

I volunteer to participate in a research project conducted by Zahra Dollie from the University of Cape Town (UCT). I understand that the project is designed to gather information about neuropsychological effects of concussion among field-hockey players. I will be one of approximately 56 players taking part in this research.

I understand that:

1. My participation in this research thesis is voluntary and that I will not be paid for my participation. I may withdraw from the research at any time without penalty.
2. My participation involves the completion of 7 assessment and tools, of which are: the Alcohol Use Disorders Identification Test (AUDIT), Barratt Impulsiveness Scale (BIS-11), Beck Depression Inventory – Second Edition (BDI-II), General Health Questionnaire (GHQ-28), State-Trait Anger Expression Inventory (STAXI), State-Trait Anxiety Inventory (STAI), and the Cognitive Testing (ImPACT). The completion of the assessments will take about 90 minutes, and will occur at Central Hockey Club and UCT ASCENT laboratory.
3. The researcher will not identify me by name in any analysis of the results and information obtained from the assessments. My confidentiality and anonymity in this study will remain secure and safe.

I have read and understood the explanation provided to me, and the expectations of me as a participant. I voluntarily agree to participate in this research.

_____ _____

My Signature Date

_____ _____

Name Signature of the Researcher

Appendix H

Table 9

Number of Concussions across Sex

	N	
Male	6	
Female	6	
Total		**12**

Appendix I

Table 10

Model Summary for Significant Outcome Variables

Model						Change Statistics				
		R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
BIS - 2										
	1	.122[a]	0.02	-0.01	10.14	0.02	0.72	1	48	.400
	2	.162[b]	0.03	-0.02	10.19	0.01	0.55	1	47	.464
	3	.205[c]	0.04	-0.04	10.33	0.02	0.38	2	45	.689
BDI - 2										
	1	.212[a]	0.05	0.03	7.98	0.05	2.25	1	48	.140
	2	.267[b]	0.07	0.03	7.95	0.03	1.34	1	47	.254
	3	.279[c]	0.08	0.00	8.09	0.01	0.17	2	45	.847
GHQ - 28										
	1	.166[a]	0.03	0.01	11.32	0.03	1.35	1	48	.251
	2	.193[b]	0.04	0.00	11.38	0.01	0.49	1	47	.488
	3	.195[c]	0.04	-0.05	11.63	0.00	0.01	2	45	.989
Anger (State)										
	1	.033[a]	0.00	-0.02	16.41	0.00	0.05	1	48	.821
	2	.053[b]	0.00	-0.04	16.57	0.00	0.08	1	47	.778
	3	.225[c]	0.05	-0.03	16.52	0.05	1.14	2	45	.330
Anger (Trait)										
	1	.060[a]	0.00	-0.02	27.83	0.00	0.17	1	48	.681
	2	.075[b]	0.01	-0.04	28.10	0.00	0.10	1	47	.758
	3	.092[c]	0.01	-0.08	28.67	0.00	0.06	2	45	.938
Symptom Score										
	1	.238[a]	0.06	0.04	16.54	0.06	2.89	1	48	.096
	2	.249[b]	0.06	0.02	16.67	0.01	0.27	1	47	.605
	3	.282[c]	0.08	0.00	16.87	0.02	0.43	2	45	.656
Verbal Memory										

Table ctd.

Model Summary for Significant Outcome Variables

	1	.230[a]	0.05	0.03	10.18	0.05	2.68	1	48	.108
	2	.233[b]	0.05	0.01	10.28	0.00	0.06	1	47	.806
	3	.264[c]	0.07	-0.01	10.42	0.02	0.38	2	45	.688
Visual Memory										
	1	.141[a]	0.02	0.00	16.68	0.02	0.97	1	48	.330
	2	.218[b]	0.05	0.01	16.61	0.03	1.36	1	47	.249
	3	.373[c]	0.14	0.06	16.14	0.09	2.39	2	45	.103
Visual Motor Processing Speed										
	1	.189[a]	0.04	0.02	8.41	0.04	1.78	1	48	.188
	2	.194[b]	0.04	0.00	8.49	0.00	0.09	1	47	.765
	3	.264[c]	0.07	-0.01	8.54	0.03	0.78	2	45	.467
Reaction Time										
	1	.237[a]	0.06	0.04	0.12	0.06	2.87	1	48	.097
	2	.262[b]	0.07	0.03	0.12	0.01	0.63	1	47	.431
	3	.275[c]	0.08	-0.01	0.12	0.01	0.17	2	45	.844

Appendix J

Table 11
Regression Coefficient for Outcome variables

Model		B	Std. Error	Beta	t	Sig.	Confidence Levels	
							Lower Bound	Upper Bound
AUDIT		5.18	3.54		1.47	.150	-1.94	12.30
	Sex	-3.46	1.37	-.35	-2.53	**.015***	-6.22	-.35
	Age	.16	.10	.21	1.57	.124	-.05	.22
	With Formal Diagnosis	.42	1.87	.03	.23	.822	-3.34	.02
	Without Formal Diagnosis	.71	2.90	.03	.25	.808	-5.13	-.01
BIS		58.08	7.58		7.66	.000	42.81	73.35
	Sex	2.58	2.94	.13	.88	.385	-3.34	8.50
	Age	-.16	.22	-.11	-.73	.467	-.60	.28
	With Formal Diagnosis	-2.71	4.01	-.10	-.68	.502	-10.79	5.36
	Without Formal Diagnosis	-3.81	6.22	-.09	-.61	.543	-16.33	8.71
BDI		10.36	5.94		1.74	.088	-1.61	22.33
	Sex	3.37	2.30	.21	1.46	.150	-1.27	8.01
	Age	-.19	.17	-.16	-1.13	.264	-.54	.15
	With Formal Diagnosis	-1.78	3.14	-.08	-.57	.575	-8.11	4.55
	Without Formal Diagnosis	-.87	4.87	-.03	-.18	.860	-10.68	8.95
GHQ		17.18	8.54		2.01	.050	-.03	34.38
	Sex	3.63	3.31	.16	1.10	.279	-3.04	10.29
	Age	-.17	.25	-.10	-.68	.500	-.66	.33
	With Formal Diagnosis	-.31	4.52	-.01	-.07	.945	-9.41	8.78
	Without Formal Diagnosis	.87	7.00	.02	.12	.902	-13.24	14.97
STAI – 1 (State)		41.76	7.15		5.84	.000	27.35	56.17
	Sex	2.31	2.77	.12	.83	.410	-3.28	7.89
	Age	-.47	.21	-.32	-2.27	**.028***	-.89	-.05
	With Formal Diagnosis	2.87	3.78	.11	.76	.452	-4.75	10.49

Table ctd.

Regression Coefficient for Outcome variables

	Without Formal Diagnosis	1.74	5.87	.04	.30	.768	-10.08	13.56
STAI – 2 (Trait)		42.19	7.33		5.76	.000	27.43	56.96
	Sex	5.51	2.84	.26	1.94	.059	-.21	11.23
	Age	-.49	.21	-.31	-2.29	**.027***	-.91	-.06
	With Formal Diagnosis	1.83	3.88	.06	.47	.639	-5.98	9.64
	Without Formal Diagnosis	-.93	6.01	-.02	-.16	.878	-13.04	11.18
Anger (State)		55.62	12.13		4.59	.000	31.19	80.06
	Sex	-.65	4.70	-.02	-.14	.891	-10.12	8.82
	Age	-.11	.35	-.05	-.32	.752	-.82	.59
	With Formal Diagnosis	5.25	6.42	.12	.82	.417	-7.67	18.17
	Without Formal Diagnosis	-11.61	9.95	-.17	-1.17	.249	-31.64	8.43
Anger (Trait)		33.47	21.05		1.59	.119	-8.93	75.88
	Sex	3.08	8.16	.06	.38	.708	-13.36	19.51
	Age	-.19	.61	-.05	-.31	.761	-1.41	1.04
	With Formal Diagnosis	3.96	11.13	.05	.36	.724	-18.46	26.39
	Without Formal Diagnosis	1.30	17.26	.01	.08	.940	-33.47	36.07
AX Index (Anger Expression)		63.24	17.14		3.69	.001	28.71	97.77
	Sex	8.53	6.64	.18	1.28	.206	-4.85	21.92
	Age	-1.28	.50	-.35	-2.58	**.013***	-2.27	-.28
	With Formal Diagnosis	-1.44	9.07	-.02	-.16	.874	-19.70	16.82
	Without Formal Diagnosis	1.12	14.06	.01	.08	.937	-27.19	29.44
Symptom Score		7.22	12.39		.58	.563	-17.74	32.17
	Sex	8.30	4.80	.25	1.73	.091	-1.37	17.97
	Age	-.19	.36	-.08	-.53	.597	-.91	.53
	With Formal Diagnosis	-.37	6.55	-.01	-.06	.955	-13.57	12.83
	Without Formal Diagnosis	-9.36	10.16	-.13	-.92	.362	-29.82	11.10

Table ctd.

Regression Coefficient for Outcome variables

Verbal Memory		74.49	7.65		9.73	.000	59.07	89.90
	Sex	4.53	2.97	.22	1.53	.134	-1.45	10.50
	Age	.06	.22	.04	.26	.794	-.39	.50
	With Formal Diagnosis	-.85	4.05	-.03	-.21	.835	-9.00	7.30
	Without Formal Diagnosis	5.11	s	.12	.81	.420	-7.53	17.75
Visual Memory		88.48	11.85		7.47	.000	64.61	112.355
	Sex	-4.53	4.59	-.14	-.99	.329	-13.78	4.72
	Age	-.40	.34	-.16	-1.18	.244	-1.09	.29
	With Formal Diagnosis	-13.71	6.27	-.31	-2.19	**.034***	-26.34	-1.09
	Without Formal Diagnosis	-2.28	9.72	-.03	-.23	.816	-21.85	17.30
Visual Motor Processing Speed		39.50	6.27		6.30	.000	26.88	52.13
	Sex	-3.37	2.43	-.20	-1.39	.172	-8.27	1.52
	Age	.06	.18	.05	.33	.744	-.31	.42
	With Formal Diagnosis	-1.78	3.31	-.08	-.54	.593	-8.46	4.89
	Without Formal Diagnosis	5.42	5.14	.15	1.06	.297	-4.93	15.78
Reaction Time		.52	.09		5.94	.000	.34	.70
	Sex	.06	.03	.25	1.71	.093	-.01	.13
	Age	<.001	<.001	.110	.77	.447	-.00	.01
	With Formal Diagnosis	.01	.05	.036	.25	.805	-.08	.11
	Without Formal Diagnosis	-.04	.07	-.072	-.50	.621	-.18	.11
Impulse Control		10.02	2.40		4.18	.000	5.19	14.86
	Sex	-.35	.93	-.051	-.38	.708	-2.23	1.52
	Age	-.21	.07	-.397	-2.96	**.005***	-.35	-.07
	With Formal Diagnosis	1.70	1.27	.180	1.34	.188	-.86	4.25
	Without Formal Diagnosis	.63	1.97	.044	.32	.749	-3.33	4.60