"Feeling Foggy?"
An Investigation into the Self-Reported Post-Concussive Symptoms In Rugby Union Players at University Level

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ABSTRACT

A study was conducted on the self-reported symptoms of Mild Traumatic Brain Injury sustained in Rugby Union at the pre- and post-season stages. A full sample of 30 rugby players at Rhodes University was compared to 27 non-contact sport controls. A reduced sample of 20 rugby players and 9 control participants provided improved control for education and IQ and was compared. Measures included the WAIS-III Vocabulary and Picture Completion Sub-tests to estimate IQ level, the symptom checklist on a widely used computer-based program (ImPACT), and a paper and pencil self-report 31-Item Post-Concussion Symptom Questionnaire. Independent and Dependent T-Test comparisons were conducted on the full and reduced samples. The symptoms reported by the rugby group appeared to be more pronounced on both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire when compared to the control group at both the pre-and post-season stages. It was concluded that the rugby players demonstrated evidence to support the hypothesis of having sustained more previous concussions and reporting more symptoms at the pre-season stage when compared to comtrol participants. No prevalent changes for either the rugby or control groups were seen in dependent comparisons from pre-to post-season.

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1. INTRODUCTION

"No head injury is too trivial to ignore"
(Hippocrates 460-377 BC, in King, 2003).

The aim of this research is to contribute to the growing literature which deals with sports-related Mild Traumatic Brain Injury (MTBI), typically referred to as a concussion, and the consequences thereof. Specifically this project focuses on a comparison between the self-reported symptoms of MTBI at the pre- and post-season stages in Rugby Union players at university level versus non-contact sport controls, using a widely used computer-based program and a supplementary Post-Concussion Symptom Questionnaire. Participation in sporting activities and events is often a daily ritual for many children, adolescents and young adults. Contact sports are by their very nature, likely to produce injuries, and this includes head injuries. When assessing athletes who have sustained a concussion, in the acute phase a variety of somatic and cognitive symptoms are spontaneously reported (Iverson, Gaetz, Lovell, & Collins, 2002b). Consequently, pre-season baseline testing is important to establish an athlete's "normal" pre-injury performance and level of functioning. This testing provides a benchmark with which to compare post-concussion recovery (Guskiewicz et.al., 2004). At the pre-season stage, after a break from participation in contact sports, symptoms displayed by sportsmen were interpreted by Iverson, Gaetz, Lovell, and Collins (2002a) to be suggestive of cumulative, lingering effects of multiple concussions. The first section of this thesis therefore sets out to contextualise sports-related MTBI within the realm of head injury in general.

1.1. OPEN AND CLOSED HEAD INJURIES

Head injuries are classified into two types: open and closed. An open or penetrating head injury is commonly caused by a gunshot or exploding shell fragments, and results in tearing of the scalp, penetration or fracture of the skull, and focal laceration of brain tissue (Lezak, 1995). A closed head injury is the result of blunt trauma to the head, causing linear or rotational acceleration of the brain (when a moving object encounters a stationary or slower-moving object), or deceleration (when a moving head and body are impacted upon by a stationary or slower-moving object). Lesions at the coup (the point of impact) and contrecoup (the area opposite

the blow) account for the specific and localised behavioural changes that accompany closed head injuries (Lezak, 1995). Diffuse damage in closed head injuries arises from rotational sheer stresses within the brain (Lishman, 1999). Lezak (1995) notes that sheering or strain due to rotational forces resulting in damage to axons in the brain-stem is the most prominent mechanism of injury in mild head trauma resulting in what is known as a concussive head injury. According to Kohler (2004) concussions may result in intracranial space occupying lesions, impact convulsions and the potential exists that repetitive minor head injuries will result in "chronic brain injury" (p.123). Metabolic autoregulation as a result of an MTBI (characterised by an increased demand for glucose and a reduction in blood flow) may create a vulnerable state within the brain cells (Wojtys et al., 1999). If players return to play prematurely, they run the risk of developing second impact syndrome which was defined by Bowen (2003) as a "rapid cerebral edema and herniation after a second head injury" (p. 288). Closed head injuries may be divided into three categories of severity, namely Mild, Moderate and Severe. Dacey and Dickman (1987) used a Glasgow Coma Scale (GCS) score in isolation to determine the severity of a head injury. A GCS score of less than 8 indicated a severe head injury, a score between 9 and 12 referred to a moderate head injury and a score above 13 suggested a mild head injury. The focus of this research is on mild concussive head injury, a term that is used synonymously with MTBI.

1.2. DEFINITIONS OF MILD TRAUMATIC BRAIN INJURY/CONCUSSION

In the sports arena MTBI tends to be termed 'concussion', a word that has its origin in the Latin verb *concultere*, "to shake violently" (Maroon et al., 2000). Over the past decade, recognition of the potential danger of concussion in the contact sports such as rugby, soccer and football has led to the development of many different concussion management guidelines that have stressed in varying degrees the importance of the presence/absence and duration of different markers of concussion, such as loss of consciousness, amnesia or disorientation (Lovell, Collins, Iverson, Johnson, & Bradley, 2004). Consequently, MTBI may be further subdivided into the subcategories of Mild (Grade 1 concussion); Moderate (Grade 2 concussion) and Severe (Grade 3 concussion). More than 15 grading systems and return-to-play parameters have been published since 1973 to assist team physicians, athletic

trainers and coaches in the evaluation and management of concussion (Collins, Field et al., 2003). Examples include the guidelines proposed by Cantu, the Congress of Neurological Surgeons Guidelines for Cerebral Concussion, the American Academy of Neurology Concussion Grading Scale, and the Colorado Guidelines (Maroon et al., 2000). For illustrative purposes the American Academy of Neurology Concussion Grading Scale (adapted from Maroon et al., 2000) follows in Table 1.1.

Table 1.1:
The American Academy of Neurology Guidelines

Grade	The American Academy of Neurology Guidelines
Grade 1 – Mild	Transient Confusion No Loss of Consciousness Symptoms resolve in less than 15 minutes
Grade 2 – Moderate	Transient Confusion No Loss of Consciousness Symptoms last longer than 15 minutes
Grade 3 - Severe	Any Loss of Consciousness (brief or prolonged)

(Adapted from Maroon et al., 2000)

However, as pointed out by Schatz, Pardini, Lovell, Collins, and Podell (2005), although these grading scales were beneficial, they were not empirically based and the management and return-to-play strategies that were recommended were largely based upon subjective clinical experience rather than on objective research.

In order to discuss concerns regarding concussion diagnosis and management, the First International Conference on Concussion in Sport was held in Vienna in 2001. The Concussion in Sport Group proposed the definition of concussion to be a ‘complex pathophysiological process affecting the brain, induced by traumatic biochemical forces’ (Aubry et al., 2002). In terms of the definition several common features incorporating clinical, pathological and biomechanical injury concepts are used to explain the nature of a concussive head injury, including: (1) Concussion

may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an 'impulsive' force transmitted to the head, (2) concussion typically results in the rapid onset of short-lived impairment of neurological functions that resolves spontaneously, (3) concussion may result in neuropathological changes but the acute clinical symptoms largely reflect functional disturbances rather than structural injury, (4) concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course, (5) concussion is typically associated with grossly normal structural neuroimaging studies (p.6).

McCrory and Johnston (2002) comment on the agreement of the above definition, but point out that no definition is able adequately to reflect the importance of the different post-concussive symptoms.

The Second International Conference of Concussion was held in Prague 2004 (McCrory et al., 2005) here it was decided to endorse the earlier definition of the Vienna Conference, with one important addition: special note was made that, in some cases, post-concussive symptoms may be prolonged or persistent. This most recent definition will be utilised for the purpose of the present research. Despite previous grading scales being criticised and found to be inadequate, a further proposal was introduced at the Prague (2004) Second International Conference of Concussion, which was the sub-division of a concussion into either a simple or complex concussion. (McCrory et al., 2005). It was argued that this sub-division, the parameters of which are summarised in Table 1.2, takes into account prolonged post-concussive symptoms, which prior grading scales had overlooked.

1.3.NEUROPSYCHOLOGICAL OUTCOME FOLLOWING MTBI/CONCUSSION

Concussions may involve immediate (acute) effects as well as long-term (chronic) effects (Grindel, Lovell, & Collins, 2001). Acute effects include the cognitive sequelae, and self-reported symptoms which usually resolve up to three months post-injury. Effects that persist for longer than three months post-injury may be considered chronic and relatively permanent (Barth et al., 1989). Specifically, with regard to post-concussive symptoms (which is the focus of this study), although most individuals reportedly make a complete recovery after a mild head injury, a

Table 1.2:

Classification of a Concussion according to the Prague Conference, 2004

Categorisation of Concussion:	Description:
Simple Concussion	Injury resolves progressively in 0-7 days (without complications)
Complex Concussion	Athletes suffer persistent symptoms for longer than 7 days Specific sequelae (convulsions) Prolonged loss of consciousness Prolonged cognitive impairment

(Adapted from McCrory et al., 2005).

small minority continues to report symptoms for an extended period after injury (Macciocchi, Barth, & Littlefield, 1998). These are frequently termed 'late symptoms' as they are often reported days or weeks after an injury (Ryan & Warden, 2003). Such symptoms are commonly known as *post-concussive symptoms*, and will be discussed in more detail below.

1.4. POST-CONCUSSIVE SYMPTOMS

The post-concussive symptoms associated with head trauma are considered to be among one of the most common and perplexing neuropsychological syndromes (Fox, Lees-Haley, Earnest & Dolezalwood, 1995). The concept of a post-concussive syndrome is in itself controversial, and has been identified in the American Psychiatric Association's (2000) Diagnostic and statistical manual of mental disorders, fourth edition, text revision (DSM-IV-R) as an area for further study for possible inclusion in future manuals. According to the DSM-IV-R (2000), the essential feature of the proposed Post-Concussional Disorder is an acquired impairment in functioning, accompanied by specific neurobehavioural symptoms that occur as a result of a closed head injury of sufficient severity to produce a significant cerebral concussion. As stated in the DSM-IV-R (2000), criteria for the diagnosis of a Post-Concussional Disorder at present include documented cognitive

deficits in either attention or memory. Accompanying the cognitive disturbances, there must be three or more symptoms present for at least three months following the closed head injury (American Psychiatric Association, 2000). These include: becoming fatigued easily; disordered sleep; headache; vertigo or dizziness; irritability or aggression on little or no provocation; anxiety; depression; or affective lability; apathy or lack of spontaneity; and other changes in personality (e.g., social or sexual inappropriateness). The symptoms develop after the head trauma has occurred, or represent a significant worsening of pre-existing symptoms.

Although most clinicians agree that there is a potential constellation of symptoms (Barth, Diamond, & Errico, 1996), the term post-concussive syndrome is used inconsistently in the literature and within clinical settings. It is not clear whether or not such a syndrome exists (McAllister & Arciniegas, 2002). Accordingly, the presence of a specified cluster of symptoms that warrants a diagnosis of a post-concussive syndrome cannot be assumed. Therefore, for the purposes of this research the mere presence or absence of post-concussive symptoms will be the focus of investigation, rather than any attempt to contribute to the debate of whether the presence of particular symptoms supports the concept of the elusive post-concussive syndrome. To facilitate discussion within this thesis, symptoms will be discussed in terms of categories of physical/neurological, cognitive and emotional/behavioural symptoms, as utilised by Shuttleworth-Edwards, Border, Reid & Radloff (2004) when reporting on post-concussive symptoms within the sporting context.

1.5. POST-CONCUSSIVE SYMPTOMS IN THE GENERAL POPULATION

1.5.1. Incidence of Post-Concussive Symptoms

Although much is known about the incidence of traumatic head injury, less is known about the frequency and duration of post-concussive symptoms. (Bohnen & Jolles, 1992). Bohnen and Jolles (1992) reviewed a number of studies whose estimates on the incidence of post-concussive symptoms varied, ranging from 20% to 80%. These discrepancies were considered to be due to differing definitions of mild traumatic brain injury, post-injury time, and the measures used to assess post-concussive symptoms. Binder (1997) states that 8% of individuals who have suffered a mild

head injury experience significant symptoms at one-year post-injury, and that these symptoms are potentially permanent. Although most individuals reportedly make a complete recovery after a head injury, a small minority continues to report symptoms for an extended period after injury (Macciocchi et al., 1998). King (2003) states that a significant number of individuals who suffer a mild head injury experience no discernible symptoms whatsoever, but at least half sustain some post-concussive symptoms. Most recover completely within 3 months post-injury, but approximately one-third have persisting symptoms.

A study conducted by Callaway et al. (1999) examined the incidence and predictors of post-concussive symptoms after minor head injury. A sample of adult patients who presented to an emergency department with transient changes in consciousness and a GCS of 13-15 was compared to a control group of 22 emergency department patients with isolated trauma. Results showed that the mean number of new symptoms was greater in mild head injury patients when compared to control participants. They found post-concussive symptoms to be common, and likely to be associated with objective memory deficits, and also to be more likely in patients suffering from headaches at the emergency department.

According to Bazarian and Atabaki (2000), up to 50% of patients who suffer a minor head injury will develop post-concussive symptoms. Davis (2002) concurs, pointing out that of the two million individuals who suffer a brain injury in the United States annually, over 80% suffer a mild traumatic brain injury. Of these, 50% are at risk for persistent post-concussive symptoms, and 10-15% may suffer post-concussive symptoms for months or years after injury. According to Satz et al. (1999), most patients with a mild traumatic brain injury recover within weeks or months without specific interventions, but approximately 15% of patients still experience disabling symptoms twelve months after injury.

1.5.2. Risk Factors for Post-Concussive Symptoms

Despite much discussion within the literature, there is still controversy regarding the precise aetiology of post-concussive symptom complaints (Fox et al., 1995). Recent studies show that symptoms may be affected by various aspects of the injury (Sotir, 2001). A postal survey conducted by Bohen et al. (1994) indicated that vague

everyday complaints were more prevalent and severe in patients who had suffered an MTBI than in patients who had not suffered an MTBI. It was found that factors increasing the likelihood of developing persisting post-concussive symptoms were: "evidence of pre-existing emotional problems, co-morbidity, neurological complication at the time of the trauma, female sex, orthopaedic fracture, hospitalisation, age, education and intoxication at the time of the trauma" (p.707).

More specifically psychosocial and injury-related factors that have been implicated in the development of persistent post-concussive symptoms include: a previous history of mild traumatic brain injury (Ryan & Warden, 2003; Sotir, 2001; Lishman, 1999), initial injury severity (Iverson, Lovell, & Smith, 2000) and evidence of neurological signs (Ryan & Warden, 2003). The extent of brain damage incurred may be important (Lishman, 1999; Davis, 2002) yet problematic because available technology can not always be expected to detect neuronal loss or focal brain dysfunction (Lishman, 1999). When positive findings do emerge it may be difficult to determine causal relationships to the varied aspects of the clinical presentation. According to Lishman (1999), a head injury is likely to highlight special vulnerabilities within one's personality. It appears likely that specific personality factors will influence the characteristics of post-traumatic disability. There appears to be a greater number of post-concussive symptoms and therefore, an increased risk for post-concussive symptoms among individuals suffering a pre-existing psychiatric disorder. There are high rates of co-morbidity of anxiety and depression symptoms with those reported as post-concussion symptoms (King, 2003). Patients with a prior history or a family history of depression may be at greater risk of developing depressive symptoms after injury (Iverson, Lovell, & Smith, 2000; McAllister & Archiniegas, 2002), although the majority of depressive episodes arise in patients with no such vulnerabilities (McAllister & Archiniegas, 2002).

Lees-Haley and Brown (1993) argue that the litigation process increases the rate of endorsement of various psychological and neuropsychological symptoms through response bias. The increase of symptoms may be attributed to over-reporting, as litigants believe that it will help their case. This is supported by Davis (2002), who found that, at one-week post injury, individuals involved in litigation or who were seeking compensation were at a high risk for post-concussive symptoms. Lishman (1999) notes that litigation can strongly motivate the aggravation and prolongation

of disability. However, Sotir (2001) notes that many patients who develop post-concussion symptoms are not influenced by litigation, and the resolution of legal action does not result in symptom resolution. King (2003) supports this, commenting that, although twice as many patients seeking compensation have post-concussive symptoms when compared with those who are not, few show significant improvement after a settlement. Older age (over age 40) has been implicated as a factor that may be related to the development of post-concussive symptoms (Ryan & Warden, 2003). According to Davis (2002), being female was predictive of post-concussive symptoms one week after injury. This is supported by King (2003) who found a higher prevalence of post-concussion syndrome in women. In addition King (2003) stresses that, when post-concussion symptoms persist, psychological features will entirely account for the symptoms in some individuals, whilst organic or quasi-organic features will entirely account for the symptoms in others.

1.5.3. Outcome studies on Post-Concussive Symptoms

A literature search within the Rhodes University Electronic Information resources on PubMed and PsycARTICLES using various combinations of the keywords ‘mild traumatic brain injury’ and/or ‘concussion’ and/or ‘post-concussive symptoms’ yielded 5 articles that appeared to focus specifically on the presence or absence of post-concussive symptoms following an MTBI in the general population. Additional material was resourced from the internet and reference lists. A summary of the available studies is presented in Appendix A, Table 1.3.

Of the studies reviewed three studies describe symptoms identified in the acute phase following an MTBI (Callaway et al., 1999; Evans, 1996; Kumar et al., 2005) and five studies focus on the chronic sequelae of MTBI (Bohen, Jolles, & Twijnstra, 1992; Chamelain & Feinstein, 2004; Chan, 2002; Mickeviene et al., 2005 ; Necajauskaite, Endiziniene, & Jureniene, 2005). Many studies do not report on specific symptom profiles (Bohen, Jolles, & Twijnstra, 1992; Chan, 2002; Iverson & Lange,2003; Kumar et al., 2005), other studies report on isolated specific symptoms (Callaway et al., 1999; Chamelain & Feinstein, 2004; Chan, 2001; Evans, 1996; Mickeviene et al., 2005 ; Necajauskaite et al., 2005)

Syntheses of specific symptoms which have been noted in the acute phase include a number of physical/neurological symptoms (fatigue, sleep disturbances) cognitive symptoms (problems with memory, concentration, and taking a longer time to think), and emotional or behavioural symptoms (anxiety, irritability and personality changes). Syntheses of specific symptoms which have been noted in the chronic phase include a number of physical/neurological symptoms (headaches, dizziness, fatigue), and emotional/behavioural symptoms (irritability and personality changes). Of note are two studies which looked at post-concussive symptoms in a non-MTBI population (Chan 2001; Iverson & Lange, 2003) that also found the presence of physical/neurological symptoms (fatigue and sleep disturbances) and cognitive symptoms (longer time to think, poor concentration and forgetfulness).

As highlighted by Iverson and Lange (2003), many symptoms which are reported following a concussion are present in the general population. For example, although depression is a common consequence of traumatic brain injury in general, many post-concussive symptoms such as subjective slowing, irritability, fatigue and sleep disturbance may misleadingly suggest an active depressive syndrome, even when individuals do not endorse items such as depressed mood (McAllister & Archiniegas, 2003). It is therefore important to identify post-concussive symptoms separate from symptoms of other psychiatric disorders.

1.6. POST-CONCUSSIVE SYMPTOMS AMONGST THE SPORTS POPULATION

1.6.1 Incidence of Post-Concussive Symptoms on a Sports Population

With reference to the sporting population, it would appear to the researcher that there are no studies which have specifically targeted the incidence of self-reported post-concussive symptoms. Rather the presence of post-concussive symptoms appears to be embedded in the very definition of a concussion within this context, that post-concussive symptoms are indicative of an MTBI. This suggests that post-concussive symptoms are common in the acute phase following a concussion. For example, McCrory and Johnston (2002) state “by its very nature, a concussion is diagnosed by its presenting symptoms” (p.17).

Accordingly at the Second International Conference for Concussion in Prague (McCrory et al., 2005), the Concussion in Sport Group Initiative noted that specifically in the acute phase a number of signs and symptoms might indicate a head injury. These may be clustered into the physical/neurological, cognitive and emotional/behavioural domains as mentioned previously p.6. Physical/neurological symptoms described are headache or pressure in one's head; balance problems or dizziness; nausea; confusion; visual problems like seeing stars; ringing in the ears; fatigue; coordination or balance; gait unsteadiness or loss of balance; slowness in answering questions or follow directions; vomiting; a vacant stare or glassy-eyed look and slurred speech. Cognitive features that were denoted include: feeling "dinged", "foggy", "stunned" or "dazed"; easily distractible or poor concentration and subjective feelings of slowness. Emotional/behavioural signs delineated include: displays of inappropriate emotion (laughing or crying); irritability or emotional changes and personality changes (p.50). It is clear that as stated by McAllister and Archiniegas, (2002) "there is an unquestionable discrepancy between the message typically given to the individual who suffers from a mild traumatic brain injury in the emergency department *'You've had a very mild injury or concussion, you'll be fine…'*) and the reality that these individuals experience" (p.270).

1.6.2. Risk Factors for Post-Concussive Symptoms in a Sports Population

Iverson, Lovell, and Collins (2003a) emphasise that a concussion is a highly individualised injury. They point out that, whilst some athletes experience immediate, pronounced problems, others experience mild problems that resolve quickly (p. 465). Putukain and Echemendia (2003) stress that many of the factors that relate to the athlete's response to injury are dependent on his or her role (or perceived role) within the team. Whether the athlete is a starter versus a back-up or reserve may also change the way that he or she is treated by the medical team and coaching staff, and may in turn determine how much impact their injury will have on the team's success. In addition, the amount of self-identity that the athlete places within his (or her) role as a team player can affect how he (or she) responds to injury. Coping resources that might affect how an athlete handles an injury may include the particular strategies that the athletes employ to cope, as well as the social support that is available to them.

Other risk factors that have been implicated in the development or maintenance of post-concussive symptoms are: “problems with relationships, job or family that cause life changes” (Putukain & Echemendia, 2003, p.619). Further risk factors for athletes as noted by Webbe and Barth (2003) include cumulative concussive and sub-concussive blows, the APOE genotype, age, gender, and a prior history of concussion. Thus personality factors that may influence a response to injury, as noted by Putukain and Echemendia (2003), include competitive trait anxiety, toughness and achievement motivation. A study conducted by Ferguson, Mittenberg, Barone, and Schneider (1999) attempted to examine the role of expectations in the symptom reports of athletes who sustained a MTBI in contact sports. They noted that the symptom increases that were perceived by the MTBI group appeared to be direct results of the expectation that post-concussion symptoms will be experienced following an MTBI.

Many cases of mild head injury in sport are not reported as such an injury might be perceived as a sign of weakness and may result in exclusion or elimination from competitions (Ruchinskas, Francis, & Barth, 1997). According to Lovell (2002), various research studies have suggested that the symptom reporting by athletes is highly inaccurate due to the minimisation of symptoms. Guskiewicz et al. (2003) noted that concussed players are unlikely to sit out unless they are forced to by a physician or a trainer.

1.6.3. Outcome Studies on Post-Concussive Symptoms on a Sports Population

A literature search reveals that there do not appear to be any studies within the sports arena which have attempted to establish the effects of MTBI with specific regard to post-concussive symptoms in players of sports. Many studies have targeted the incidence of MTBI in general in the sporting context, or have focused upon the neuropsychological consequences including both cognitive and post-concussive symptoms. To the authors knowledge there is no review of the studies in sport and their findings with regard to post-concussive symptoms. The present review attempts to isolate those studies which have specifically included post-concussive symptoms as part of the study, for athletes in general, boxing, american football, soccer and rugby union.

Athletes in General

A literature search within the Rhodes University Electronic Information resources on PubMed and PsycARTICLES Using various combinations of the keywords 'mild traumatic brain injury' and/or 'concussion' and/or 'athletes' and/or 'post-concussive' symptoms, a literature search yielded no articles. Additional material resourced from the internet and reference lists yielded eleven articles. A summary of the available studies are presented in Appendix A, Table 1.4.

All eleven of the studies reviewed focus exclusively on acute rather than persistent (chronic) symptoms (Asplund, McKeag & Olsen, 2004; Collins, Field et al., 2003; Collins, Iverson et al., 2003; Erlanger et al., 2003; Field, Collins, Lovell, & Maroon, 2003; Iverson, Gaetz, Lovell & Collins, 2002a; Iverson, Gaetz, Lovell, & Collins, 2002b; Kaut, DePompei, Kerr, & Congeni, 2003; Lovell et al., 2003; Lovell, Collins, Iverson, Johnston & Bradley, 2004, Killam, Cautin, & Santucci, 2005). Many studies do not report on specific symptom profiles (Collins, Iverson et al., 2003; Erlanger et al., 2003; Field et al., 2003; Lovell et al., 2003; Lovell et al., 2004, Killam et al., 2005) other studies report on isolated specific symptoms (Asplund et al., 2004; Collins, Field et al., 2003; Iverson, Gaetz, Lovell & Collins, 2002a; Iverson, Gaetz, Lovell, & Collins, 2002b; Kaut et al., 2003).

In respect of these studies, symptoms which have been noted in the acute phase include a number of physical/neurological symptoms (headaches and dizziness), cognitive symptoms (difficulty concentrating, memory problems, difficulty thinking and feelings of fogginess). All of these are commensurate with post-concussive symptoms reported in the general population, with the exception of feelings of subjective fogginess (Iverson, Gaetz, Lovell, & Collins, 2002b). Aside from the important contribution of noting the prevalence of this symptom in the sports concussion context, Iverson, Gaetz, Lovell, & Collins (2002a) investigated the symptomatic profile for athletes with a history of cumulative (3 or more) concussions, revealing that at the pre-season stage, athletes who had sustained previous concussions reported more post-concussive symptoms than matched control participants. A further contribution by Lovell et al. (2003) was to highlight the incongruence between formal memory testing and the number of self-reported symptoms. They note that this gives rise to some concern, as many sporting

activities rely solely on the self-reports of players and not on objective neuropsychological testing.

Boxing

The nature of boxing includes direct impact, rotational forces and multiple sub-concussive and concussive blows (Barth, 2000). These normal activities in a boxing match place the participant at risk of incurring a head injury. There appear to be no studies which have attempted to establish the effects of MTBI with special regard to the post-concussive symptoms reported by boxers. Rather, many studies have commented on CT scan evidence of cerebral atrophy in professional boxers, and impaired cognitive functions following long boxing careers. A relationship between the incidence of abnormalities and the number of fights has been established, supporting the evidence of cognitive dysfunction as a result of cumulative head injury (Barth et al., 1989; Butler, Forsyth, Beverley, & Adams, 1993). The terms *punch drunk*, *chronic boxer encephalopathy*, *traumatic boxer's encephalopathy*, and *dementia pugilistica* have been used to describe the long-term or severe effects in some boxers (Barth, 2000; Ruchinskas et al., 1997).

Ruchinskas et al., (1997) have described the symptoms of punch-drunkenness as tending to occur in three stages, comprising elements that fall within each of the physical/neurological, cognitive and emotional/behavioural domains. The first disturbances that appear are physical disturbances (co-ordination), and emotional/behavioural changes (affect and emotion). These may be followed by physical problems such as dysarthia (speech problems) and a tendency to tremor. Finally the boxer may experience further physical/neurological symptoms (difficulty in hearing, increased tremors, worsening co-ordination) and cognitive symptoms (a decreased ability to think clearly, and memory problems). Further in accordance with Ruchinskas et al., (1997) description, these changes may occur in conjunction with the emotional/behavioural disturbances (changes in personality and decreased social skills).

American Football

Vigorous body contact has always occurred in American Football, but in spite of wearing helmets that provide both padding and a suspension system, the athlete is not completely protected as the mechanism of most MTBI's is the sudden deceleration combined with rotation of the players head (Wilberger, 1988). The type and severity of injury in American Football appears to be directly related to the number and recency of previous blows to the head or acceleration/deceleration injuries (Barth et al., 1989). Despite many studies, whenever the presence of post-concussive symptoms as a general phenomenon is mentioned, a specific breakdown of these symptoms are usually not described in detail. A literature search within the Rhodes University Electronic Information resources on PubMed and PsycARTICLES using various combinations of the keywords 'mild traumatic brain injury', and/or 'concussion' and/or 'american football', and/or 'post-concussive symptoms' yielded 1 article that appeared to focus specifically on the presence or absence of post-concussive symptoms following an MTBI in American Football. Additional material was resourced from the internet and reference lists yielding two articles. A summary of the available studies are presented in Appendix A, Table 1.5.

All three of the studies reviewed focus exclusively on acute rather than persistent symptoms (Collins, Grindel, Lovell, et. al., 1999; Pellman, Powell, et. al., 2004; Pellman, Viano, Casson, Arfken, & Powell, 2004). One study does not report on specific symptom profiles (Collins, Grindel, Lovell, et. al., 1999), but merely indicates that generally there is an increase in post-concussive symptoms in particular associated with a history of concussion. It was noted that a non-verifiable, self-reported history of concussion, and the self-reporting of concussions during the season may have resulted in the under reporting of post-concussive symptoms. Two other studies report on a profile of symptoms (Pellman, Powell, et. al., 2004; Pellman, Viano et al., 2004). A synthesis of symptoms noted in the acute phase include a number of physical/neurological symptoms (headaches, dizziness, blurred vision, double vision, photophobia and fatigue) and cognitive symptoms (memory problems and cognitive problems).

Soccer

Head injuries in soccer tend to occur either though impact with another object (e.g. foot, elbow, head, ground or goalpost) resulting in an acute injury, or through repetitive minor head injuries caused by heading the ball resulting in chronic injury (Jordan, Green, Galanty, Mandelbaum, & Jabour, 1996). A literature search within the Rhodes University Electronic Information resources on PubMed and PsycARTICLES using various combinations of the keywords 'mild traumatic brain injury', and/or 'concussion', and/or 'soccer', and/or 'post-concussive symptoms' yielded no articles that appeared to focus specifically on the presence or absence of post-concussive symptoms following an MTBI in soccer players. Additional Material was resourced from the internet and reference lists yielding four articles. A summary of the available studies are presented in Appendix A, Table 1.6.

Of the four studies reviewed two studies describe symptoms identified in the acute phase following an MTBI (Barnes et al., 1998; Putukain, Echemendia, & Mackin, 2000), and one study focuses on the chronic sequelae of MTBI (Jordan et al., 1996). In addition, one study examined both the acute and chronic symptoms following an MTBI (Tysvaer & Stoli, 1981). One study does not examine specific symptom profiles (Putukain, et al., 2000) other studies report on specific symptoms (Barnes et al., 1998; Jordan et al., 1996). A synthesis of symptoms which have been noted in the acute phase include a number of physical/neurological symptoms (headaches, being dazed, dizziness, neck pain, insomnia, and difficulty hearing), cognitive symptoms (weakened memory) and emotional or behavioural symptoms (irritability). Two studies do not report on specific symptom profiles (Jordan et al., 1996; Putukain et al., 2000) but indicated that generally post-concussive symptoms did not correlate with the number of times that a soccer player headed the ball.

Rugby Union

Due to bodily collisions Rugby Union is classified as one of the world's most dangerous sports (Hillis, McIntyre, Maclean, Goodwin, & McKenna, 1994; Wekesa, Asembo, & Njororai, 1996) and is considered to be one of the sports with the highest dynamic and static demands (Hillis et al., 1994). Rugby Union accounts for the highest rate of sports-related brain injury in New Zealand. In one season of New Zealand club rugby, 30% of players reported at least one Central Nervous System-related head injury (Willis & Leathem, 2001). Rugby Union appears to be more

dangerous than American Football, Rugby League and Australian Rules Football. It is also the most susceptible to concussion (Shuttleworth-Edwards et al., 2004).

Despite being one of the most dangerous sports, there is limited published research which has targeted the effects of concussion amongst rugby players, or specifically targeted post-concussive symptoms. A literature search within the Rhodes University Electronic Information resources on PubMed and PsycARTICLES using various combinations of the keywords 'mild traumatic brain injury', and/or 'concussion', and/or 'rugby', and/or 'post-concussive symptoms' yielded no articles that appeared to focus specifically on the presence or absence of post-concussive symptoms following an MTBI in the general population. Additional material was resourced from the internet and reference lists. There appear to be two studies on Rugby Union available for the purposes of this review (Shuttleworth-Edwards et al., 2004; Shuttleworth-Jordan, Puchert, & Balarin, 1993). A summary in respect of these studies their outcome on post-concussive symptoms is presented in Appendix A, Table 1.7.

The first study by Shuttleworth-Jordan et al. (1993) focuses on post-concussive symptoms identified in the acute phase following an MTBI. This study which was conducted using university students tracked the profile of post-concussive symptoms amongst concussed players until the end of the rugby season. A synthesis of symptoms been noted by the researchers include a number of physical/neurological symptoms (headaches, visual problems, insomnia, fatigue, vomiting, restlessness, loss of appetite, sensitivity to noise, weakness of limbs, clumsiness and speech problems) cognitive symptoms (poor attention and concentration) and emotional or behavioural symptoms (anxiety). Findings from this study showed that post-concussive symptoms resolved within three months.

The more recent study by Shuttleworth-Edwards et al. (2004) appears to be the study which provides the most detail, than all other studies reviewed thus far within the sporting population, regarding the chronic post-concussive symptoms following a concussion. For the purposes of this study a 31-Item Post-Concussion Symptom Questionnaire was used at the pre-season stage in an attempt to tap residual (chronic) symptoms, that was clearly sensitive in identifying a cluster of symptoms which may again be divided into the three categories of physical/neurological,

cognitive and emotional/behavioural being utilised in this thesis, as mentioned previously (p. 6). Symptoms noted by these researchers include a number of physical/neurological symptoms (speech problems, sensitivity to noise, clumsiness, fatigue, and sleep difficulties) cognitive symptoms (poor sustained attention and concentration) and emotional or behavioural symptoms (argumentativeness, short temperedness, aggressiveness and becoming easily angered).

This study, despite being the most detailed with regards to post-concussive complaints, appears to be tentative in nature. A greater number of self-reported post-concussive complaints were found in rugby players when compared to controls. However, the same symptoms are not reported across all groups of professional, under 21 and schoolboy rugby players (Refer to Appendix 1, Table 1.7). Furthermore university level players were not targeted within this study. This is clearly a gap in the research literature in respect of Rugby Union and hence was chosen as the target population for the present research.

Summary

Overall, the research on post-concussive symptoms in the sports arena tended to focus on acute outcomes of concussion, although there are a number of isolated studies which focus on the residual effects following a concussion. As noted at the Prague Conference, 2004, generally in either the acute or chronic phase, the presence of post-concussive symptoms is clearly an established consequence of sports concussion (McCrory et al., 2005), comprising symptoms that have been identified after sustaining an MTBI in the general population. These include a number of physical/neurological symptoms (headaches, feeling dazed, dizziness including vertigo, insomnia, difficulty in hearing double vision, photophobia, appetite problems, sleeping difficulties, restlessness, acute sensitivity to noise, clumsiness and slurred speech), cognitive symptoms (difficulty in concentrating, memory difficulties) and emotional/behavioural symptoms (irritability, worry, anxiety, argumentativeness, short-temperedness, aggressiveness, becoming easily angered, and depression).

It is of interest is that ‘subjective feelings of fogginess’ is a symptom that appears to have arisen particularly within the sport-related context and does not appear in

reports of the general population. Either this symptom does not appear in the general population or this is a term coined possibly by athletes who are fit and generally thinking clearly, within the sports arena, being a colloquial term rather than a medical term, in the same way concussion is favoured over MTBI amongst the sport population. Of importance to consider is that athletes are often assessed on-field immediately following an MTBI, whereas in the general population assessment of a head injury usually occurs at the hospital department a few hours following the injury by which time the symptom of subjective feelings of fogginess may have resolved or may not be so prevalent. Of further difference is the potential for over-reporting of symptoms amongst the general population, in particular in cases of litigation (Lees-Hayley & Brown, 1993). This is in contrast to the sporting context where athletes have a tendency to under-report their symptomotology due to a number of factors (see earlier discussion p.12). Despite the problem of the under-reporting of symptoms, it appears that within the sports literature reviewed a substantial number of symptoms have been noted, and this has important implications for the management of sports-related MTBI.

1.7. MANAGEMENT OF SPORTS CONCUSSION

It is important to monitor the symptoms that follow a concussion in order to manage the concussed player accurately. The management of sports related MTBI is controversial and at present there are no universally-accepted recommendations for concussion management (Aubry et al., 2001). The past approach to concussion management has been criticised and a number of management guidelines have been devised such as that by McCrory (2002), and Kohler (2004) which highlight the need for an individualised approach to concussion management (Guskiewicz et.al., 2004). Post-concussion recovery rates vary between individuals (McCrory, 2002; Kohler, 2004). Consequently, differences in individual recovery, together with the demands and risks of a particular sport, need to be taken into account when making the medical decision to return-to-play (McCrory, 2002). More recently, a number of computer-based measures have been developed especially for concussion management in the acute phase (Schirring, 2001). Computer-based programs are both cost-and time-effective as well as reliable, allowing response variability and thus eliminating practice effects (Kohler, 2004; Guskiewicz et al., 2004). A further advantage is ease of administration (Guskiewicz et al., 2004). Programs already in

use include CogSport (originating in Australia), The Concussion Resolution Index (also referred to as HeadMinder) and ImPACT (both from the United States).

Current recommendations discussed at the Second International Conference of Concussion, in Prague 2004 (McCrory et al., 2005) indicated that neuropsychological testing is not required for a simple concussion, but may be necessary for complex concussions. However, researchers have reported that neuropsychological testing is regarded as the most sensitive method for the evaluation of both acute and chronic effects following concussion (McCrea, Kelly, Randolph, Cisler, & Berger, 2002). With specific regards to the tapping of self-reported symptoms, following a concussion, CogSport does not appear to include a symptom checklist and seemingly focuses only on the cognitive outcome following an MTBI. HeadMinder attempts to assess the presence and intensity of self-reported neurophysiologic symptoms. Fourteen post-concussive symptoms are included: headaches, vomiting, dizziness, nausea, fatigue, weakness, sleep problems, difficulty in concentrating, memory problems, irritability, depression, photophobia, diplopia and sensory abnormalities, these appear to be assessed only following a trauma, not at the baseline phase (Erlanger et al., 2002). The ImPACT measure contains a more comprehensive post-concussive symptom scale comprising the 22 symptoms which are incorporated into the program at all testing intervals. The ImPACT measure is utilised in the present study and will be discussed in greater detail below.

1.7.1. ImPACT (Immediate Post-concussion Assessment and Cognitive Testing)

ImPACT in its original version was developed between 1999-2000, and was designed specifically for sports-related concussions. The ImPACT battery is a computer-administered neuropsychological assessment tool that consists of seven individual modules which measure aspects of cognitive functioning (Maroon et al., 2000; Iverson, Gaetz, Lovell & Collins, 2002a; Guskiewicz et al., 2004; Lovell & Collins, 2002a). The ImPACT program may be administered with minimal supervision by a technician, trainer or even someone who is only slightly familiar with the software. It takes 20-25 minutes to complete (Maroon, Field, Lovell, Collins, & Bost, 2002).

The ImPACT Symptom Scale, has 22 symptoms commonly, associated with concussion. These include physical/neurological symptoms (headaches, nausea, vomiting, balance problems, dizziness, fatigue, trouble falling asleep, sleeping more than usual, sleeping less than usual, drowsiness, sensitivity to light, sensitivity to noise, numbness/tingling, and visual problems), cognitive symptoms (feeling slowed down, feeling mentally foggy, difficulty concentrating and difficulty remembering), and emotional/behavioural symptoms (irritability, sadness, and feeling more emotional). This scale was originally developed for use with the Pittsburgh Steelers (a professional American football team) and is now used throughout professional and amateur sports (Iverson, Gaetz, Lovell, & Collins, 2002a; Iverson, Lovell, & Collins, 2003a; Aubry et al., 2002). ImPACT taps into all the symptoms mentioned in section (1.6.3), with the exception of a small cluster of symptoms that have been included on the 31-Item Post-Concussion Symptom Questionnaire (Shuttleworth-Edwards et al., 2004) namely: aggression, language difficulties, restlessness, worry, depression, and anxiety. Of these symptoms: aggression/argumentative behaviour and language difficulties were reported at relatively high frequencies across the professional, under-21 and schoolboy rugby groups in Shuttleworth-Edwards et al. (2004). Despite these omissions, ImPACT, in its recently updated version (Lovell & Collins, 2002b), is clearly the most comprehensive of the three computer-based systems with regard to the post-concussive symptoms following a concussion.

1.8. RATIONALE FOR THE CURRENT RESEARCH

As noted at the Second International Conference for Concussion in Prague (McCrory et al., 2005), in the acute phase a number of signs and symptoms might indicate a head injury, in addition post-concussive symptoms appear to be a common persistent outcome of concussion. However, very few studies have exclusively targeted the outcome in respect of post-concussive symptoms following a concussion within the sports context. It was therefore decided to examine the specific symptom profile in a university rugby player population compared with non-contact-sport controls, making use of what appears to be the most comprehensive of the computer-based systems with regards to self-reported post-concussive symptoms (ImPACT Symptom Scale). This will be combined with the self-reported 31-Item Post-Concussion Symptom Questionnaire, which was found sensitive to the effects of concussion in prior Rugby Union research in rugby players versus non-contact sport controls

(Shuttleworth-Edwards et al., 2004), amongst professional, under-21 and school-boy level rugby union players, omitting the university population.

2. METHODOLOGY

The present study formed part of an ongoing computer-based research study that is investigating the use of the ImPACT program at various levels of play, including the top two Rhodes university rugby teams. The ImPACT test was administered in conjunction with a 31-Item Post-Concussion Symptom Questionnaire, two tests of old acquired knowledge to provide an estimate of IQ (Picture Completion and Vocabulary) and cognitive tests which are sensitive to diffuse damage (Digit Span and the Trail Making Test A and B). The neurocognitive aspects of both ImPACT and the additional cognitive tests form part of a different study. The current study was restricted to the analysis of the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire. The procedure will be reported on with reference to the tests that were used for the purposes of the present study on post-concussive symptoms only.

2.1. PARTICIPANTS

The participants consisted of 30 university athletes from the top two rugby teams at Rhodes University, as well as 17 non-contact sport players who played either cricket or swimming. The control group was recruited via advertisements or word of mouth. Exclusion criteria included individuals who have had a history of substance abuse, a learning disability, a history of having sustained a moderate or severe head injury, a prior neurological disorder or a previously diagnosable psychiatric disorder. On the basis of the exclusion criteria there were no exclusions from the study. In the event of a concussion athletes were referred to the researchers by the rugby coach. Only one player was referred for follow-up testing following a concussion during the 2005 rugby season, and the analysis of the follow-up data for this player forms the basis of a separate study. Three rugby participants did not return for testing at the post-season stage. In addition two control participants were excluded as outliers as their post-concussive symptom score fell greater than three times the inter-quartile range from the third quartile. The final sample at the pre-season comprised a total of N=47 participants, divided into two subgroups of rugby (n=30) and controls (n=17). The final sample at the post-season stage comprised a total of N=44 participants, divided into two subgroups of rugby (n=27) and controls (n=17). See Table 2.1. and Table 2.2. for a summary of the participant's demographic data.

Table 2.1:

Demographic Data of Participants at the Pre-Season Stage on the Full Sample

Pre-Season	Rugby (n=30) Mean (SD)	Control (n=17) Mean (SD)	t-value	p-value
Age	19.93 (1.46)	23.76 (3.70)	-4.092	0.001**
Education	13.27 (1.08)	14.88 (1.76)	-3.430	0.002**
IQ Estimate	10.90• (2.11)	9.85• (2.14)	1.626	0.056
No. of Concussions	1.60 (1.45)	0.47 (0.51)	3.853	0.000~~

Note. • Control for estimated IQ is established on the average of the Picture Completion and Vocabulary Scaled Scores

*** p < .01, two-tailed. ~~ p < .01, one-tailed*

Table 2.2:

Demographic Data of Participants at the Post-Season Stage on the Full Sample

Post-Season	Rugby (n=27) Mean (SD)	Control (n=17) Mean (SD)	t-value	p-value
Age	19.85 (1.46)	23.76 (3.70)	-4.161	0.001**
Education	13.22 (1.09)	14.88 (1.76)	-3.487	0.002**
IQ Estimate •	10.65 (1.74)	9.85 (2.14)	1.349	0.185
No. of Concussions	1.56 (1.50)	0.47 (0.51)	3.446	0.001~~

Note. • Control for estimated IQ is established on the average of the Picture Completion and Vocabulary Scaled Scores

*** p < .01, two-tailed. ~~ p < .01, one-tailed*

Both the pre-season and post-season comparison of the demographic data of participants revealed highly significant differences for age and education, with the control group having a higher mean age and education than the rugby group ($p < 0.01$ in both cases). A highly significant result was also found for number of concussions with rugby having a greater number of concussions, than the control group ($p < 0.01$). The number of concussions rounded to the nearest integer suggests an average of approximately two concussions per rugby player versus zero concussions per control participant. Given the known propensity for the under-reporting of sports concussions, combined with the literature suggesting that multiple concussions may result in lingering, deleterious effects (Iverson, Gaetz, Lovell, & Collins, 2002a), the highly significant difference between the rugby and the control groups for number of concussions is considered have clinical significance. Descriptively the differences in age and education appear relatively small (albeit statistically different). However, it was considered that these differences might have psychosocial influences since the rugby group incorporated a substantial number of first years in contrast to the control group that comprised a substantial number of post-graduate students. Therefore it was decided to examine a more balanced set of samples by reducing the sample. All masters and PhD students were excluded from the control group, as there were no such students in the rugby group. Similarly, all first year students were removed from the rugby group, as there were no first year students in the control group. The final reduced sample at the pre-season comprised a total of N=29 participants, divided into two subgroups of rugby (n=20) and controls (n=9). The final reduced sample at the post-season stage comprised a total of N=44 participants, divided into two subgroups of rugby (n=20) and controls (n=9). The demographic data set of the reduced sample appears in Tables 2.3. and 2.4.

The pre- and post-season comparisons of the demographic data of participants on the reduced sample, revealed a much improved control for age, education and IQ between the rugby group and the control group compared with the full data set, with no significant differences for education and IQ. However, there was still a significant difference for age at the $p < .05$ level, with the control group being approximately 1.5 years older than rugby participants (compared to the difference of approximately four years in the full sample). Since the new groups are well matched

Table 2.3:

Demographic Data of Participants at the Pre-Season Stage on the Reduced Sample

Pre-Season	Rugby (n=20) Mean (SD)	Control (n=9) Mean (SD)	t-value	p-value
Age	20.25 (1.33)	21.78 (1.71)	-2.613	0.015∗
Education	13.65 (0.88)	13.78 (0.83)	-0.369	0.715
IQ Estimate •	10.85 (2.40)	10.11 (2.0)	0.806	0.427
No. of Concussions	1.85 (1.57)	0.78 (0.44)	2.825	0.005~~

Note. • Control for estimated IQ is established on the average of the Picture Completion and Vocabulary Scaled Scores.

∗ p < .05, two-tailed. ~~ p < .01, one-tailed

Table 2.4:

Demographic Data of Participants at the Post -Season Stage on the Reduced Sample

Post-Season	Rugby (n=20) Mean (SD)	Control (n=9) Mean (SD)	t-value	p-value
Age	20.18 (1.33)	21.78 (1.72)	-2.638	0.014∗
Education	13.65 (0.86)	13.78 (0.83)	-0.372	0.713
IQ Estimate•	10.44 (1.89)	10.11 (2.00)	0.416	0.681
No. of Concussions	1.82 (1.67)	0.78 (0.44)	2.431	0.013~

Note. • Control for estimated IQ is established on the average of the Picture Completion and Vocabulary Scaled Scores.

∗ p < .05, two-tailed. ~~ p < .01, one-tailed

with regards to education and IQ levels, it is not considered that this small age difference would be of clinical significance. Similar to the full sample, a highly significant difference was found for number of concussions ($p < 0.01$) with the rugby group having a greater number of concussions than the control group. This is considered to be clinically significant (see argument above, p. 31).

2.2. PROCEDURE

Pre-Season

1.Consent from the Head of Sporting Administration at Rhodes University was obtained through an informational interview conducted by the research co-ordinator.

2. At the pre season stage, February 2005, an informational talk was conducted by the three masters students involved in the current research, regarding the importance and validity of the study. An opportunity to ask questions pertaining to the study was provided to the participants regarding the nature of MTBI and the importance and value of neuropsychological testing for return-to-play and concussion management. Each participant was then given a consent form and demographic questionnaire as well as the WAIS-III Picture Completion and Vocabulary sub-tests.

3. Within seven days of the informational talk participants were required to come to the Rhodes Psychology Clinic at a set appointment time where the remainder of the pre-season test battery (comprised of ImPACT, and the 31-Item Post-Concussion Symptom Questionnaire) was administered.

Post-Season

At the post-season stage, September 2005, ImPACT and the 31-Item Post-Concussion Symptom Questionnaire were administered.

2.3.MATERIALS:

2.3.1. Pre-Season Questionnaire: (Appendix B)

The demographic questionnaire consisted of questions relating to important demographic information on age, level of education and current studies as well as sport playing history, previous head injuries, exclusion criteria as delineated above (p. 22) and other personal details.

2.3.2.General Intellectual Functioning

Two tests which are known to be good indicators of premorbid IQ (Lezak, 1995), namely the Vocabulary and Comprehension subtests of the Weschler Intelligence Scale-III (WAIS-III) were administered in a group setting for both the rugby and control groups. It was considered that the same administrative procedure would circumvent standardisation issues. The purpose was not to acquire an IQ level per se, but rather to ensure the matching of rugby and control participants in respect of these tests of old acquired knowledge known to be resistant to the effects of diffuse brain damage.

- ***Vocabulary (Appendix C)***

In the Vocabulary subtest of the SA-WAIS-III, subjects are asked to define 35 words of increasing difficulty (Kaplan & Saddock, 2002). Vocabulary assesses an individual's established knowledge, language development and verbal ability. It correlates highly with general intelligence (Groth-Marnat, 2000). Each word was read aloud and repeated if necessary. Participants were given a numbered answer form and asked to write a comprehensive definition of the word which would illustrate their understanding. Answer sheets were scored and counterchecked by the three masters students involved in the research. Since the test was administered in a group setting there was no discontinue rule and participants had to complete all words presented to the end of the list.

- ***Picture Completion (Appendix D)***

The Picture Completion Subtest of the SA-WAIS-III consists of completing a picture in which a part is missing (Kaplan & Saddock, 2002). Picture Completion assesses visual recognition, visual organization, visual alertness and reasoning abilities. In addition it assesses the subjects ability to differentiate essential from irrelevant stimuli (Groth-Marnat, 2000). Pictures were displayed on a large screen projector and participants were given a numbered answer form and asked to write down or explain the part of the picture which was omitted. Answer sheets were scored and counterchecked by the three masters students involved in the research. Since the test was administered in a group setting there was no discontinue rule and participants had to complete all items presented to the end of the pictures.

2.3.3. ImPACT (Immediate Postconcussion Assessment and Cognitive Testing) Version 3.0

The computerised neuropsychological ImPACT programme, version 3.0 was utilised in the current research. ImPACT 3.0 was released in 2004 and consists of a demographic questionnaire that includes relevant demographic information, as well details on the players medical and concussion history. The test battery consists of six individual modules which encompass several aspects of cognitive functioning which are sensitive to traumatic brain injury as well as a 22-Item Symptom Scale. The ImPACT Symptom Scale includes physical/neurological, cognitive symptoms, and emotional/behavioural symptoms as discussed previously (See p.20). The athlete is asked to choose (via a click of the mouse), the point on the scale, which is graded from 0-6 in terms of severity, that most accurately reflects his or her status with regard to each symptom at that point in time. The computer programme includes automatic scoring of tests and a report is generated which shows a detailed breakdown of scores and overall composite scores (Lovell & Collins, 2002a), that scores for each symptom and the total symptom score. As indicated above only the post-concussion symptom scale composite scores were used in this study. The ImPACT Symptom Scale is used throughout amateur and professional sports and encourages the quantification of the severity of symptoms (Lovell & Collins, 2002a). The scale allows for the tracking of recovery of individual symptoms

throughout the injured players recovery process and may serve as an educational tool to alert the athlete, team staff and parents regarding the presence of post-concussive symptoms (Lovell & Collins, 2002a).

Current research has demonstrated that the neuropsychological test indices and post-concussion symptom scale on ImPACT are sensitive to the changes which may occur following a concussion. These deficits resolve or return to baseline, upon concussion recovery (Schatz et al., 2005, p.4). Validity studies which have been conducted on the ImPACT measure have found the test to be able to distinguish injured from uninjured controls, particularly on the memory composite score and the post-concussion symptom scale (Iverson, Lovell, & Collins, 2002b).

2.3.4. 31-Item Self-Report Post-Concussive Questionnaire: (Appendix E)

For the purpose of this rugby research, a 31-Item Post-Concussive Symptom Questionnaire was used which was modified from a 0-3 Likert scale to a 0-6 Likert Scale as per the ImPACT Symptom Scale. Scoring was conducted by the researcher and counterchecked by other members of the research team. Scores were generated for each symptom (e.g. a rating of 4 for the physical/neurological symptom headache translated into a score of 4 for this symptom) as well as a total symptom score (individual symptom scores were added together to obtain a total score) as per the ImPACT Symptom Scale This questionnaire has been used in prior research by Shuttleworth-Edwards et al. (2004) and includes all the symptoms included in the ImPACT Symptom Scale as well as a cluster of symptoms (aggression, sexual problems, language difficulties, difficulty hearing, restlessness, poor appetite, social withdrawal, depression, and anxiety), which are omitted in the ImPACT Symptom Scale.

2.4. DATA PROCESSING

T-Tests were used to make pre-season and post-season comparisons between the rugby and control groups on both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire. For demographic data a non-directional hypothesis was assumed for age and education between groups (two tailed test of significance), whereas for number of concussions a directional hypothesis was

assumed (one tailed test of significance) in that it was expected that rugby participants would report a greater number of concussions than the control group (Iverson, Gaetz, Lovell, & Collins, 2002a). A directional hypothesis was assumed (one tailed test of significance) for the independent t-tests comparisons between rugby versus controls at the pre- and post-season stages, it was expected that the rugby group would report a higher number of post-concussive symptoms at both the pre- and post-season stages than the control group due to having sustained a greater number of concussive and sub-concussive episodes through participation in sport. A non-directional hypothesis was assumed for the dependent t-test comparisons between the rugby group at pre-season and post-season and similarly for the dependent t-test comparisons of the control group at pre-season and post-season. On these comparisons it was unclear what direction one would expect more post-concussive symptoms. One might expect concussed rugby participants to display more post-concussive symptoms at the post-season stage, but this study excluded concussed players. Although participants might have sustained sub-concussive blows during the season, these would only have been sustained over one season and it was uncertain whether any effects would be evident.

All tests were run with the full data set (termed the full sample) and re-run with the new, reduced data set (termed the reduced sample). Comparative data arising out of these analyses were tabled in respect of the means, standard deviations, t-statistics and significance levels. For list of comparisons see Table 2.5.

Table 2.5:

Statistical Comparisons

Comparison	Table
Rugby versus Controls at the pre-season stage on the ImPACT Symptom Scale	3.1 and 3.5
Rugby versus Controls at the pre-season stage on the 31-Item Post-Concussion Symptom Questionnaire	3.2and 3.6
Rugby versus Controls at the post-season stage on the ImPACT Symptom Scale	3.3 and 3.7
Rugby versus Controls at the post-season stage on the 31-Item Post-Concussion Symptom Questionnaire	3.4 and 3.8
Rugby Pre-Season versus Rugby Post-season on the ImPACT Symptom Scale	3.9 and 3.13
Rugby Pre-Season versus Rugby Post-season on the 31-Item Post-Concussive Symptom Questionnaire	3.10 and 3.14
Controls Pre-Season versus Controls Post-season on the ImPACT Symptom Scale	3.11 and 3.15
Controls Pre-Season versus Controls Post-season on the 31-Item Post-Concussive Symptom Questionnaire	3.12 and 3.16
Summary grid to show significance for individual symptoms for independent and dependent samples, on the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire	3.17 and 3.18

3. RESULTS

Symptoms in the results tables are presented in the order in which they were elicited on the ImPACT Symptom Scale and on the 31-Item Post-Concussion Symptom Questionnaire. Symptoms appearing in the grid summaries are presented in the categories of physical/neurological, cognitive and motional/behavioural symptoms as discussed on p.6.

3.1. INDEPENDENT T-TEST SAMPLES COMPARISONS

3.1.1. Rugby versus Controls on the Full Sample

Results appear together on the pages following the end of the subsection on pages 36-45, Tables 3.1-3.4.

Pre-Season ImPACT Symptom Scale, Full Sample (Table 3.1)

The pre-season comparison of the ImPACT Symptom Scale Score between the rugby and the control groups revealed a highly consistent trend for the rugby participants to report a more pronounced symptom profile than controls, comprising a higher score for rugby participants on 20 of the 22 symptoms and for the total symptom score. Of these, six symptoms were highly significant at the $p < .01$ level (nausea, vomiting, balance problems, dizziness, feeling mentally foggy and visual problems). The total symptom score and six symptoms were significant at the $p < .05$ level (headache, sensitivity to noise, irritability, numbness, feeling slowed down and difficulty in remembering), and one symptom was approaching significance at the $.05 < p < .15$ level (sleeping less). The two symptoms for which there was a tendency towards the control group reporting more than the rugby group (sleeping more and nervousness) were not significant (0.320 and 0.475 respectively).

Pre-Season 31-Item Post-Concussion Symptom Questionnaire, Full Sample (Table 3.2)

The pre-season comparison of the 31-Item Post-Concussion Symptom Questionnaire between the rugby and the control groups revealed a strong trend for the rugby participants to report a more pronounced symptom profile than controls, comprising

a higher score for rugby participants on 19 of the 31 symptoms and the total symptom score. Of these, four symptoms were significant at the $p < .05$ level (nausea, sleeping less than usual, sensitivity to noise and aggression). Five symptoms were approaching significance at the $.05 < p < .15$ level (fatigue or tiredness, drowsiness, sadness, difficulty in remembering and speech problems). Of the eleven symptoms for which there was a tendency towards the control group reporting more than the rugby group one result was highly significant at the $p < .01$ level (anxiety), three symptoms were approaching significance at the $.05 < p < .15$ level (sleeping more, restlessness and sexual problems). It is of note that the symptoms nausea, and a sensitivity to noise were significant for rugby participants on both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire respectively.

Post-Season ImPACT Symptom Scale, Full Sample (Table 3.3)

As at pre-season, the post-season comparison of the ImPACT Symptom Scale Score between the rugby and the control groups revealed a strong trend for the rugby participants to report a more pronounced symptom profile than controls, comprising a higher score for rugby participants including 16 of the 22 symptoms and the total symptom score. Of these, one symptom was highly significant at $p < .01$ (sensitivity to light), and three symptoms were approaching significance at the $.05 < p < 0.15$ level (sleeping less, sensitivity to noise and difficulties in concentrating). The six symptoms for which there was a tendency towards the control group reporting more than the rugby group (balance problems, dizziness, nervousness, feeling more emotional, numbness, and feeling slowed down) were not significant (0.417, 0.473, 0.207, 0.234, 0.306, and 0.340 respectively).

Post-Season 31-Item Post-Concussion Symptom Questionnaire, Full Sample (Table 3.4)

As at pre-season, the post-season comparison of the 31-Item Post-Concussion Symptom Questionnaire between the rugby and the control groups revealed a trend for the rugby participants to report a more pronounced symptom profile than controls, comprising a higher score for rugby participants on 19 of the 31 symptoms and the total symptom score. Of these, three symptoms were significant at the $p <$

.05 level (a sensitivity to light, sensitivity to noise and aggression). Two symptoms were approaching significance at the .05 < p < .15 level (restlessness and difficulties in hearing). Neither the rugby group, nor the control group experienced sexual problems. Of the ten symptoms for which there was a tendency towards the control group, reporting more than the rugby group one symptom was significant at the p < .05 level (feeling slowed down) and two symptoms were approaching significance at the .05 < p < .15 level (dizziness and fatigue). It is of note that the symptom sensitivity to light was significant for rugby participants on both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire respectively at the post-season stage.

3.1.2. Rugby versus Controls on the Reduced Sample

Results appear together on the page following the end of the subsection on pages 48-57, Tables 3.5-3.8.

Pre-Season ImPACT Symptom Scale, Reduced Sample (Table 3.5)

When compared with the pre-season comparisons on the full sample, the pre-season comparison of the ImPACT Symptom Scale on the reduced sample between the rugby and the control groups revealed a greater trend for the rugby participants to report a more pronounced symptom profile than controls, comprising a higher score for rugby participants on 18 of the 22 symptoms and the total symptom score. Of these, four symptoms were highly significant at the p < .01 level (headaches, sensitivity to noise, irritability and visual problems). Four symptoms were significant at the p < .05 level (nausea, vomiting, dizziness and feeling mentally foggy). The total symptom score and five symptoms were approaching significance at the .05 < p < .15 level (balance problems, feeling slowed down, difficulties in concentrating and difficulties in remembering). The four symptoms for which there was a tendency towards the control group reporting more than the rugby group (sleeping more, sleeping less, drowsiness and sensitivity to light) were not significant (0.237, 0.484, 0.286 and 0.370 respectively). It is of note that the symptoms headaches, nausea, vomiting, irritability, sensitivity to noise, visual problems, dizziness and feeling mentally foggy, were significant for rugby participants on the ImPACT Symptom Scale on both the full and reduced sample.

Table 3.1:

Independent T-Tests for Rugby versus Controls at the Pre-Season stage on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=30)	16.07	15.9	2.219	.016*
	Control (n=17)	8.18	8.420		
Headache	Rugby (n=30)	0.63	1.13	2.330	.013*
	Control (n=17)	0.12	0.33		
Nausea	Rugby (n=30)	0.53	1.04	2.804	.005**
	Control (n=17)	0.00	0.00		
Vomiting	Rugby (n=30)	0.23	0.50	2.536	.009**
	Control (n=17)	0.00	0.00		
Balance Problems	Rugby (n=30)	0.37	0.56	2.624	.006**
	Control (n=17)	0.06	0.24		
Dizziness	Rugby (n=30)	0.60	1.19	2.757	.005**
	Control (n=17)	0.00	0.00		
Fatigue	Rugby (n=30)	1.37	1.54	0.687	.248
	Control (n=17)	1.06	1.35		
Insomnia	Rugby (n=30)	1.03	1.10	0.779	.220
	Control (n=17)	0.76	1.20		
Sleeping More	Rugby (n=30)	0.50	0.86	-0.472	.320
	Control (n=17)	0.65	1.2		
Sleeping Less	Rugby (n=30)	1.37	1.351	1.330	.095~
	Control (n=17)	0.82	1.33		
Drowsiness	Rugby (n=30)	0.80	1.22	0.263	.397
	Control (n=17)	0.71	1.11		
Sensitivity to Light	Rugby (n=30)	0.73	1.14	0.363	.359
	Control (n=17)	0.59	1.58		
Sensitivity to Noise	Rugby (n=30)	0.37	0.67	3.003	.003*
	Control (n=17)	0.00	0.00		

Continued p.37

Table 3.1 (continued)

Irritability	Rugby (n=30)	1.03	1.25	1.966	.028*
	Control (n=17)	0.47	0.72		
Sadness	Rugby (n=30)	0.73	1.23	0.775	.221
	Control (n=17)	0.47	0.87		
Nervousness	Rugby (n=30)	0.80	1.19	-0.064	.475
	Control (n=17)	0.82	1.24		
Emotional	Rugby (n=30)	0.37	0.67	0.061	.476
	Control (n=17)	0.35	0.86		
Numbness	Rugby (n=30)	0.33	0.96	1.904	.034*
	Control (n=17)	0.00	0.00		
Slowed Down	Rugby (n=30)	0.77	1.04	2.273	.014*
	Control (n=17)	0.24	0.56		
Mentally Foggy	Rugby (n=30)	0.77	0.97	3.332	.001**
	Control (n=17)	0.12	0.33		
Concentration	Rugby (n=30)	1.20	1.30	2.109	.205
	Control (n=17)	0.53	0.87		
Remembering	Rugby (n=30)	0.97	1.30	2.017	.025*
	Control (n=17)	0.35	0.79		
Visual Problems	Rugby (n=30)	0.57	0.90	2.917	.003**
	Control (n=17)	0.06	0.24		

Note. ** $p < .01$. * $p < .05$. ~ $.05 < p < .15$

Table 3.2:

Independent T-Tests for Rugby versus Controls at the Pre-Season stage on the 31-Item Post-Concussive Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=30)	11.60	7.98	0.809	.212
	Control (n=17)	9.76	6.45		
Headache	Rugby (n=30)	0.60	1.00	0.455	.326
	Control (n=17)	0.47	0.80		
Nausea	Rugby (n=30)	0.17	0.46	1.980	.029*
	Control (n=17)	0.00	0.00		
Vomiting	Rugby (n=30)	0.00	0.00	*No Statistic*	
	Control (n=17)	0.00	0.00		
Poor Appetite	Rugby (n=30)	0.30	0.65	0.343	.367
	Control (n=17)	0.24	0.56		
Balance Problems	Rugby (n=30)	0.20	0.41	0.171	.433
	Control (n=17)	0.18	0.53		
Dizziness	Rugby (n=30)	0.23	0.50	0.401	.346
	Control (n=17)	0.18	0.39		
Fatigue/ Tiredness	Rugby (n=30)	1.40	0.89	1.190	.120~
	Control (n=17)	1.06	1.03		
Trouble Fall Asleep	Rugby (n=30)	0.97	1.03	0.688	.248
	Control (n=17)	0.76	0.83		
Sleeping More	Rugby (n=30)	0.37	0.67	-1.588	.063~
	Control (n=17)	0.82	1.07		
Sleeping Less	Rugby (n=30)	0.83	1.12	2.167	.018*
	Control (n=17)	0.29	0.59		
Drowsiness	Rugby (n=30)	0.70	0.95	1.086	.142~
	Control (n=17)	0.41	0.71		
Sensitivity to Light	Rugby (n=30)	0.40	0.72	0.662	.256
	Control (n=17)	0.24	0.97		

Continued p.39

Table 3.2 (continued)

Sensitivity to Noise	Rugby (n=30)	0.13	0.35	2.112	.021*
	Control (n=17)	0.00	0.00		
Difficulty Hearing	Rugby (n=30)	0.20	0.41	-0.248	.403
	Control (n=17)	0.24	0.56		
Irritability	Rugby (n=30)	0.63	0.89	-0.290	.387
	Control (n=17)	0.71	0.69		
Aggression	Rugby (n=30)	0.70	0.95	1.805	.039*
	Control (n=17)	0.29	0.59		
Sadness	Rugby (n=30)	0.40	0.81	1.671	.051~
	Control (n=17)	0.12	0.33		
Nervousness	Rugby (n=30)	0.67	1.03	0.234	.408
	Control (n=17)	0.59	1.23		
Feeling More Emotional	Rugby (n=30)	0.23	0.50	-0.726	.236
	Control (n=17)	0.35	0.61		
Numbness / Tingling	Rugby (n=30)	0.07	0.25	-0.755	.227
	Control (n=17)	0.18	0.73		
Feeling Slowed Down	Rugby (n=30)	0.37	0.62	0.395	.348
	Control (n=17)	0.29	0.59		
Mentally Foggy	Rugby (n=30)	0.13	0.43	-0.772	.222
	Control (n=17)	0.24	0.44		
Difficulty Concentrating	Rugby (n=30)	0.73	0.83	0.795	.216
	Control (n=17)	0.53	0.87		
Difficulty Remembering	Rugby (n=30)	0.63	0.85	1.119	.135~
	Control (n=17)	0.41	0.51		
Visual Problems	Rugby (n=30)	0.30	0.54	0.391	.349
	Control (n=17)	0.24	0.56		
Speech Problems	Rugby (n=30)	0.17	0.38	1.187	.121~
	Control (n=17)	0.06	0.24		

Continued p. 40

Table 3.2 (continued)

Anxiety Problems	Rugby (n=30)	0.00	0.00	-1.852	.042*
	Control (n=17)	0.35	0.79		
Restlessness	Rugby (n=30)	0.07	0.37	-1.691	.053~
	Control (n=17)	0.41	0.80		
Social Withdrawal	Rugby (n=30)	0.00	0.00	-1.000	.166
	Control (n=17)	0.06	0.24		
Depression	Rugby (n=30)	0.00	0.00	*No Statistic*	
	Control (n=17)	0.00	0.00		
Sexual Problems	Rugby (n=30)	0.00	0.00	-1.000	.166~
	Control (n=17)	0.06	0.24		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void.

** $p < .05$. ~ $.05 < p < .15$*

Table 3.3:

Independent T-Tests for Rugby versus Controls at the Post-Season Stage on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=30)	12.52	11.81	0.736	.233
	Control (n=17)	10.06	8.91		
Headache	Rugby (n=30)	0.54	0.96	0.022	.492
	Control (n=17)	0.53	0.87		
Nausea	Rugby (n=30)	0.33	0.68	0.863	.197
	Control (n=17)	0.18	0.39		
Vomiting	Rugby (n=30)	0.15	0.47	0.742	.231
	Control (n=17)	0.06	0.24		
Balance Problems	Rugby (n=30)	0.15	0.36	-0.211	.417
	Control (n=17)	0.18	0.53		
Dizziness	Rugby (n=30)	0.22	0.64	-0.069	.473
	Control (n=17)	0.24	0.56		
Fatigue	Rugby (n=30)	1.44	1.28	0.235	.408
	Control (n=17)	1.35	1.22		
Insomnia	Rugby (n=30)	1.04	1.13	0.736	.233
	Control (n=17)	0.76	1.30		
Sleeping More	Rugby (n=30)	0.89	1.12	0.311	.379
	Control (n=17)	0.76	1.52		
Sleeping Less	Rugby (n=30)	0.96	1.43	1.221	.115~
	Control (n=17)	0.47	1.07		
Drowsiness	Rugby (n=30)	0.96	1.09	0.424	.337
	Control (n=17)	0.82	1.02		
Sensitivity to Light	Rugby (n=30)	0.56	0.97	2.528	.009**
	Control (n=17)	0.06	0.24		
Sensitivity to Noise	Rugby (n=30)	0.22	0.64	1.196	.120~
	Control (n=17)	0.06	0.24		

Continued p.42

Table 3.3 (continued)

Irritability	Rugby (n=30)	0.81	1.00	0.354	.363
	Control (n=17)	0.71	0.99		
Sadness	Rugby (n=30)	0.44	0.75	0.403	.345
	Control (n=17)	0.35	0.70		
Nervousness	Rugby (n=30)	0.48	0.85	-0.827	.207
	Control (n=17)	0.71	0.92		
Emotional	Rugby (n=30)	0.37	0.69	-0.735	.234
	Control (n=17)	0.53	0.72		
Numbness	Rugby (n=30)	0.11	0.32	-0.512	.306
	Control (n=17)	0.18	0.53		
Slowed Down	Rugby (n=30)	0.48	0.80	-0.416	.340
	Control (n=17)	0.59	0.87		
Mentally Foggy	Rugby (n=30)	0.48	0.80	0.040	.485
	Control (n=17)	0.47	1.01		
Concentration	Rugby (n=30)	0.96	1.06	1.449	.078~
	Control (n=17)	0.53	0.80		
Remembering	Rugby (n=30)	0.70	1.03	1.022	.157
	Control (n=17)	0.41	0.71		
Visual Problems	Rugby (n=30)	0.26	0.71	0.767	.224
	Control (n=17)	0.12	0.33		

Note. ** $p < .01$. ~ $.05 < p < .15$

Table 3.4 :

Independent T-Tests for Rugby versus Controls at the Post-Season Stage on the 31-Item Post-Concussion Symptom Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=30)	11.26	7.96	0.304	.382
	Control (n=17)	10.53	7.41		
Headache	Rugby (n=30)	0.41	0.84	-0.513	.305
	Control (n=17)	0.53	0.62		
Nausea	Rugby (n=30)	0.15	0.47	0.742	.231
	Control (n=17)	0.06	0.24		
Vomiting	Rugby (n=30)	0.04	0.19	0.790	.217
	Control (n=17)	0.00	0.00		
Poor Appetite	Rugby (n=30)	0.22	0.51	-0.765	.226
	Control (n=17)	0.41	0.94		
Balance Problems	Rugby (n=30)	0.15	0.46	0.211	.417
	Control (n=17)	0.12	0.49		
Dizziness	Rugby (n=30)	0.07	0.27	-1.106	.141~
	Control (n=17)	0.24	0.56		
Fatigue/ Tiredness	Rugby (n=30)	1.11	0.93	-1.177	.123~
	Control (n=17)	1.47	1.07		
Trouble Fall Asleep	Rugby (n=30)	0.70	0.82	0.429	.335
	Control (n=17)	0.59	0.94		
Sleeping More	Rugby (n=30)	0.70	0.72	0.995	.163
	Control (n=17)	0.41	1.23		
Sleeping Less	Rugby (n=30)	0.63	1.01	0.536	.298
	Control (n=17)	0.47	0.87		
Drowsiness	Rugby (n=30)	0.81	0.92	0.863	.197
	Control (n=17)	0.59	0.71		
Sensitivity to Light	Rugby (n=30)	0.37	0.79	1.908	.033*
	Control (n=17)	0.06	0.24		

Continued p.44

Table 3.4 (continued)

Sensitivity to Noise	Rugby (n=30)	0.11	0.32	1.803	.042*
	Control (n=17)	0.00	0.00		
Difficulty Hearing	Rugby (n=30)	0.30	0.67	1.177	.123~
	Control (n=17)	0.12	0.33		
Irritability	Rugby (n=30)	0.67	0.73	-0.410	.342
	Control (n=17)	0.76	0.83		
Aggression	Rugby (n=30)	0.78	0.93	2.109	.021*
	Control (n=17)	0.29	0.59		
Sadness	Rugby (n=30)	0.30	0.61	0.358	.361
	Control (n=17)	0.24	0.44		
Nervousness	Rugby (n=30)	0.37	0.74	-0.887	.190
	Control (n=17)	0.59	0.87		
Feeling More	Rugby (n=30)	0.30	0.54	0.391	.349
Emotional	Control (n=17)	0.24	0.44		
Numbness / Tingling	Rugby (n=30)	0.04	0.19	0.790	.217
	Control (n=17)	0.00	0.00		
Feeling Slowed	Rugby (n=30)	0.26	0.53	-1.947	.032*
Down	Control (n=17)	0.71	0.85		
Mentally Foggy	Rugby (n=30)	0.33	0.62	-0.097	.462
	Control (n=17)	0.35	0.70		
Difficulty	Rugby (n=30)	0.81	0.83	0.689	.247
Concentrating	Control (n=17)	0.65	0.70		
Difficulty	Rugby (n=30)	0.48	0.51	0.063	.475
Remembering	Control (n=17)	0.47	0.62		
Visual Problems	Rugby (n=30)	0.15	0.36	0.897	.188
	Control (n=17)	0.06	0.24		
Speech Problems	Rugby (n=30)	0.04	0.19	-0.330	.372
	Control (n=17)	0.06	0.24		

Continued p.45

Table 3.4 (continued)

Anxiety Problems	Rugby (n=30)	0.15	0.36	-0.627	.267
	Control (n=17)	0.24	0.56		
Restlessness	Rugby (n=30)	0.59	0.84	1.189	.121~
	Control (n=17)	0.35	0.49		
Social Withdrawal	Rugby (n=30)	0.04	0.19	-1.347	.098
	Control (n=17)	0.29	0.77		
Depression	Rugby (n=30)	0.19	0.40	0.071	.472
	Control (n=17)	0.18	0.39		
Sexual Problems	Rugby (n=30)	0.00	0.00	*No Statistic*	
	Control (n=17)	0.00	0.00		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void.

$* p < .05$. $\sim .05 < p < .15$

Pre-Season 31-Item Post-Concussion Symptom Questionnaire, Reduced Sample (Table 3.6)

When compared with the pre-season comparison on the full sample, the pre-season comparison of the 31-Item Post-Concussion Symptom Questionnaire on the reduced sample between the rugby and the control groups revealed an even stronger trend for the rugby participants to report a more pronounced symptom profile than controls, comprising a higher score for rugby participants including 20 of the 31 symptoms and the total symptom score. Of these, one symptom was highly significant at the $p < .01$ level (aggression), three symptoms were significant at the $p < .05$ level (headaches, drowsiness and sensitivity to noise), and five symptoms were approaching significance at the $.05 < p < .15$ level (nausea, poor appetite, balance problems, fatigue or tiredness, trouble falling asleep, sadness, difficulty remembering, and visual problems). Neither the rugby nor the control group reported having experienced vomiting, social withdrawal or depression. Of the eight symptoms for which there was a tendency towards the control group reporting more than the rugby group two symptoms were approaching significance at the .05 < p .15 level (sleeping more and anxiety). It is of note that the symptoms of headaches, and sensitivity to noise were significant for rugby participants on both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire at the pre-season stage using the reduced sample. Of further note are the symptoms aggression and sensitivity to noise, which were significant for rugby participants on the 31-Item Post-Concussion Symptom Questionnaire using the full and reduced sample.

Post-Season ImPACT Symptom Scale, Reduced Sample (Table 3.7)

When compared with the post-season comparison on the full sample, the post-season comparison of the ImPACT Symptom Scale on the reduced sample between the rugby and the control groups revealed a similarly predominant trend for the rugby participants to report a more pronounced symptom profile than controls, comprising a higher score for rugby participants on 20 of the 22 symptoms and the total symptom score. Of these one symptom was highly significant at the $p < .01$ (insomnia). Four symptoms were significant at $p < .05$ (sensitivity to light, sadness, difficulties in concentrating and difficulties in remembering). The total symptom score and three symptoms were approaching significance at the $.05< p < .15$ level

(sleeping less, irritability, and visual problems). The two symptoms for which there was a tendency towards the control group reporting more than the rugby group (balance problems and dizziness) were not significant (0.333 and 0.450 respectively). It is of note that the symptom sensitivity to light was significant for rugby participants on the ImPACT Symptom Scale at the post-season stage on both the full and the reduced sample.

Post-Season 31-Item Post-Concussion Symptom Questionnaire, Reduced Sample (Table 3.8)

When compared to the post-season comparison on the full sample, the post-season comparison of the 31-Item Post-Concussion Symptom Questionnaire on the reduced sample between the rugby and the control groups revealed an even stronger trend for the rugby participants to report a more pronounced symptom profile than controls, comprising a higher score for rugby participants on 23 of the 31 symptoms and the total symptom score. Of these, two symptoms were highly significant at the $p < .01$ level (trouble falling asleep and aggression). Two symptoms were significant at the $p < .05$ level (restlessness and depression). Four symptoms were approaching significance at the $.05 < p < .15$ level (sensitivity to light, sensitivity to noise, sadness and difficulty in concentrating). There were no reports in either the rugby group or the control group of experiencing sexual problems. Of the seven symptoms for which there was a tendency towards the control group reporting more than the rugby group one symptom was approaching significance at the $.05 < p < .15$ level (feeling slowed down). It is of note that the related variables, insomnia and trouble falling asleep are significant for rugby participants on both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire at the post-season stage on the reduced sample. Of further note is the symptom aggression which was significant for rugby participants on the 31-Item Post-Concussion Symptom Questionnaire at post-season on the full and reduced sample. For the control group, feeling slowed down was significant on the full and the reduced sample, when using the 31-Item Post-Concussion Symptom Questionnaire.

Table 3.5:

Independent T-Tests for Rugby versus Controls at the Pre-Season stage on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=19)	17.25	17.59	1.485	.075~
	Controls (n=7)	9.78	9.40		
Headache	Rugby (n=19)	0.75	1.29	2.595	.009**
	Controls (n=7)	0.00	0.00		
Nausea	Rugby (n=19)	0.55	1.15	2.146	.023*
	Controls (n=7)	0.00	0.00		
Vomiting	Rugby (n=19)	0.30	0.57	2.349	.015*
	Controls (n=7)	0.00	0.00		
Balance Problems	Rugby (n=19)	0.40	0.60	1.661	.055~
	Controls (n=7)	0.11	0.33		
Dizziness	Rugby (n=19)	0.75	1.37	2.445	.012*
	Controls (n=7)	0.00	0.00		
Fatigue	Rugby (n=19)	1.45	1.64	0.177	.431
	Controls (n=7)	1.33	1.66		
Insomnia	Rugby (n=19)	1.05	1.05	0.339	.369
	Controls (n=7)	0.89	1.45		
Sleeping More	Rugby (n=19)	0.50	0.83	-0.726	.237
	Controls (n=7)	0.78	1.20		
Sleeping Less	Rugby (n=19)	1.20	1.32	-0.040	.484
	Controls (n=7)	1.22	1.48		
Drowsiness	Rugby (n=19)	0.70	1.30	-0.571	.286
	Controls (n=7)	1.00	1.32		
Sensitivity to Light	Rugby (n=19)	0.90	1.29	-0.335	.370
	Controls (n=7)	1.11	2.09		
Sensitivity to Noise	Rugby (n=19)	0.50	0.76	2.939	.004**
	Controls (n=7)	0.00	0.00		

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Table 3.5 (continued)

Irritability	Rugby (n=19)	1.25	1.29	3.169	.002**
	Controls (n=7)	0.22	0.44		
Sadness	Rugby (n=19)	0.80	1.24	0.752	.229
	Controls (n=7)	0.44	1.01		
Nervousness	Rugby (n=19)	0.95	1.28	0.114	.455
	Controls (n=7)	0.89	1.45		
Emotional	Rugby (n=19)	0.35	0.59	0.57	.478
	Controls (n=7)	0.33	1.00		
Numbness	Rugby (n=19)	0.40	1.14	1.040	.154
	Controls (n=7)	0.00	0.00		
Slowed Down	Rugby (n=19)	0.65	0.93	1.676	.053~
	Controls (n=7)	0.22	0.44		
Mentally Foggy	Rugby (n=19)	0.80	1.06	2.077	.024*
	Controls (n=7)	0.22	0.441		
Concentration	Rugby (n=19)	1.25	1.33	1.659	.056~
	Controls (n=7)	0.56	0.88		
Remembering	Rugby (n=19)	1.05	1.40	1.193	.122~
	Controls (n=7)	0.44	0.88		
Visual Problems	Rugby (n=19)	0.70	1.03	3.036	.004**
	Controls (n=7)	0.00	0.00		

Note. ** $p < .01$. * $p < .05$. ~ $.05 < p < .15$

Table 3.6:

Independent T-Tests for Rugby versus Controls at the Pre-Season stage on the 31-Item Post-Concussion Symptom Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=19)	13.05	7.42	1.404	.086~
	Controls (n=7)	9.11	5.86		
Headache	Rugby (n=19)	0.90	1.12	2.335	.014*
	Controls (n=7)	0.22	0.44		
Nausea	Rugby (n=19)	0.20	0.52	1.710	.052~
	Controls (n=7)	0.00	0.00		
Vomiting	Rugby (n=19)	0.00	0.00	*No Statistic*	
	Controls (n=7)	0.00	0.00		
Poor Appetite	Rugby (n=19)	0.40	0.75	1.431	.082~
	Controls (n=7)	0.11	0.33		
Balance Problems	Rugby (n=19)	0.30	0.47	1.235	.115~
	Controls (n=7)	0.11	0.33		
Dizziness	Rugby (n=19)	0.20	0.41	0.569	.287
	Controls (n=7)	0.11	0.33		
Fatigue/ Tiredness	Rugby (n=19)	1.50	0.95	1.619	.059~
	Controls (n=7)	0.89	0.93		
Trouble Fall Asleep	Rugby (n=19)	1.15	1.09	1.426	.084~
	Controls (n=7)	0.67	0.71		
Sleeping More	Rugby (n=19)	0.45	0.76	-1.276	.107~
	Controls (n=7)	0.89	1.05		
Sleeping Less	Rugby (n=19)	0.70	0.98	0.699	.246
	Controls (n=7)	0.44	0.73		
Drowsiness	Rugby (n=19)	0.65	0.93	2.279	.016*
	Controls (n=7)	0.11	0.33		
Sensitivity to Light	Rugby (n=19)	0.40	0.60	-0.125	.451
	Controls (n=7)	0.44	1.33		

Continued p.51

Table 3.6 (continued)

Sensitivity to Noise	Rugby (n=19)	1.15	0.37	1.831	.042*
	Controls (n=7)	0.00	0.00		
Difficulty Hearing	Rugby (n=19)	0.25	0.44	0.156	.439
	Controls (n=7)	0.22	0.44		
Irritability	Rugby (n=19)	0.70	0.98	0.414	.341
	Controls (n=7)	0.56	0.53		
Aggression	Rugby (n=19)	0.85	1.04	2.867	.004**
	Controls (n=7)	0.11	0.33		
Sadness	Rugby (n=19)	0.40	0.75	1.431	~ .082
	Controls (n=7)	0.11	0.33		
Nervousness	Rugby (n=19)	0.80	1.06	0.45	.482
	Controls (n=7)	0.78	1.56		
Feeling More Emotional	Rugby (n=19)	0.20	0.41	-0.757	.228
	Controls (n=7)	0.33	0.50		
Numbness / Tingling	Rugby (n=19)	0.05	0.22	-0.841	.212
	Controls (n=7)	0.33	1.00		
Feeling Slowed Down	Rugby (n=19)	0.35	0.59	0.066	.474
	Controls (n=7)	0.33	0.71		
Mentally Foggy	Rugby (n=19)	0.15	0.49	-0.378	.354
	Controls (n=7)	0.22	0.44		
Difficulty Concentrating	Rugby (n=19)	0.80	0.83	0.758	.228
	Controls (n=7)	0.56	0.73		
Difficulty Remembering	Rugby (n=19)	0.75	0.91	0.933	.180~
	Controls (n=7)	0.44	0.53		
Visual Problems	Rugby (n=19)	0.40	0.60	1.661	.055~
	Controls (n=7)	0.11	0.33		
Speech Problems	Rugby (n=19)	0.25	0.44	0.835	.206
	Controls (n=7)	0.11	0.33		

Continued p.51

Table 3.6 (continued)

Anxiety Problems	Rugby (n=19)	0.00	0.00	-1.644	.070~
	Controls (n=7)	0.56	1.01		
Restlessness	Rugby (n=19)	0.10	0.45	-0.684	.250
	Controls (n=7)	0.22	0.44		
Social Withdrawal	Rugby (n=19)	0.00	0.00	*No Statistic*	
	Controls (n=7)	0.00	0.00		
Depression	Rugby (n=19)	0.00	0.00	*No Statistic*	
	Controls (n=7)	0.00	0.00		
Sexual Problems	Rugby (n=19)	0.00	0.00	-1.000	.174
	Controls (n=7)	0.11	0.33		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void.

*** p < .01. * p < .05. ~ .05 < p < .15*

Table 3.7:

Independent T-Tests for Rugby versus Controls at the Post-Season Stage on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=19)	14.24	14.00	1.307	.102~
	Controls (n=7)	7.56	8.32		
Headache	Rugby (n=19)	0.67	1.14	0.266	.397
	Controls (n=7)	0.56	0.73		
Nausea	Rugby (n=19)	0.41	0.80	0.659	.258
	Controls (n=7)	0.22	0.44		
Vomiting	Rugby (n=19)	0.24	0.56	0.605	.276
	Controls (n=7)	0.11	0.33		
Balance Problems	Rugby (n=19)	0.24	0.44	-0.439	.333
	Controls (n=7)	0.33	0.71		
Dizziness	Rugby (n=19)	0.29	0.77	-0.127	.450
	Controls (n=7)	0.33	0.71		
Fatigue	Rugby (n=19)	1.47	1.33	0.257	.400
	Controls (n=7)	1.33	1.23		
Insomnia	Rugby (n=19)	1.24	1.15	3.752	.001**
	Controls (n=7)	0.11	0.33		
Sleeping More	Rugby (n=19)	0.88	0.93	0.429	.336
	Controls (n=7)	0.67	1.66		
Sleeping Less	Rugby (n=19)	1.12	1.54	1.235	.115~
	Controls (n=7)	0.44	0.73		
Drowsiness	Rugby (n=19)	0.82	1.07	0.362	.360
	Controls (n=7)	0.67	1.00		
Sensitivity to Light	Rugby (n=19)	0.82	1.13	2.407	.013*
	Controls (n=7)	0.11	0.33		
Sensitivity to Noise	Rugby (n=19)	0.18	0.39	0.424	.338
	Controls (n=7)	0.11	0.33		

Continued p.53

Table 3.7 (continued)

Irritability	Rugby (n=19)	0.94	1.09	1.227	.116~
	Controls (n=7)	0.44	0.73		
Sadness	Rugby (n=19)	0.53	0.87	1.747	.047*
	Controls (n=7)	0.11	0.33		
Nervousness	Rugby (n=19)	0.41	0.87	0.248	.403
	Controls (n=7)	0.33	0.50		
Emotional	Rugby (n=19)	0.41	0.80	0.248	.403
	Controls (n=7)	0.33	0.71		
Numbness	Rugby (n=19)	0.18	0.39	0.424	.338
	Controls (n=7)	0.11	0.33		
Slowed Down	Rugby (n=19)	0.53	0.87	0.249	.403
	Controls (n=7)	0.44	0.73		
Mentally Foggy	Rugby (n=19)	0.53	0.87	0.983	.168
	Controls (n=7)	0.22	0.44		
Concentration	Rugby (n=19)	1.12	1.17	2.809	.005**
	Controls (n=7)	0.22	0.44		
Remembering	Rugby (n=19)	0.88	1.22	2.000	.029*
	Controls (n=7)	0.22	0.44		
Visual Problems	Rugby (n=19)	0.41	0.87	1.260	.110~
	Controls (n=7)	0.11	0.33		

Note. ** $p < .01$. * $p < .05$. ~ $.05 < p < .15$

Table 3.8 :

Independent T-Tests for Rugby versus Controls at the Post-Season Stage on the 31-Item Post-Concussion Symptom Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby (n=19)	12.35	8.98	1.009	.162
	Controls (n=7)	8.89	6.85		
Headache	Rugby (n=19)	0.59	1.00	0.091	.464
	Controls (n=7)	0.56	0.53		
Nausea	Rugby (n=19)	0.18	0.53	0.336	.370
	Controls (n=7)	0.11	0.33		
Vomiting	Rugby (n=19)	0.06	0.24	0.721	.239
	Controls (n=7)	0.00	0.00		
Poor Appetite	Rugby (n=19)	0.24	0.56	0.053	.479
	Controls (n=7)	0.22	0.67		
Balance Problems	Rugby (n=19)	0.18	0.53	-0.192	.425
	Controls (n=7)	0.22	0.67		
Dizziness	Rugby (n=19)	0.12	0.33	-0.866	.204
	Controls (n=7)	0.33	0.71		
Fatigue/ Tiredness	Rugby (n=19)	1.12	0.86	-0.283	.354
	Controls (n=7)	1.22	0.97		
Trouble Fall Asleep	Rugby (n=19)	0.82	0.88	2.953	.004**
	Controls (n=7)	0.11	0.33		
Sleeping More	Rugby (n=19)	0.59	0.62	0.073	.471
	Controls (n=7)	0.56	1.67		
Sleeping Less	Rugby (n=19)	0.71	0.99	0.699	.246
	Controls (n=7)	0.44	0.73		
Drowsiness	Rugby (n=19)	0.71	0.92	0.111	.456
	Controls (n=7)	0.67	0.71		
Sensitivity to Light	Rugby (n=19)	0.47	0.87	1.501	.074~
	Controls (n=7)	0.11	.33		

Continued p.54

Table 3.8 (continued)

Sensitivity to Noise	Rugby (n=19)	0.12	0.33	1.461	.082~
	Controls (n=7)	0.00	0.00		
Difficulty Hearing	Rugby (n=19)	0.24	0.56	0.605	.276
	Controls (n=7)	0.11	0.33		
Irritability	Rugby (n=19)	0.76	0.75	-0.041	.484
	Controls (n=7)	0.78	0.83		
Aggression	Rugby (n=19)	0.88	0.93	3.074	.003**
	Controls (n=7)	0.11	0.33		
Sadness	Rugby (n=19)	0.35	0.70	1.190	.123~
	Controls (n=7)	0.11	0.33		
Nervousness	Rugby (n=19)	0.35	0.79	-0.566	.289
	Controls (n=7)	0.56	1.01		
Feeling More Emotional	Rugby (n=19)	0.41	0.62	0.813	.212
	Controls (n=7)	0.22	0.44		
Numbness / Tingling	Rugby (n=19)	0.06	0.23	0.721	.239
	Controls (n=7)	0.00	0.00		
Feeling Slowed Down	Rugby (n=19)	0.24	0.56	-1.703	.051~
	Controls (n=7)	0.67	0.71		
Mentally Foggy	Rugby (n=19)	0.41	0.71	0.268	.396
	Controls (n=7)	0.33	0.71		
Difficulty Concentrating	Rugby (n=19)	0.82	0.88	1.369	.092~
	Controls (n=7)	0.44	0.53		
Difficulty Remembering	Rugby (n=19)	0.53	0.51	0.347	.366
	Controls (n=7)	0.44	0.73		
Visual Problems	Rugby (n=19)	0.24	0.44	0.743	.233
	Controls (n=7)	0.11	0.33		
Speech Problems	Rugby (n=19)	0.00	0.00	-1.000	.174
	Controls (n=7)	0.11	0.33		

Continued p.56

Table 3.8 (continued)

Anxiety Problems	Rugby (n=19)	0.18	0.39	0.424	.338
	Controls (n=7)	0.11	0.33		
Restlessness	Rugby (n=19)	0.71	0.92	1.811	.042*
	Controls (n=7)	0.22	0.44		
Social Withdrawal	Rugby (n=19)	0.06	0.24	0.721	.239
	Controls (n=7)	0.00	0.00		
Depression	Rugby (n=19)	0.24	0.44	2.219	.021*
	Controls (n=7)	0.00	0.00		
Sexual Problems	Rugby (n=19)	0.00	0.00	*No Statistic*	
	Controls (n=7)	0.00	0.00		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void.

*** p < .01. * p < .05. ~ .05 < p < .15*

3.2. DEPENDENT T-TEST SAMPLE COMPARISONS

3.2.1. Pre-Season versus Post-Season on the Full Sample

Results appear together on the pages following the end of the subsection on pages 60-79, Tables 3.9-3.12.

Rugby Pre-Season versus Rugby Post-Season on the ImPACT Symptom Scale, Full Sample (Table 3.9)

The comparison of the ImPACT Symptom Scale between the rugby group at pre-season and rugby group at post-season revealed no particular trend for the rugby participants between the pre- or post-season intervals, in that a substantial number of symptoms were reported as worse at the post-season stage whilst other symptoms improved. For three symptoms there was a tendency towards the rugby group at post-season to report more than the rugby group at pre-season (fatigue, sleeping more and drowsiness), none of these were significant (0.736, 0.265 and 0.731 respectively). For three symptoms there was a tendency to towards the rugby group at pre-season to report more than the rugby group at post-season, all of these were significant at the $p < .05$ level (balance problems, feeling mentally foggy and visual problems). The total symptom score and four symptoms were approaching significance at the $.05 < p < .15$ level (dizziness, sadness, nervousness and feeling slowed down). Overall this suggests no real difference between the rugby group at pre-season and the rugby group at post-season on the ImPACT Symptom Scale.

Rugby Pre-Season versus Rugby Post-Season on the 31-Item Post-Concussion Symptom Questionnaire, Full Sample (Table 3.10)

The comparison of the 31-Item Post-Concussion Symptom Questionnaire between the rugby group at pre-season and the rugby group at post-season revealed no particular direct trends for the rugby participants between the pre- or post-season intervals, in that a substantial number of symptoms were reported as worse at the post-season stage, other symptoms remained unchanged or improved. For thirteen symptoms there was a tendency towards the rugby group at post-season to report more than the rugby group at pre-season, of these three symptoms were significant at the $p < .05$ level (anxiety, restlessness and depression). There was no change from

pre- to post-season on reports of experiencing irritability and feelings of numbness or tingling. For 16 symptoms there was a tendency towards the rugby group at pre-season to report more than the rugby group at post-season, of these four symptoms were approaching significance at the $.05 < p < .15$ level (dizziness, nervousness, visual problems and speech problems). Overall, as with results of the ImPACT Symptom Scale, this suggests no real difference between reported symptoms between the pre- and post-season stages respectively for rugby participants, using the full sample.

Controls Pre-Season versus Controls post-Season on the ImPACT Symptom Scale, Full Sample (Table 3.11)

The comparison of the ImPACT Symptom Scale between the control group at pre-season and control group at post-season revealed mixed trends for the control participants between the pre- or post-season intervals, in that a substantial number of symptoms were reported as worse at the post-season stage, other symptoms remained unchanged or improved. For 15 symptoms there was the tendency for the control group at post-season to report more than the control group at pre-season, of these three symptoms were approaching significance at the $.05 < p < .15$ level (headaches, nausea and dizziness). There was no change from pre- to post-season on reports of insomnia and difficulties in concentrating. For five symptoms (fatigue, insomnia, sleeping less, sadness and nervousness) there was a tendency towards the control group at pre- season to report more than the control group at post-season no results were significant (0.557, 1.00, 0.393, 0.668 and 0.683 respectively). Overall this suggests no real difference between the controls at the pre-season and post-season stages respectively.

Controls Pre-Season versus Controls Post-Season on the 31-Item Post-Concussion Symptom Questionnaire, Full Sample (Table 3.12)

The comparison of the 31-Item Post-Concussion Symptom Questionnaire between the control group at pre-season and the control group at post-season revealed mixed trends for the control participants between the pre- or post-season intervals, in that a substantial number of symptoms were reported as worse at the post-season stage, other symptoms remained unchanged. For 15 symptoms there was the tendency for

the control group at post-season to report more than the control group at pre-season, however none of these were significant. There was no change from pre- to post-season on reports of aggression, nervousness and speech problems. There were no reports amongst the control group of vomiting or sensitivity to noise at either the pre- or post-season stage. For eleven symptoms there was a tendency towards the control group at pre-season to report more than the control group at post-season, of these three results were approaching significance at the $.05 < p < .15$ level (feeling slowed down, social withdrawal and depression). Overall, as with results of the ImPACT Symptom Scale, this suggests no real difference between reported symptoms between the pre- and post- season stages respectively for control participants, using the full sample.

3.2.2. Pre-Season versus Post-Season on the Reduced Sample

Results appear together on the pages following the end of the subsection on pages 72-81, Tables 3.15-3.19.

Rugby Pre versus Rugby Post on the ImPACT Symptom Scale, Reduced Sample (Table 3.13)

Commensurate with the comparison on the full sample, the comparison of the ImPACT Symptom Scale on the reduced sample between the rugby group at pre-season and rugby group at post-season revealed mixed trends for the rugby participants between the pre- or post-season, in that a number of symptoms were reported as worse at the post-season stage, other symptoms remained unchanged. For three symptoms (fatigue, insomnia and sleeping more) there was a tendency towards the rugby group at post-season to report more than the rugby group at pre-season no results were significant (0.894, 0.778 and 0.351 respectively). There was no change from pre- to post-season on reports of sleeping less than usual, drowsiness and feeling more emotional. For 17 symptoms there was a tendency towards the rugby group at pre-season to report more than the rugby group at post-season, of these two symptoms were significant at the $p<0.05$ level (sensitivity to noise and nervousness). Four symptoms were approaching significance at the $.05 < p < .15$ level (dizziness, sadness, feeling mentally foggy and visual problems).

Table 3.9:

Dependent T-Tests for Rugby Pre versus Rugby Post on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby Pre (n=27)	16.85	16.60	1.601	.122~
	Rugby Post (n=27)	12.52	11.81		
Headache	Rugby Pre (n=27)	0.59	1.15	0.593	.558
	Rugby Post (n=27)	0.48	0.94		
Nausea	Rugby Pre (n=27)	0.59	1.08	1.230	.230
	Rugby Post (n=27)	0.33	0.68		
Vomiting	Rugby Pre (n=27)	0.26	0.53	1.363	.185
	Rugby Post (n=27)	0.15	0.46		
Balance Problems	Rugby Pre (n=27)	0.41	0.57	2.563	.017*
	Rugby Post (n=27)	0.15	0.36		
Dizziness	Rugby Pre (n=27)	0.67	1.24	2.000	.056~
	Rugby Post (n=27)	0.22	0.64		
Fatigue	Rugby Pre (n=27)	1.33	1.52	-0.341	.736
	Rugby Post (n=27)	1.44	1.28		
Insomnia	Rugby Pre (n=27)	1.07	1.11	0.118	.907
	Rugby Post (n=27)	1.04	1.13		
Sleeping More	Rugby Pre (n=27)	0.56	0.89	-1.140	.265
	Rugby Post (n=27)	0.89	1.12		
Sleeping Less	Rugby Pre (n=27)	1.33	1.36	1.082	.289
	Rugby Post (n=27)	0.96	1.43		
Drowsiness	Rugby Pre (n=27)	0.89	1.25	-0.348	.731
	Rugby Post (n=27)	0.96	1.09		
Sensitivity to Light	Rugby Pre (n=27)	0.78	1.19	1.237	.227
	Rugby Post (n=27)	0.56	0.97		
Sensitivity to Noise	Rugby Pre (n=27)	0.41	0.69	1.154	.259
	Rugby Post (n=27)	0.22	0.64		

Continued p.61

Table 3.9 (continued)

Irritability	Rugby Pre (n=27)	1.04	1.29	0.923	.364
	Rugby Post (n=27)	0.81	1.00		
Sadness	Rugby Pre (n=27)	0.81	1.27	1.586	.125~
	Rugby Post (n=27)	0.44	0.75		
Nervousness	Rugby Pre (n=27)	0.81	1.21	1.732	.095~
	Rugby Post (n=27)	0.48	0.85		
Emotional	Rugby Pre (n=27)	0.41	0.69	0.205	.839
	Rugby Post (n=27)	0.37	0.69		
Numbness	Rugby Pre (n=27)	0.33	1.00	1.140	.265
	Rugby Post (n=27)	0.11	0.32		
Slowed Down	Rugby Pre (n=27)	0.78	1.05	1.772	.088~
	Rugby Post (n=27)	0.48	0.80		
Mentally Foggy	Rugby Pre (n=27)	0.85	0.99	2.078	.048*
	Rugby Post (n=27)	0.48	0.80		
Concentration	Rugby Pre (n=27)	1.22	1.34	1.097	.283
	Rugby Post (n=27)	0.96	1.06		
Remembering	Rugby Pre (n=27)	1.07	1.33	1.412	.170
	Rugby Post (n=27)	0.70	1.03		
Visual Problems	Rugby Pre (n=27)	0.63	0.93	2.078	.048*
	Rugby Post (n=27)	0.26	0.71		

Note. $* p < .05.$ $\sim .05 < p < .15$

Table 3.10:

Dependent T-Tests for Rugby Pre versus Rugby Post on the 31-Item Post-Concussion Symptom Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby Pre (n=27)	11.93	8.32	0.403	.690
	Rugby Post (n=27)	11.26	7.96		
Headache	Rugby Pre (n=27)	0.37	0.74	-0.440	.663
	Rugby Post (n=27)	0.41	0.84		
Nausea	Rugby Pre (n=27)	0.19	0.48	0.440	.663
	Rugby Post (n=27)	0.15	0.46		
Vomiting	Rugby Pre (n=27)	0.00	0.00	-1.000	.327
	Rugby Post (n=27)	0.04	0.19		
Poor Appetite	Rugby Pre (n=27)	0.33	0.68	0.769	.449
	Rugby Post (n=27)	0.22	0.51		
Balance Problems	Rugby Pre (n=27)	0.22	0.42	0.700	.490
	Rugby Post (n=27)	0.15	0.46		
Dizziness	Rugby Pre (n=27)	0.26	0.53	1.727	.096~
	Rugby Post (n=27)	0.07	0.27		
Fatigue/ Tiredness	Rugby Pre (n=27)	1.44	0.89	1.472	.153
	Rugby Post (n=27)	1.11	0.93		
Trouble Fall Asleep	Rugby Pre (n=27)	0.93	1.04	0.927	.340
	Rugby Post (n=27)	0.70	0.82		
Sleeping More	Rugby Pre (n=27)	0.41	0.69	-1.442	.161
	Rugby Post (n=27)	0.70	0.72		
Sleeping Less	Rugby Pre (n=27)	0.89	1.16	0.908	.372
	Rugby Post (n=27)	0.63	1.01		
Drowsiness	Rugby Pre (n=27)	0.74	0.98	0.348	.731
	Rugby Post (n=27)	0.81	0.92		
Sensitivity to Light	Rugby Pre (n=27)	0.44	0.75	0.359	.722
	Rugby Post (n=27)	0.37	0.79		

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Table 3.10 (continued)

Sensitivity to Noise	Rugby Pre (n=27)	0.15	0.36	0.440	.663
	Rugby Post (n=27)	0.11	0.32		
Difficulty Hearing	Rugby Pre (n=27)	0.22	0.42	-0.527	.602
	Rugby Post (n=27)	0.30	0.67		
Irritability	Rugby Pre (n=27)	0.67	0.92	0.000	1.000
	Rugby Post (n=27)	0.67	0.73		
Aggression	Rugby Pre (n=27)	0.74	0.98	-0.225	.823
	Rugby Post (n=27)	0.78	0.93		
Sadness	Rugby Pre (n=27)	0.44	0.85	0.750	.460
	Rugby Post (n=27)	0.30	0.61		
Nervousness	Rugby Pre (n=27)	0.67	1.04	1.551	.133~
	Rugby Post (n=27)	0.37	0.74		
Feeling More Emotional	Rugby Pre (n=27)	0.26	0.53	-0.238	.814
	Rugby Post (n=27)	0.30	0.54		
Numbness / Tingling	Rugby Pre (n=27)	0.04	0.19	0.00	1.000
	Rugby Post (n=27)	0.04	0.19		
Feeling Slowed Down	Rugby Pre (n=27)	0.37	0.63	0.721	.477
	Rugby Post (n=27)	0.26	0.53		
Mentally Foggy	Rugby Pre (n=27)	0.15	0.46	-1.154	.259
	Rugby Post (n=27)	0.33	0.62		
Difficulty Concentrating	Rugby Pre (n=27)	0.74	0.86	-0.402	.691
	Rugby Post (n=27)	0.81	0.83		
Difficulty Remembering	Rugby Pre (n=27)	0.67	0.88	1.905	.284
	Rugby Post (n=27)	0.48	0.51		
Visual Problems	Rugby Pre (n=27)	0.33	0.56	1.727	.096~
	Rugby Post (n=27)	0.15	0.36		
Speech Problems	Rugby Pre (n=27)	0.19	0.40	1.688	.103~
	Rugby Post (n=27)	0.04	0.19		

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Table 3.10 (continued)

Anxiety	Rugby Pre (n=27)	0.00	0.00	-2.126	.043*
Problems	Rugby Post (n=27)	0.15	0.36		
Restlessness	Rugby Pre (n=27)	0.07	0.39	-2.762	.010*
	Rugby Post (n=27)	0.59	0.84		
Social	Rugby Pre (n=27)	0.00	0.00	-1.000	.327
Withdrawal	Rugby Post (n=27)	0.04	0.19		
Depression	Rugby Pre (n=27)	0.00	0.00	-2.431	.022*
	Rugby Post (n=27)	0.19	0.40		
Sexual	Rugby Pre (n=27)	0.00	0.00	*No Statistic*	
Problems	Rugby Post (n=27)	0.00	0.00		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void.

** p < .05. ~ .05 < p < .15*

Table 3.11:

Dependent T-Tests for Controls Pre versus Controls Post on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Control Pre (n=17)	8.18	8.42	-0.704	.491
	Control Post (n=17)	10.06	8.91		
Headache	Control Pre (n=17)	0.12	0.33	1.692	.110~
	Control Post (n=17)	0.53	0.87		
Nausea	Control Pre (n=17)	0.00	0.00	-1.852	.083~
	Control Post (n=17)	0.18	0.39		
Vomiting	Control Pre (n=17)	0.00	0.00	-1.000	.332
	Control Post (n=17)	0.06	0.24		
Balance Problems	Control Pre (n=17)	0.06	0.24	-1.000	.332
	Control Post (n=17)	0.18	0.53		
Dizziness	Control Pre (n=17)	0.00	0.00	-1.725	.104~
	Control Post (n=17)	0.24	0.56		
Fatigue	Control Pre (n=17)	1.06	1.35	-0.599	.557
	Control Post (n=17)	1.35	1.22		
Insomnia	Control Pre (n=17)	0.76	1.20	0.00	1.000
	Control Post (n=17)	0.76	1.30		
Sleeping More	Control Pre (n=17)	0.65	1.27	-0.523	.608
	Control Post (n=17)	0.76	1.52		
Sleeping Less	Control Pre (n=17)	0.82	1.33	0.879	.393
	Control Post (n=17)	0.47	1.07		
Drowsiness	Control Pre (n=17)	0.71	1.11	-0.356	.727
	Control Post (n=17)	0.82	1.11		
Sensitivity to Light	Control Pre (n=17)	0.59	1.58	1.376	.188
	Control Post (n=17)	0.06	0.24		
Sensitivity to Noise	Control Pre (n=17)	0.00	0.00	-1.000	.332
	Control Post (n=17)	0.06	0.24		

Continued p.66

Table 3.11 (continued)

Irritability	Control Pre (n=17)	0.47	0.72	-0.846	.410
	Control Post (n=17)	0.71	0.99		
Sadness	Control Pre (n=17)	0.47	0.87	0.436	.668
	Control Post (n=17)	0.35	0.70		
Nervousness	Control Pre (n=17)	0.82	1.24	0.416	.683
	Control Post (n=17)	0.71	0.92		
Emotional	Control Pre (n=17)	0.35	0.86	-0.643	.529
	Control Post (n=17)	0.53	0.71		
Numbness	Control Pre (n=17)	0.00	0.00	-1.376	.188
	Control Post (n=17)	0.18	0.53		
Slowed Down	Control Pre (n=17)	0.24	0.56	-1.376	.188
	Control Post (n=17)	0.59	0.87		
Mentally Foggy	Control Pre (n=17)	0.12	0.33	-1.461	.163
	Control Post (n=17)	0.47	1.01		
Concentration	Control Pre (n=17)	0.53	0.87	0.00	1.000
	Control Post (n=17)	0.53	0.80		
Remembering	Control Pre (n=17)	0.35	0.79	-0.251	.805
	Control Post (n=17)	0.41	0.71		
Visual Problems	Control Pre (n=17)	0.06	0.24	-0.566	.579
	Control Post (n=17)	0.12	0.33		

Note. $* p < .05; \sim .05 < p < .15$

Table 3.12:

Dependent T-Tests for Controls Pre versus Controls Post on the 31-Item Post-Concussion Symptom Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Control Pre (n=17)	9.76	6.45	-0.432	.672
	Control Post (n=17)	10.53	7.41		
Headache	Control Pre (n=17)	0.47	0.80	-0.251	.805
	Control Post (n=17)	0.53	0.62		
Nausea	Control Pre (n=17)	0.00	0.00	-1.000	.332
	Control Post (n=17)	0.06	0.24		
Vomiting	Control Pre (n=17)	0.00	0.00	*No Statistic*	
	Control Post (n=17)	0.00	0.00		
Poor Appetite	Control Pre (n=17)	0.24	0.56	-0.614	.548
	Control Post (n=17)	0.41	0.94		
Balance Problems	Control Pre (n=17)	0.18	0.53	0.324	.750
	Control Post (n=17)	0.12	0.49		
Dizziness	Control Pre (n=17)	0.18	0.39	-0.324	.750
	Control Post (n=17)	0.24	0.56		
Fatigue/ Tiredness	Control Pre (n=17)	1.06	1.03	-1.281	.219
	Control Post (n=17)	1.47	1.07		
Trouble Fall Asleep	Control Pre (n=17)	0.76	0.83	0.527	.605
	Control Post (n=17)	0.59	0.94		
Sleeping More	Control Pre (n=17)	0.82	1.07	1.444	.168
	Control Post (n=17)	0.41	1.23		
Sleeping Less	Control Pre (n=17)	0.29	0.59	-0.765	.455
	Control Post (n=17)	0.47	0.87		
Drowsiness	Control Pre (n=17)	0.41	0.71	-0.899	.382
	Control Post (n=17)	0.59	0.71		
Sensitivity to Light	Control Pre (n=17)	0.24	0.97	0.717	.484
	Control Post (n=17)	0.06	0.24		

Continued p.68

Table 3.12 (continued)

Sensitivity to Noise	Control Pre (n=17)	0.00	0.00	*No Statistic*	
	Control Post (n=17)	0.00	0.00		
Difficulty Hearing	Control Pre (n=17)	0.24	0.56	0.808	.431
	Control Post (n=17)	0.12	0.33		
Irritability	Control Pre (n=17)	0.71	0.69	-0.223	.826
	Control Post (n=17)	0.76	0.83		
Aggression	Control Pre (n=17)	0.29	0.59	0.00	1.000
	Control Post (n=17)	0.29	0.59		
Sadness	Control Pre (n=17)	0.12	0.33	-0.808	.431
	Control Post (n=17)	0.24	0.44		
Nervousness	Control Pre (n=17)	0.59	1.23	0.00	1.000
	Control Post (n=17)	0.59	0.87		
Feeling More Emotional	Control Pre (n=17)	0.35	0.61	0.696	.496
	Control Post (n=17)	0.24	0.44		
Numbness / Tingling	Control Pre (n=17)	0.18	0.73	1.000	.332
	Control Post (n=17)	0.00	0.00		
Feeling Slowed Down	Control Pre (n=17)	0.29	0.59	-1.692	.110~
	Control Post (n=17)	0.71	0.85		
Mentally Foggy	Control Pre (n=17)	0.24	0.44	-0.808	.431
	Control Post (n=17)	0.35	0.70		
Difficulty Concentrating	Control Pre (n=17)	0.53	0.87	-0.566	.579
	Control Post (n=17)	0.65	0.70		
Difficulty Remembering	Control Pre (n=17)	0.41	0.51	-0.436	.668
	Control Post (n=17)	0.47	0.62		
Visual Problems	Control Pre (n=17)	0.24	0.56	1.144	.269
	Control Post (n=17)	0.06	0.24		
Speech Problems	Control Pre (n=17)	0.06a	0.24		
	Control Post (n=17)	0.06a	0.24		

Continued p.69

Table 3.12 (continued)

Anxiety Problems	Control Pre (n=17)	0.35	0.79	0.489	.632
	Control Post (n=17)	0.24	0.56		
Restlessness	Control Pre (n=17)	0.41	0.80	0.368	.718
	Control Post (n=17)	0.35	0.49		
Social Withdrawal	Control Pre (n=17)	0.06	0.24	-1.725	.104~
	Control Post (n=17)	0.29	0.77		
Depression	Control Pre (n=17)	0.00	0.00	-1.852	.083~
	Control Post (n=17)	0.18	0.39		
Sexual Problems	Control Pre (n=17)	0.06	0.24	1.000	.332
	Control Post (n=17)	0.00	0.00		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void; a = t cannot be computed as the standard error of the difference is 0

** p < .05. ~ .05 < p < .15*

Rugby Pre versus Rugby Post on the 31-Item Post-Concussion Symptom Questionnaire, Reduced Sample (Table 3.14)

Commensurate with the comparison on the full sample, the comparison of the 31-Item Post-Concussion Symptom Questionnaire on the reduced sample between the rugby group at pre-season and the rugby group at post-season revealed mixed trends for the rugby participants between the pre- or post-season, in that a number of symptoms were reported as worse at the post-season stage, other symptoms remained unchanged. For 16 symptoms there was a tendency for rugby participants to report a more pronounced symptom profile at the post-season stage than at the pre-season stage, of these one symptom was significant at the $p < .05$ level (speech problems), and one symptom was approaching significance at the $.05 < p < .15$ level (nervousness). There was no change from pre- to post-season on reports of experiencing headaches, drowsiness, sensitivity to light, irritability and difficulty in concentrating. There were no reports amongst the rugby group of experiencing sexual problems at either the pre- or post-season stage. For nine symptoms there was a tendency towards the rugby group at pre-season to report more than the rugby group at post-season, of these two results were significant at the $p < .05$ level (restlessness and depression). Overall, as with results of the ImPACT Symptom Scale, this suggests no real difference between reported symptoms between the pre- and post-season stages respectively for rugby participants, using the reduced sample.

Controls Pre versus Controls Post on the ImPACT Symptom Scale, Reduced Sample (Table 3.15)

Commensurate with the comparison on the full sample, the comparison of the ImPACT Symptom Scale on the reduced sample between the control group at pre-season and control group at post-season revealed mixed trends for the control participants between the pre- or post-season, in that a number of symptoms were reported as worse at the post-season stage, other symptoms remained unchanged. For 10 symptoms there was a tendency for rugby participants to report a more pronounced symptom profile at the post-season stage than at the pre-season stage, of these one symptom was highly significant at the $p < .01$ level (fatigue), and one symptom was approaching significance at the $.05 < p < .15$ level (headaches). There

was no change from pre- to post-season on experiencing fatigue, feeling more emotional or reports of feeling mentally foggy. For nine symptoms there was a tendency towards the control group at pre-season to report more than the control group at post-season, of these one symptom was approaching significance at the .05 < p .15 level (sleeping less).

Controls Pre versus Controls Post on the 31-Item Post-Concussion Symptom Questionnaire, Reduced Sample (Table 3.16)

The comparison of the 31-Item Post-Concussion Symptom Questionnaire between the Control group at pre-season and the Control group at post-season revealed mixed trends for the control participants between the pre or post-season, in that a number of symptoms were reported as worse at the post-season stage, other symptoms remained unchanged. For 10 symptoms there was a tendency for rugby participants to report a more pronounced symptom profile at the post-season stage than at the pre-season stage, of these, one result was approaching significance at the $0.05 < p < 0.15$ level (drowsiness). There was no change from pre- to post-season on reports of sleeping less than usual, aggression, sadness, difficulties in remembering, visual problems, speech problems or restlessness. There were no reports amongst the control group of vomiting, sensitivity to noise, social withdrawal or depression at either the pre- or post-season stages. For 10 symptoms there was a tendency for rugby participants to report a more pronounced symptom profile at the pre-season stage than at the post-season stage, of these one result was approaching significance at the $0.05 < p < 0.15$ level (trouble falling asleep). Overall, as with results of the ImPACT Symptom Scale, this suggests no real difference between reported symptoms between the pre-and post- season stages respectively for control participants, using the reduced sample.

Summary of Research Findings

According to the grid analyses (See Tables 3.20 and 3.21), the pre-and post-season results of the reduced sample are strongly commensurate with those of the full sample, for both ImPACT and the 31-Item Post-Concussion Symptom Questionnaire, with the overall indication of a predominantly more pronounced symptom profile for rugby participants than for control participants.

Table 3.13 :

Dependent T-Tests for Rugby Pre versus Rugby Post on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby Pre (n=17)	18.71	18.71	1.104	.286
	Rugby Post (n=17)	14.24	14.00		
Headache	Rugby Pre (n=17)	0.71	1.36	0.460	.651
	Rugby Post (n=17)	0.59	1.12		
Nausea	Rugby Pre (n=17)	0.65	1.22	0.808	.431
	Rugby Post (n=17)	0.41	0.80		
Vomiting	Rugby Pre (n=17)	0.35	0.61	1.000	.332
	Rugby Post (n=17)	0.24	0.56		
Balance Problems	Rugby Pre (n=17)	0.47	0.62	1.725	.104
	Rugby Post (n=17)	0.24	0.44		
Dizziness	Rugby Pre (n=17)	0.88	1.45	1.830	.086~
	Rugby Post (n=17)	0.29	0.77		
Fatigue	Rugby Pre (n=17)	1.41	1.62	-0.136	.894
	Rugby Post (n=17)	1.47	1.33		
Insomnia	Rugby Pre (n=17)	1.12	1.05	-0.287	.778
	Rugby Post (n=17)	1.24	1.15		
Sleeping More	Rugby Pre (n=17)	0.59	0.87	-0.960	.351
	Rugby Post (n=17)	0.88	0.93		
Sleeping Less	Rugby Pre (n=17)	1.12	1.32	0.000	1.000
	Rugby Post (n=17)	1.12	1.54		
Drowsiness	Rugby Pre (n=17)	0.82	1.38	0.00	1.000
	Rugby Post (n=17)	0.82	1.07		
Sensitivity to Light	Rugby Pre (n=17)	1.00	1.37	0.717	.484
	Rugby Post (n=17)	0.82	1.13		
Sensitivity to Noise	Rugby Pre (n=17)	0.59	0.80	2.746	.014*
	Rugby Post (n=17)	0.18	0.39		

Continued p.73

Table 3.13 (continued)

Irritability	Rugby Pre (n=17)	1.29	1.36	1.144	.269
	Rugby Post (n=17)	0.94	1.09		
Sadness	Rugby Pre (n=17)	0.94	1.30	1.514	.150~
	Rugby Post (n=17)	0.53	0.87		
Nervousness	Rugby Pre (n=17)	1.00	1.32	2.279	.037*
	Rugby Post (n=17)	0.41	0.87		
Emotional	Rugby Pre (n=17)	0.41	0.62	0.000	1.00
	Rugby Post (n=17)	0.41	0.80		
Numbness	Rugby Pre (n=17)	0.41	1.23	0.775	.450
	Rugby Post (n=17)	0.18	0.39		
Slowed Down	Rugby Pre (n=17)	0.65	0.93	0.621	.543
	Rugby Post (n=17)	0.53	0.87		
Mentally Foggy	Rugby Pre (n=17)	0.94	1.09	1.692	.110~
	Rugby Post (n=17)	0.53	0.87		
Concentration	Rugby Pre (n=17)	1.29	1.40	0.566	.579
	Rugby Post (n=17)	1.12	1.17		
Remembering	Rugby Pre (n=17)	1.24	1.44	1.000	.332
	Rugby Post (n=17)	0.88	1.22		
Visual Problems	Rugby Pre (n=17)	0.82	1.07	1.514	.150~
	Rugby Post (n=17)	0.41	0.87		

Note. $* p < .05$. $\sim .05 < p < .15$

Table 3.14:

Dependent T-Tests for Rugby Pre versus Rugby Post on the 31-Item Post-Concussion Symptom Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Rugby Pre (n=17)	13.82	7.73	0.758	.460
	Rugby Post (n=17)	12.35	8.98		
Headache	Rugby Pre (n=17)	0.59	0.87	0.000	1.000
	Rugby Post (n=17)	0.59	1.00		
Nausea	Rugby Pre (n=17)	0.24	0.56	0.566	.579
	Rugby Post (n=17)	0.18	0.53		
Vomiting	Rugby Pre (n=17)	0.00	0.00	-1.000	.332
	Rugby Post (n=17)	0.06	0.24		
Poor Appetite	Rugby Pre (n=17)	0.47	0.80	1.167	.260
	Rugby Post (n=17)	0.24	0.56		
Balance Problems	Rugby Pre (n=17)	0.35	0.49	1.144	.269
	Rugby Post (n=17)	0.18	0.53		
Dizziness	Rugby Pre (n=17)	0.24	0.44	1.000	.332
	Rugby Post (n=17)	0.12	0.33		
Fatigue/ Tiredness	Rugby Pre (n=17)	1.59	0.94	1.646	.119
	Rugby Post (n=17)	1.12	0.86		
Trouble Fall Asleep	Rugby Pre (n=17)	1.12	1.11	0.893	.385
	Rugby Post (n=17)	0.82	0.88		
Sleeping More	Rugby Pre (n=17)	0.53	0.80	-0.212	.835
	Rugby Post (n=17)	0.59	0.62		
Sleeping Less	Rugby Pre (n=17)	0.76	1.03	0.155	.878
	Rugby Post (n=17)	0.71	0.99		
Drowsiness	Rugby Pre (n=17)	0.71	0.99	0.000	1.000
	Rugby Post (n=17)	0.71	0.92		
Sensitivity to Light	Rugby Pre (n=17)	0.47	0.62	0.000	1.000
	Rugby Post (n=17)	0.47	0.87		

Continued p.75

Table 3.14 (continued)

Sensitivity to Noise	Rugby Pre (n=17)	0.18	0.39	0.436	.668
	Rugby Post (n=17)	0.12	0.33		
Difficulty Hearing	Rugby Pre (n=17)	0.29	0.47	0.436	.668
	Rugby Post (n=17)	0.24	0.56		
Irritability	Rugby Pre (n=17)	0.76	1.03	0.000	1.000
	Rugby Post (n=17)	0.76	0.75		
Aggression	Rugby Pre (n=17)	0.94	1.09	0.324	.750
	Rugby Post (n=17)	0.88	0.93		
Sadness	Rugby Pre (n=17)	0.47	0.80	0.489	.632
	Rugby Post (n=17)	0.35	0.70		
Nervousness	Rugby Pre (n=17)	0.82	1.07	2.057	.056~
	Rugby Post (n=17)	0.35	0.79		
Feeling More	Rugby Pre (n=17)	0.24	0.44	-0.899	.382
Emotional	Rugby Post (n=17)	0.41	0.62		
Numbness / Tingling	Rugby Pre (n=17)	0.00	0.00	-1.000	.332
	Rugby Post (n=17)	0.06	0.24		
Feeling Slowed Down	Rugby Pre (n=17)	0.35	0.61	0.566	.579
	Rugby Post (n=17)	0.24	0.56		
Mentally Foggy	Rugby Pre (n=17)	0.18	0.53	-1.000	.332
	Rugby Post (n=17)	0.41	0.71		
Difficulty	Rugby Pre (n=17)	0.82	0.88	0.000	1.000
Concentrating	Rugby Post (n=17)	0.82	0.88		
Difficulty	Rugby Pre (n=17)	0.82	0.95	1.231	.236
Remembering	Rugby Post (n=17)	0.53	0.51		
Visual Problems	Rugby Pre (n=17)	0.47	0.62	1.461	.163
	Rugby Post (n=17)	0.24	0.44		
Speech Problems	Rugby Pre (n=17)	0.29	0.47	2.582	.020*
	Rugby Post (n=17)	0.00	0.00		

Continued p.76

Table 3.14 (continued)

Anxiety Problems	Rugby Pre (n=17)	0.00	0.00	-1.852	.083
	Rugby Post (n=17)	0.18	0.39		
Restlessness	Rugby Pre (n=17)	0.12	0.49	-2.163	.046*
	Rugby Post (n=17)	0.71	0.92		
Social Withdrawal	Rugby Pre (n=17)	0.00	0.00	-1.000	.332
	Rugby Post (n=17)	0.06	0.24		
Depression	Rugby Pre (n=17)	0.00	0.00	-2.219	.041*
	Rugby Post (n=17)	0.24	0.44		
Sexual Problems	Rugby Pre (n=17)	0.00	0.00	*No Statistic*	
	Rugby Post (n=17)	0.00	0.00		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void.

** $p < .05$. ~ $.05 < p < .15$*

Table 3.15:

Dependent T-Tests for Controls Pre versus Controls Post on the ImPACT Symptom Scale

	ImPACT	Mean	S.D	t-value	p-value
Total Symptom Score	Control Pre (n=9)	9.78	9.40	0.647	.536
	Control Post (n=9)	7.56	8.32		
Headache	Control Pre (n=9)	0.00	0.00	-2.294	.051~
	Control Post (n=9)	0.56	0.73		
Nausea	Control Pre (n=9)	0.00	0.00	-1.512	.169
	Control Post (n=9)	0.22	0.44		
Vomiting	Control Pre (n=9)	0.00	0.00	-1.000	.347
	Control Post (n=9)	0.11	0.33		
Balance Problems	Control Pre (n=9)	0.11	0.33	-1000	.347
	Control Post (n=9)	0.33	0.71		
Dizziness	Control Pre (n=9)	0.00	0.00	-1.414	.195
	Control Post (n=9)	0.33	0.71		
Fatigue	Control Pre (n=9)	1.33	1.66	0.000	.000
	Control Post (n=9)	1.33	1.23		
Insomnia	Control Pre (n=9)	0.89	1.45	1.492	.174
	Control Post (n=9)	0.11	0.33		
Sleeping More	Control Pre (n=9)	0.78	1.20	0.316	.760
	Control Post (n=9)	0.67	1.66		
Sleeping Less	Control Pre (n=9)	1.22	1.48	1.673	.133~
	Control Post (n=9)	0.44	0.73		
Drowsiness	Control Pre (n=9)	1.00	1.32	0.603	.563
	Control Post (n=9)	0.67	1.00		
Sensitivity to Light	Control Pre (n=9)	1.11	2.09	1.414	.195
	Control Post (n=9)	0.11	0.33		
Sensitivity to Noise	Control Pre (n=9)	0.00	0.00	-1.000	.347
	Control Post (n=9)	0.11	0.33		

Continued p.78

Table 3.15 (continued)

Irritability	Control Pre (n=9)	0.22	0.44	-1.000	.347
	Control Post (n=9)	0.44	0.73		
Sadness	Control Pre (n=9)	0.44	1.01	1.000	.347
	Control Post (n=9)	0.11	0.33		
Nervousness	Control Pre (n=9)	0.89	1.45	1.348	.214
	Control Post (n=9)	0.33	0.50		
Emotional	Control Pre (n=9)	0.33	1.00	0.000	1.000
	Control Post (n=9)	0.33	0.71		
Numbness	Control Pre (n=9)	0.00	0.00	-1.000	0.347
	Control Post (n=9)	0.11	0.33		
Slowed Down	Control Pre (n=9)	0.22	0.44	-1.000	.347
	Control Post (n=9)	0.44	0.73		
Mentally Foggy	Control Pre (n=9)	0.22a	0.44		
	Control Post (n=9)	0.22a	0.44		
Concentration	Control Pre (n=9)	0.56	0.88	1.414	.195
	Control Post (n=9)	0.22	0.44		
Remembering	Control Pre (n=9)	0.44	0.88	0.800	.447
	Control Post (n=9)	0.22	0.44		
Visual Problems	Control Pre (n=9)	0.00	0.00	-1.000	.347
	Control Post (n=9)	0.11	0.33		

Note. a= t cannot be computed as the standard error of the difference is 0

** $p < .05$. ~ $.05 < p < .15$*

Table 3.16:

Dependent T-Tests for Controls Pre versus Controls Post on the 31-Item Post-Concussion Symptom Questionnaire

	Post-Concussive Questionnaire	Mean	S.D	t-value	p-value
Total Symptom Score	Control Pre (n=9)	9.11	5.86	0.123	.905
	Control Post (n=9)	8.89	6.85		
Headache	Control Pre (n=9)	0.22	0.44	-1.414	.195
	Control Post (n=9)	0.56	0.53		
Nausea	Control Pre (n=9)	0.00	0.00	-1.000	.347
	Control Post (n=9)	0.11	0.33		
Vomiting	Control Pre (n=9)	0.00	0.00	*No Statistic*	
	Control Post (n=9)	0.00	0.00		
Poor Appetite	Control Pre (n=9)	0.11	0.33	-0.426	.681
	Control Post (n=9)	0.22	0.67		
Balance Problems	Control Pre (n=9)	0.11	0.33	-0.426	.681
	Control Post (n=9)	0.22	0.67		
Dizziness	Control Pre (n=9)	0.11	0.33	-0.800	.447
	Control Post (n=9)	0.33	0.71		
Fatigue/ Tiredness	Control Pre (n=9)	0.89	0.93	-0.816	.438
	Control Post (n=9)	1.22	0.97		
Trouble Fall Asleep	Control Pre (n=9)	0.67	0.71	2.294	.051~
	Control Post (n=9)	0.11	0.33		
Sleeping More	Control Pre (n=9)	0.89	1.05	0.894	.397
	Control Post (n=9)	0.56	1.67		
Sleeping Less	Control Pre (n=9)	0.44	0.73	0.000	1.000
	Control Post (n=9)	0.44	0.73		
Drowsiness	Control Pre (n=9)	0.11	0.33	-2.294	~ .051
	Control Post (n=9)	0.67	0.71		
Sensitivity to Light	Control Pre (n=9)	0.44	1.33	0.707	.500
	Control Post (n=9)	0.11	0.33		

Continued p.80

Table 3.16 (continued)

Sensitivity to Noise	Control Pre (n=9)	0.00	0.00	*No Statistic*	
	Control Post (n=9)	0.00	0.00		
Difficulty Hearing	Control Pre (n=9)	0.22	0.44	1.000	.347
	Control Post (n=9)	0.11	0.33		
Irritability	Control Pre (n=9)	0.56	0.53	-0.686	.512
	Control Post (n=9)	0.78	0.83		
Aggression	Control Pre (n=9)	0.11a	0.33		
	Control Post (n=9)	0.11a	0.33		
Sadness	Control Pre (n=9)	0.11	0.33	0.000	1.000
	Control Post (n=9)	0.11	0.33		
Nervousness	Control Pre (n=9)	0.78	1.56	0.800	.447
	Control Post (n=9)	0.56	1.01		
Feeling More Emotional	Control Pre (n=9)	0.33	0.50	0.555	.594
	Control Post (n=9)	0.22	0.44		
Numbness / Tingling	Control Pre (n=9)	0.33	1.00	1.000	.347
	Control Post (n=9)	0.00	0.00		
Feeling Slowed Down	Control Pre (n=9)	0.33	0.71	-1.000	.347
	Control Post (n=9)	0.67	0.71		
Mentally Foggy	Control Pre (n=9)	0.22	0.44	-1.000	.347
	Control Post (n=9)	0.33	0.71		
Difficulty Concentrating	Control Pre (n=9)	0.56	0.73	0.426	.681
	Control Post (n=9)	0.44	0.53		
Difficulty Remembering	Control Pre (n=9)	0.44	0.53	0.000	1.000
	Control Post (n=9)	0.44	0.73		
Visual Problems	Control Pre (n=9)	0.11	0.33	0.000	1.000
	Control Post (n=9)	0.11	0.33		
Speech Problems	Control Pre (n=9)	0.11a	0.33		
	Control Post (n=9)	0.11a	0.33		

Continued p.81

Table 3.16 (continued)

Anxiety Problems	Control Pre (n=9)	0.56	1.01	1.315	.225
	Control Post (n=9)	0.11	0.33		
Restlessness	Control Pre (n=9)	0.22	0.44	0.000	1.000
	Control Post (n=9)	0.22	0.44		
Social Withdrawal	Control Pre (n=9)	0.00	0.00	*No Statistic*	
	Control Post (n=9)	0.00	0.00		
Depression	Control Pre (n=9)	0.00	0.00	*No Statistic*	
	Control Post (n=9)	0.00	0.00		
Sexual Problems	Control Pre (n=9)	0.11	0.33	1.000	.347
	Control Post (n=9)	0.00	0.00		

Note. Where *No Statistic* is reported, all the subjects have no impairment thus rendering a statistical comparison null and void; a = t cannot be computed as the standard error of the difference is 0

*$* p < .05$. *$\sim 0.05 < p < 0.15$*

Specific symptoms demonstrating significance ($p < .05$) in the direction of rugby worse than controls (independent samples) and rugby worse at post-season (dependent samples) on the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire, are summarised in the summary grid (See Table 3.17). A large cluster of symptoms were revealed as significant at the pre-season stage, these constituted physical/neurological symptoms (headaches, nausea, vomiting ,balance problems, dizziness, sensitivity to noise, numbness, visual problems, sleeping less, and drowsiness), three cognitive symptoms (feeling slowed down, feeling mentally foggy, and difficulties in remembering), and two emotional/behavioural symptom (irritability and aggression). At the post-season stage symptoms revealed as significant included physical/neurological symptoms (sensitivity to light, insomnia, sensitivity to noise, visual problems and restlessness), four cognitive symptoms (feeling slowed down, difficulties in concentrating and remembering) and three emotional/behavioural symptoms (sadness, aggression, feeling more emotional, and depression). With regards to the control group, (See Summary Grid, Table 3.18) on the independent t-test sample comparisons between rugby and controls, only one emotional/behavioural symptom was revealed as significant at the pre-season stage (anxiety), and at the post-season stage only one cognitive symptom (feeling slowed down) reached significance. Clearly rugby participants are demonstrating a more pronounced symptom profile than control participants on the independent sample comparisons at the pre- and post-season stages.

For the pre- versus post season dependent samples comparison, analysis of the results of the reduced sample are strongly commensurate with those of the full sample, for both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire, with the overall indication that there was no particular direction of change in the symptom presentation from the pre- to post-season stages in either the rugby players or the control participants. Only isolated changes reaching significance ($p < . 05$). All symptoms which are significant for the rugby group are included in the 31-Item Post-Concussion Symptom Questionnaire, and not on the ImPACT Symptom Scale. These included: two physical/neurological symptoms (restlessness and speech problems) and one emotional/neurobehavioural symptom (depression). For the control group only one physical/neurological symptom was significant on the ImPACT Symptom Scale.

Table: 3.17:

Summary Grid to show significance for individual symptoms (p < .05) in the direction of rugby worse than controls (independent samples) and rugby worse at post-season (dependent samples) on the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire

		Independent Samples				Dependent Samples	
		ImPACT		P-C-Q		ImPACT	P-C-Q
		Pre	Post	Pre	Post		
Physical/ Neurological:	Headache	*~		~			
	Nausea	*~		*			
	Vomiting	*~					
	Balance Problems	*					
	Dizziness	*~					
	Fatigue						
	Insomnia				~		
	Sleeping More						
	Sleeping Less			*			
	Drowsiness			~			
	Sensitivity to Light		*~		*		
	Sensitivity to Noise	*~		*~	*		
	Numbness	*					
	Visual problems	*~		~	*~		
	Speech problems•						~
	Poor Appetite•						
	Difficulty hearing•						
	Sexual Problems•						
	Restlessness•				~		*~
Cognitive:	Slowed Down	*			*		
	Mentally Foggy	*~					
	Concentration		~				
	Remembering	*	~				
Emotional / Behavioural	Aggression•			*~	*~		
	Anxiety problems•						
	Irritability	*~					
	Sadness		~				
	Nervousness						
	Emotional						
	Social Withdrawal•						
	Depression•				~		*~

* = significant on the full sample; ~ significant on the reduced sample; • symptoms which appear on the 31-Item Post-Concussion Symptom Questionnaire and not on ImPACT

Table 3.18: Summary grid to show significance for individual symptoms in the direction of controls worse than rugby (independent samples) and where controls are worse at post-season (dependent samples) on the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire

		Independent Samples				Dependent Samples	
		ImPACT		P-C-Q		ImPACT	P-C-Q
		Pre	Post	Pre	Post		
Physical/ Neurological:	Headache						
	Nausea						
	Vomiting						
	Balance Problems						
	Dizziness						
	Fatigue					~	
	Insomnia						
	Sleeping More						
	Sleeping Less						
	Drowsiness						
	Sensitivity to Light						
	Sensitivity to Noise						
	Numbness						
	Visual problems						
	Speech problems•						
	Poor Appetite•						
	Difficulty hearing•						
	Sexual Problems•						
	Restlessness•						
Cognitive:	Slowed Down				*		
	Mentally Foggy						
	Concentration						
	Remembering						
Emotional / Behavioural	Aggression•						
	Anxiety problems•			*			
	Irritability						
	Sadness						
	Nervousness						
	Emotional						
	Social Withdrawal•						
	Depression•						

* = significant on the full sample; ~ significant on the reduced sample; • symptoms which appear on the 31-Item Post-Concussion Symptom Questionnaire and not on ImPACT

4. DISCUSSION

The aim of this research was to contribute to the growing literature which deals with sports-related Mild Traumatic Brain Injury (MTBI) and the consequences thereof. The present study formed part of an ongoing computer-based research program that is investigating the use of the ImPACT program at various levels of play, including the top two university rugby teams. In particular, this project focused on a comparison between the self-reported symptoms of MTBI at the pre- and post-season stages in Rugby Union players at university level versus non-contact sport controls, using the ImPACT program, in conjunction with a 31-Item Post-Concussion Symptom Questionnaire. T-Tests were used to make pre-season and post-season comparisons between the rugby and control groups on both the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire. It was hypothesised that the rugby group would report a higher number of post-concussive symptoms at both the pre- and post-season stages when compared to the control group. When the rugby group at pre-season was compared to the rugby group at post-season it was unclear what results were to be expected, as concussed players were excluded from the study. One might expect evidence of sub-concussive effects, which are not as easily identified as concussions. However, this was unlikely as the study was conducted over only one season.

On examining the demographic data for the full sample of participants, a highly significant result was found, as expected, for number of concussions, with rugby having a greater number of concussions (an average of 2 when rounded off to the nearest integer) than the control group. Moreover, highly significant differences were also found for age and level of education, with the control group having a higher mean age and education standard than the rugby group. On the reduced sample, a similarly significant result was found for number of concussions. The reduced sample groups were well matched for level of education and IQ, although there was still a significant age disparity. It is considered that the small age difference (1.5 years) between the rugby group and the control group would not be of clinical significance. Thus, the results in synthesis are likely to be explainable in terms of the highly significant difference between the two groups for numbers of concussions sustained.

Results of the independent t-tests are consistent on all samples at the pre- and post-season stages, with the expected outcome that rugby participants reported a greater number of symptoms when compared to controls. This supports a study by Field, Collins, Lovell, and Maroon (2003) who recorded both a greater number of concussions and a higher incidence of post-concussive symptoms in their rugby concussion group when compared to their control group. Iverson, Gaetz, Lovell, and Collins (2002a) found that, at baseline, athletes who had sustained prior concussions reported more post-concussive symptoms than controls. Since the acute effects of concussion would have resolved during the off-season break, for participants in the present study it would appear that the pre-season symptoms displayed by rugby players are suggestive of the cumulative, lingering effects of multiple concussions as proposed by Iverson, Gaetz, Lovell and Collins (2002a).

In contrast to the independent sample t-tests, the dependent sample t-tests found no change in the symptomatic profile of the rugby participants when the rugby group at the pre-season stage was compared to the rugby group at the post-season stage. This suggests that, despite the possibility of having sustained sub-concussive blows, these may not have been severe enough to result in changes after only one rugby season. It would appear that changes occur cumulatively over many years of participation in rugby. One could expect that the symptom pattern of the rugby participants would worsen as further rugby seasons are taken into consideration, but this is clearly not the case in this research as the study is limited to one season. As a result, rugby participants are similar to controls, showing no change from the pre- to the post-season intervals. *Consequently all future discussion of symptom patterns elicited in this research will be discussed with reference to the independent t-test sample analyses.*

Across the independent t-test analyses, only one symptom, the emotional/behavioural symptom anxiety, was reported by the control group to occur significantly more frequently than the rugby group. This may suggest that the control group was by nature a more anxious group than the rugby group, or it may imply that the rugby group had more physical symptoms to report. In contrast, and as expected, several symptoms were revealed to be significantly more prevalent in the rugby group when compared to controls, across both the full and the reduced

sample. At the pre-season stage, on the ImPACT Symptom Scale, physical/neurological symptoms included: headaches, nausea, vomiting, sensitivity to noise, and dizziness. Cognitive symptoms included feeling mentally foggy and emotional/behavioural symptoms included irritability. As noted at the Second International Conference for Concussion in Prague, these self-reported symptoms are commonly reported following an MTBI (McCrory et al., 2005). The permanent symptoms which were found by Tysvaer & Storli (1981), in soccer players, included symptoms similar to the present study, namely: physical symptoms headaches, dizziness, difficulty in hearing, and insomnia) cognitive symtoms (weakened memory) and emotional/behavioural symptoms (irritability). Chamelain and Feinsten (2004) found that the presence of the physical symptom dizziness was associated with worse psychosocial functioning and poorer return to work. Consequently, the significance for the symptom dizziness may have important implications for academic performance of the university rugby players who participated in this study. It is of note that the symptom 'feeling mentally foggy' isa feature of the sports concussion literature, and has been especially emphasized in research by Iverson, Gaetz, Lovell, & Collins (2002b), as discussed previously (p.19).

On the 31-Item Post-Concussion Symptom Questionnaire, the additional emotional/behavioural symptom of aggression (which is not present in the ImPACT Symptom Scale) appeared to be consistently significant across analyses. This may suggest that the rugby group is by nature a more aggressive group of participants than the control group. According to Lishman (1999) it is possible that outbursts of aggression might represent the exaggeration of already-present personality traits. However, aggression has also been noted as one of the symptoms commonly associated with frontal lobe damage (Lishman, 1999) which may be the result of a closed head injury. Furthermore it is included as a symptom of the proposed Post-Concussional Disorder included within the DSM-IV-R (See p. 6). Damage to the frontal lobe may result in a lack of foresight and insight in conjunction with diminished control over impulsive, instinctual behaviour (Webster, 2002). Evidence has shown that frontal lobe damage acquired early in life contributes to disabilities in the areas of insight, foresight, social judgement and empathy (Price, Daffner, & Stowe, 1990). There is a high incidence of a history of brain abnormality or head injury amongst prisoners and individuals who display anti-social behaviours (Lewis,

Pincus, & Feldman, 1986; Malloy, Noel, & Lonabaugh, 1990; Schmeck, 1985). This is alarming given the high frequency of concussions amongst contact sports players.

In addition to the emotional/behavioural symptom of aggression, eight additional symptoms are omitted from the ImPACT Symptom Scale which are incorporated into the 31-Item Post-Concussion Symptom Questionnaire. These include five physical/neurological symptoms (speech problems, difficulty in hearing, poor appetite, sexual problems and restlessness), and five emotional/behavioural symptoms (anxiety, social withdrawal and depression). Four of these self-reported symptoms which do not appear on ImPACT were seen to be significantly worse for rugby when compared to controls in the present research, across analyses on the 31-Item Post-Concussion Symptom Questionnaire, as follows (symptoms are presented in order from the highest number of times this symptom reached significance across all analyses, to the lowest): aggression, depression, restlessness, and speech problems.

Findings in the 31-Item Post Concussion Symptom Questionnaire replicates prior research by Shuttleworth-Edwards et al. (2004) in a study of professional, under-21 and schoolboy rugby players, where a similar symptoms were shown to have discriminatory abilities on this questionnaire. These symptoms included aggression, speech problems, sensitivity to noise, fatigue, and difficulties in concentrating, which were reported as significantly worse for rugby participants than control participants. All of these symptoms are described as the emotional or behavioural consequences of having suffered an MTBI (Lezak, 1995; Lishman, 1999) and may have important social relevance (for example: speech problems might contribute to the development of a low self-esteem; cognitive symptoms might result in poorer academic performance; frontal lobe symptoms such as aggression may contribute to anti-social tendencies within the environment, as discussed earlier on p.88). However, for the present study, one cannot exclude the possibility that such symptoms may be the result of pre-selection factors due to its largely cross-sectional, rather than prospective design. In other words, it is possible that the rugby group is by nature a more aggressive group than the more anxious control group. In contrast, the rugby group in this study may be demonstrating the consequences of prolonged participation in rugby associated with multiple incidents of concussion. In the case of aggression in particular, it is possible that the outcome

represents a combination of an initial character in combination with an overlay of typical MTBI effects (see discussion earlier p. 88). It is noted that aggression is one of the included symptoms for the proposed Post-Concussional Disorder in the DSM-IV-R (American Psychiatric Association, 2000), but however appears to an omission form the ImPACT Symptom Scale.

In conclusion, the present research strongly suggests the presence of residual post-concussive symptoms at the pre-season stage among rugby players when compared to controls. The rugby group reported a greater number of symptoms than the control group, at both the pre- and post-season stages. The most common symptoms which have been identified may be divided into the physical/neurological, cognitive and emotional/behavioural domains. Common physical/neurological symptoms include headaches, nausea, vomiting, sensitivity to noise, visual problems, dizziness, and restlessness. The most common cognitive symptoms appear to be feeling mentally foggy, difficulties in concentrating and remembering, and the most common emotional/behavioural symptoms are irritability and aggression. Whereas the cognitive symptom 'subjective feelings of fogginess' appear to be well documented in the sports concussion literature by researchers such as Iverson, Gaetz, Lovell, & Collins (2002b) and is included in the ImPACT Symptom Scale, the emotional/behavioural symptom aggression (a common outcome of frontal lobe damage frequently associated with head injuries) is not.

5.EVALUATION OF THE STUDY

5.1 Limitations of the Study

Limitations of the study include the small sample sizes of 30 rugby participants and particularly only 17 control participants in the full sample, and 20 rugby participants and 9 control participants in the reduced sample. According to Satz et al. (2002) the minimum sample size for research into head injuries is 20 participants, therefore the large sample is barely adequate and the reduced sample control group is inadequate. However, the problem of a small sample size would be the failure to identify differences when there are differences (Type II error), and in spite of the small sample size in the present study, significance results and clear trends are clearly demonstrated on the reduced sample. This is in keeping with the

theoretical expectation and research literature. Although groups were matched for education and IQ on the reduced sample, a significant difference was still found for age, although the difference of 1.5 years is considered unlikely to have influenced the results. Due to the largely cross-sectional nature of the study one cannot exclude pre-existing differences between groups. However, it appears unlikely that the rugby group would be disproportionately different over such a wide range of symptoms from controls, in particular a cluster of symptoms which have been documented to be associated with outcome following MTBI or specific frontal lobe pathology, including headaches, nausea, vomiting, speech difficulties, aggression, and irritability. These symptoms are therefore more likely to be the result of previous head injuries. This study focused exclusively on male university students and the generalisation of such results to female university athletes is unknown. Overall, in spite of the limitations outlined above, these do not appear to preclude the validity of the results which provide compelling evidence that university players, after a number of years of playing rugby, are displaying cumulative effects of MTBI in the form of enhanced levels of post-concussive symptoms.

5.2 Strengths of this Study

This study is the first study to focus exclusively on post-concussive symptoms at the pre- and post-season stages. To date no studies have incorporated a review of studies conducted on post-concussive symptoms as included in this research. The study utilised a computer-based measure (ImPACT which has been found effective in the identification of the concussion sequelae), in conjunction to a more traditional pen-and paper questionnaire. This allowed for comparisons between the ImPACT Symptom Scale and the 31-Item Post-Concussion Symptom Questionnaire, and recommendations for the refinement of the ImPACT Symptom Scale to be made.

6. RECOMMENDATIONS FOR FURTHER RESEARCH

If the study were to be replicated, it would be useful do so with a larger sample size, and to provide comparative groups of female athletes. While it was not expected to find differences amongst rugby forwards and rugby backs at a university level, further studies should incorporate these subdivisions in order to confirm the null hypothesis. The ImPACT Symptom Scale should be broadened to include the additional symptoms from the 31-Item-Post-Concussion Symptom Questionnaire; this should be validated in future research. In the overall research study of which this mini-thesis forms one part, an in-depth analysis of post-concussive symptoms, and a battery of cognitive tests were utilised. It would be important as the next step to consider the joint implications of these results.

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APPENDIX A: Summary of Outcome Studies

Table 1.3:

Summary of Outcome Studies of Post-Concussive Symptoms in the General Population

Researchers	Nature of Investigation	Acute or Chronic	Participants	Results & Conclusions
Bohnen, Jolles & Twijnstra (1992)	The link between Pts with PCS at six months and cognitive functions	Chronic	23 male and 23 female Pts who had suffered an MTBI.	9 Pts who reported PCS at 6 months after the MTBI were significantly slower on cognitive testing than matched patients displaying no such PCS, and also than healthy controls. There was no significant difference on cognitive testing between patients without persisting PCS and healthy controls.
Callaway et al. (1999)	The incidence & predictors of PCS after a minor head injury.	Acute	102 Hosp MTBI Pts + 22 Hosp controls	MTBI Pts: Most commonly reported changes in memory (28%) or concentration (23%). 22 Hosp Controls: more commonly reported Depression (18%).
Chamelain & Feinstein (2004)	Effect of dizziness on psycho-social outcome after mild to moderate traumatic brain injury	Chronic	207 adults who had suffered a mild or moderate TBI	66.7% reported dizziness. Dizziness was associated with worse psycho-social functioning, and poorer return to work
Chan (2001)	Base rates of PCS among non-MTBI participants		85 non-MTBI Pts	PCS reported: Longer time to think (65.9%), forgetfulness (58.9%), poor concentration (58.9%), fatigue easily (53.5%) and sleep disturbances (50.6%).
Chan (2002)	The examination of attentional performance in Pts with persisting PCS	Chronic	92 Pts reporting persisting PCS + 86 controls	Pts with Persisting PCS demonstrated a deficit in attention when compared with Controls.

Continued p.

Table 1.3 (continued)

Evans (1996)	A Study of non-Athletes examined 4 weeks after a MTBI	Acute	Non-Athletes	PCS reported: 19.0% memory loss 21.0% of concentration difficulties, and 20.1% reported somatic complaints. The most common PCS were fatigue, anxiety, personality changes, irritability & sleep disturbances.
Iverson & Lange (2003)	The prevalence of Post-Concussive-like Symptoms in Healthy Individuals		104 healthy individuals	Endorsement for PCS ranged from 35.9% to 75.7%. PCS showed a correlation with Self-Reported Depressive Symptoms. Post-Concussive-like Symptoms are not confined to head injuries and are commonly found among healthy individuals.
Kumar et al. (2005)	Investigated the role of PCS Sensory Gating Impairment in MTBI Pts.	Acute	30 MTBI Pts	Using a multiple regression method, it was concluded that the PCS reported by MTBI Pts are the result of poor modulation of incoming sensory information.
Mickeviciene et al. (2005)	Controlled prospective study on post-concussive symptoms examined after 3 months and one year.	chronic	300 MTBI subjects each matched for sex and age to controls	No differences found in headaches or several unspecified PCS. Significant findings on memory problems, concentration, dizziness & tiredness.
Necajauskaite, Endiziniene & Jureniene (2005)	Clinical features and prevalence of symptoms post-concussive syndrome	Chronic	301 MTBI Pts 301 non-head injury Pts Pts were matched for age, gender, and date of admission to Hosp	Prior to trauma no difference on reports of headaches, irritability, sleep disorders, learning difficulties, concentration & memory problems. In MTBI Pts a significant decrease was found in headaches, irritability after the trauma. Among controls a decrease concentration problems prior to examination.

Note. PCS = post-concussive symptoms; Pts = patients; Hosp = hospital; MTBI = mild traumatic brain injury.

Table 1.4:

Summary of Outcome Studies of Post-Concussive Symptoms in Athletes

Researchers	Nature of Investigation	Acute or Chronic	Participants	Results & Conclusions
Asplund, McKeag & Olsen (2004)	Predictive value of MTBI signs and symptoms based on return-to-play guidelines	Acute	91 male Ath 10 female Ath	Headaches longer than three hours and difficulty concentrating longer than three hours may indicate a more severe injury or prolonged recovery.
Collins, Field, et al., (2003)	Post-concussion headache and neuropsychological test performance	Acute	109 high-school Ath	7 days post MTBI Ath with headaches report larger number of other PCS than Ath with no headaches. Post-concussion headaches were associated with significantly slower reaction times and poorer performance in memory tasks
Collins, Iverson, et al. (2003)	On-field markers of concussion severity and post-injury neuropsychological and symptom presentation	Acute	78 Ath	Ath exhibiting pronounced PCS and memory deficits at 2 days post-injury were ten times more likely to have experienced retrograde amnesia compared with those having fewer PCS and a good outcome from injury. Ath with degree of post-traumatic amnesia were four times as likely to exhibit poor post-injury presentation from a MTBI. Brief LOC was not found to be predictive of PCS or neurocognitive deficits.
Erlanger et al. (2003)	Relationship between history of concussion & number of PCS , duration of PCS	Acute	47 Ath who had sustained an MTBI	LOC & history of concussion were not good predictors of the duration of PCS. Ath reporting memory problems at follow-up examinations also reported more PCS, longer durations of PCS, and decreases in scores on neurocognitive tests Decline of scores on neurocognitive testing scores was associated with an increased duration of PCS.

Continued p.

Table 1.4 (continued)

Table 1.4:

Summary of Outcome Studies of Post-Concussive Symptoms in Athletes

Researchers	Nature of Investigation	Acute or Chronic	Participants	Results & Conclusions
Asplund, McKeag & Olsen (2004)	Predictive value of MTBI signs and symptoms based on return-to-play guidelines	Acute	91 male Ath 10 female Ath	Headaches longer than three hours and difficulty concentrating longer than three hours may indicate a more severe injury or prolonged recovery.
Collins, Field, et al., (2003)	Post-concussion headache and neuropsychological test performance	Acute	109 high-school Ath	7 days post MTBI Ath with headaches report larger number of other PCS than Ath with no headaches. Post-concussion headaches were associated with significantly slower reaction times and poorer performance in memory tasks
Collins, Iverson, et al. (2003)	On-field markers of concussion severity and post-injury neuropsychological and symptom presentation	Acute	78 Ath	Ath exhibiting pronounced PCS and memory deficits at 2 days post-injury were ten times more likely to have experienced retrograde amnesia compared with those having fewer PCS and a good outcome from injury. Ath with degree of post-traumatic amnesia were four times as likely to exhibit poor post-injury presentation from a MTBI. Brief LOC was not found to be predictive of PCS or neurocognitive deficits.
Erlanger et al. (2003)	Relationship between history of concussion & number of PCS , duration of PCS	Acute	47 Ath who had sustained an MTBI	LOC & history of concussion were not good predictors of the duration of PCS. Ath reporting memory problems at follow-up examinations also reported more PCS, longer durations of PCS, and decreases in scores on neurocognitive tests Decline of scores on neurocognitive testing scores was associated with an increased duration of PCS.

Continued p.

Table 1.4 (continued)

Field, Collins, Lovell, and Maroon (2003)	Symptoms and neurocognitive recovery patterns after sustaining an MTBI	Acute	371 college Ath 183 high school Ath	Sole reliance on PCS was found to be inadequate in return-to-play decisions. Self-reporting of PCS was not predictive of poor performance on neuropsychological testing.
Iverson, Gaetz, Lovell, and Collins (2002a)	Cumulative effects MTBI	Acute	19 Ath who reported a history of 3 + concussions. 19 controls who reported no prior MTBI	At baseline (pre-season) Ath who had sustained previous concussions reported PCS than the matched controls. Headaches, memory problems and the difficulty thinking clearly were highly endorsed by those with multiple concussions
Iverson, Gaetz, Lovell, & Collins (2002b)	Subjective reports of feeling mentally foggy at 1-week post-concussion and acute neurological outcome	Acute	110 Ath who had sustained a sports-related MTBI .	Ath with persistent fogginess had significantly slower reaction times, reduced memory performance and processing speed. Ath who reported feelings of fogginess reported a large number of other PCS when compared with Ath who did not report feeling foggy. Feelings of fogginess were associated with an increased risk of incomplete recovery one week after suffering an MTBI.
Kaut, DePompei, Kerr, and Congeni (2003)	Prevalence of head injuries and related symptoms Behavioural tendencies whilst symptomatic.	Acute	461 male and female college Ath	32% of Ath sustained a blow to the head which had resulted in dizziness. >25% confirmed somatic complaints following a MTBI. 28.2 % and 30.4 % of individuals reporting dizziness and headaches respectively continued to play whilst symptomatic.

Continued p.

Table 1.4 (continued)

Lovell et al. (2003)	Memory dysfunction and the self-reporting of PCS in high school Ath following an MTBI. On-field markers of concussion and the recovery of memory processes within 1 week of sustaining an MTBI.	Acute	64 high school Ath who sustained a concussion 24 who had not (control group).	A significant difference was found between the presence of self-reported PCS at baseline and at 36 hours post-concussion. The concussion group reported more PCS after a concussion than they did during the pre-season stage. No difference was found in symptom reporting at days 4 & 7. A measurable memory decline in a small group of Ath was found one week after sustaining an MTBI.
Lovell, Collins, Iverson, Johnston, and Bradley (2004)	Neuropsychological functioning following an MTBI	Acute	35 male, 8 female high school Ath	36 hours post injury; Ath who had sustained an MTBI demonstrated a decline in memory and a sharp increase in self-reported symptoms when compared to their baseline (pre-season) performance.
Killam, Cautin, & Santucci (2005)	Residual Neuropsychological effects of head trauma	Acute	28 Ath undergraduate students of at least 20 years old.	In recent MTBI Ath, lower memory scores correlated with more severe PCS checklist scores. PCS scores correlated negatively with scores of attention.

Note. Pts = patients; Ath = athletes; MTBI = mild traumatic brain injury; PCS = post- concussive symptoms; LOC Loss of Consciousness; * = Measures (where applicable).

Table 1.5:

Summary of Outcome Studies of Post-Concussive Symptoms in American Football

Researchers	Nature of Investigation	Acute or Chronic	Participants	Results & Conclusions
Collins, Grindel, Lovell, et al. (1999)	Relationship between a history of prior concussions and a diagnosed learning disability.	Acute	393 male college football players	Participants who had a prior history of concussion were found to have an increase in self-reported PCS
Pellman, Powell, et al. (2004)	Circumstances, causes, and outcomes of concussions	Acute	National Football League teams	Most common initial PCS for concussed players were headaches, dizziness, memory problems, cognitive problems and somatic complaints. Headaches(55%0, dizziness, including vertigo (45.7 %) , blurred vision (16.3 %), double vision (2%), photophobia (4.1%), memory and cognitive problems (45.9%), difficulties with immediate recall (25.5%), disorientated to time (8%), disorientated to place (5.1%), disorientated to person (2.9%). Most players complained of more than one symptom.
Pellman, Viano, Casson, Arfken, and Powell (2004)	Signs, symptoms and outcome of concussions which resulted in 7+ days away from play, or an extended recovery following MTBI	Acute	887 concussions reported by the National Football League teams	PCS were grouped into general symptoms, somatic complaints, cranial nerve effects, cognition problems, memory problems and unconsciousness. . PCS occurred at a greater frequency on initial examination (baseline) among players who : spent seven or more days away from play, were disorientation to time, retrograde amnesia, fatigue and the general category of cognitive problems 1.6% suffered prolonged PCS

Note. PCS = post-concussive symptoms; MTBI = mild traumatic brain injury; LOC = loss of consciousness; * Measures used (where applicable).

Table 1.6:

Summary of Outcome Studies of Post-Concussive Symptoms in Soccer

Researchers	Focus of Study	Acute or Chronic	Subjects	Results & Conclusions
Barnes et al., (1998)	The mechanism, frequency and sequelae following soccer injuries	Acute	39 male players & 23 female players	Most common PCS included headaches, being dazed and dizziness.
Jordan, Green, Galantty, Mandelbaum & Jabour (1996)	Chronic encaephalopathy in elite soccer players resulting from repetitive heading	Chronic	25 male soccer players 20 age matched track athlete controls mean age 24.9	Symptoms did not correlate with age, years of play or the number of headers. PCS correlated with history of prior acute MTBI
Putukian, Echemendia & Mackin (2000)	Acute effects of heading in soccer on cognitive function.	Acute	44 male & 56 female college soccer players	No differences were found in the number of symptoms before and after heading when compared to controls.
Tysvaer & Storli (1981)	Symptoms after Soccer ball heeding	Acute / Chronic	128 soccer players	Protracted Symptoms that were reported include headaches, neck pain, dizziness, irritability, insomnia & hearing disturbances. Permanent symptoms that were reported include headache, dizziness, irritability, insomnia, difficulty hearing, weakened memory and an abnormal alcohol reaction.

Note. PCS = post-concussive symptoms.

Table 1.7:

Outcome Studies of Post-Concussive Symptoms in Rugby

Researchers	Focus of Study	Acute, Chronic or Sub-Concussive	Subjects	Results & Conclusions
Shuttleworth-Jordan, Puchert & Balarin (1993)	Effects of MTBI	Acute	60 university rugby players at the pre-season stage, 20 rugby players at the post-season stage 25 non-sport controls	5 MTBI subjects at 3 days post-concussion reported the following PCS: headaches, visual problems, poor attention & concentration, anxiety, insomnia, fatigue, vomiting, restlessness, loss of appetite, sensitivity to noise, weakness of limbs, clumsiness & speech problems. At one month a reduction in PCS was seen. At 3 month PCS had resolved.
Shuttleworth-Edwards, Border, Reid & Radloff (2004)	Effects of concussion in rugby	Chronic	26 Professional; 19 Under 21; 47 School rugby players 76 controls (hockey and cricket)	PCS were 20-30% greater in rugby players vs controls. Professionals reported high percentages of argumentativeness (62%), clumsy speech (50%), sustained attention (73%) and sensitivity to noise (23%). Under 21's reported high percentages of sensitivity to noise (42%), aggressiveness (42%), clumsiness (42%), fatigue (63%) and clumsy speech (58%). School rugby reported high percentages of sleep difficulties (36%), easily angered (13%), and clumsy speech (53%).

Note. PCS = post-concussive symptoms; vs = versus; * Measures used (where applicable).

Table 1.4:

Summary of Outcome Studies of Post-Concussive Symptoms in Athletes

Researchers	Nature of Investigation	Acute or Chronic	Participants	Results & Conclusions
Asplund, McKeag & Olsen (2004)	Predictive value of MTBI signs and symptoms based on return-to-play guidelines	Acute	91 male Ath 10 female Ath	Headaches longer than three hours and difficulty concentrating longer than three hours may indicate a more severe injury or prolonged recovery.
Collins, Field, et al., (2003)	Post-concussion headache and neuropsychological test performance	Acute	109 high-school Ath	7 days post MTBI Ath with headaches report larger number of other PCS than Ath with no headaches. Post-concussion headaches were associated with significantly slower reaction times and poorer performance in memory tasks
Collins, Iverson, et al. (2003)	On-field markers of concussion severity and post-injury neuropsychological and symptom presentation	Acute	78 Ath	Ath exhibiting pronounced PCS and memory deficits at 2 days post-injury were ten times more likely to have experienced retrograde amnesia compared with those having fewer PCS and a good outcome from injury. Ath with degree of post-traumatic amnesia were four times as likely to exhibit poor post-injury presentation from a MTBI. Brief LOC was not found to be predictive of PCS or neurocognitive deficits.
Erlanger et al. (2003)	Relationship between history of concussion & number of PCS , duration of PCS	Acute	47 Ath who had sustained an MTBI	LOC & history of concussion were not good predictors of the duration of PCS. Ath reporting memory problems at follow-up examinations also reported more PCS, longer durations of PCS, and decreases in scores on neurocognitive tests Decline of scores on neurocognitive testing scores was associated with an increased duration of PCS.

Continued p.

Table 1.4 (continued)

Field, Collins, Lovell, and Maroon (2003)	Symptoms and neurocognitive recovery patterns after sustaining an MTBI	Acute	371 college Ath 183 high school Ath	Sole reliance on PCS was found to be inadequate in return-to-play decisions. Self-reporting of PCS was not predictive of poor performance on neuropsychological testing.
Iverson, Gaetz, Lovell, and Collins (2002a)	Cumulative effects MTBI	Acute	19 Ath who reported a history of 3 + concussions. 19 controls who reported no prior MTBI	At baseline (pre-season) Ath who had sustained previous concussions reported PCS than the matched controls. Headaches, memory problems and the difficulty thinking clearly were highly endorsed by those with multiple concussions
Iverson, Gaetz, Lovell, & Collins (2002b)	Subjective reports of feeling mentally foggy at 1-week post-concussion and acute neurological outcome	Acute	110 Ath who had sustained a sports-related MTBI .	Ath with persistent fogginess had significantly slower reaction times, reduced memory performance and processing speed. Ath who reported feelings of fogginess reported a large number of other PCS when compared with Ath who did not report feeling foggy. Feelings of fogginess were associated with an increased risk of incomplete recovery one week after suffering an MTBI.
Kaut, DePompei, Kerr, and Congeni (2003)	Prevalence of head injuries and related symptoms . Behavioural tendencies whilst symptomatic.	Acute	461 male and female college Ath	32% of Ath sustained a blow to the head which had resulted in dizziness. >25% confirmed somatic complaints following a MTBI. 28.2 % and 30.4 % of individuals reporting dizziness and headaches respectively continued to play whilst symptomatic.

Continued p.

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Continued p.

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Continued p.

APPENDIX B: Pre-Season Questionnaire

Dear Rugby/Hockey/Cricket /Swimming member

RHODES UNIVERSITY RESEARCH STUDY: CONCUSSION IN SPORT

In keeping with the need to maximize the safety of sports players generally, and particularly in the contact sports where there is a known risk of concussion, it has been decided to implement the latest internationally approved risk prevention strategies for concussion for top team rugby and hockey players at Rhodes University. *The initiative has the full support of the Director of Sports Administration, Peter Andrew, who believes that the study will (i) provide short-term benefit to concussed players, and (ii) in the long-term contribute to the refinement of sports concussion management.*

It is generally considered that computer-based screening of reaction times and memory function provides easily accessible, yet *crucial* information for concussion management especially with respect to return-to-play decisions. Our objective is to initiate an innovative study, which aims to develop such facilities within the South African school and university contexts, which are already extensively in place in sports playing institutions in countries such as the USA, Australia and New Zealand. Consequently, you will have the unique opportunity to participate in this groundbreaking research by clinicians at Rhodes University, who are working in collaboration with the University of Pittsburgh Medical School, USA and the MRC/UCT Research Unit for Exercise Science and Sports Medicine, Newlands, South Africa.

Members of the top two rugby teams will be the first to participate in this monitoring and risk prevention project at university level. Measuring for the effects of any past or future concussions will take place pre and post winter sport season using scientifically valid computerized screening systems developed in the USA specifically for concussion management. Screening will involve the evaluation of functions such as memory, reaction time and processing speed and will take the form of simple paper and pencil exercises and computer games. These are usually enjoyable and take 40 minutes to complete. In addition, you will be asked to provide a brief medical background and complete a symptom checklist, with relevance to the research.

There will be ongoing sports concussion monitoring through the winter season and appropriate intervention. In the event of a concussion, follow-up evaluation of concussed players will take place within 36 hours of injury and then again at weekly intervals, until acute symptoms resolve. The data will be examined by researchers at Rhodes University and if the outcome proves favourable in terms of minimizing risk to players, the strategy will be considered for future use at top team levels where there is a higher injury risk. The results of the research will be used for scientific publication purposes only by the collaborating universities.

It is important to be aware that this study does not interfere with or substitute for good medical practice. We therefore advise that all individuals with concussion should be seen as soon as possible by their general practitioner or other medical practitioners and should not return to contact sport for at least 3 weeks from the time of injury and thereafter on the advice of the medical practitioner. The information collected on individual players will be strictly confidential and will only be made available to individuals and/or a medical practitioner on request. This information may form part of the management decision in individual cases. However, the researchers will not be held accountable for medical decisions made by medical practitioners or individual players on the basis of that information.

We believe that it is to your benefit to participate in this concussion risk prevention project. However, participation is voluntary and you have the right to withdraw form the entire project or part thereof if you so wish. Non-participation in this study will exclude you from the benefit of computer-based cognitive screening in the event of a concussion.

Yours sincerely

Prof Ann Edwards (Research Coordinator)

Peter Andrew (Director: Sports Administration)

(Researcher)

(Researcher)

(Researcher)

RHODES UNIVERSITY
DEPARTMENT OF PSYCHOLOGY

CONSENT FORM

I, _____ have been informed of the nature of the research which will be conducted by three Rhodes University masters students, Ian Smith, Melissa Boulind and Stephanie Case, on the effects of concussion in University rugby.

I understand that:

1) The above mentioned students are conducting the concussion management research as a requirement for a MA degree at Rhodes University in collaboration with the University of Pittsburgh Medical School, USA and the MRC/UCT Research Unit for Exercise Science and Sports Medicine, Newlands, South Africa. The research has the full support of the Rhodes University Director of Sports Administration, Mr Peter Andrew.

2) The research will involve all willing members of the top two rugby and hockey teams at Rhodes University. Team members will be assessed for the effects of any past or future concussions using internationally validated computer-based neuropsychological screening batteries, pre and post winter sport season. In the event of a concussion, a follow-up assessment will take place within 6 days, of injury and then again at weekly intervals, until acute symptoms resolve. In addition, individuals will be requested to fill out a brief demographic questionnaire with medical background and a symptom checklist, with relevance to the research.

3) This study does not interfere with or substitute for good medical practice. It is therefore advised that in the event of a concussion, individuals should be seen as soon as possible by a general practitioner or other medical practitioners and should not return to contact sport for at least 3 weeks from the time of injury and thereafter on the advice of the medical practitioner.

4) Participation in the research is strictly voluntary. Individuals have the right to withdraw from the study at any stage, although by not participating in the project, no base-line scores or concussion follow-up by the researchers will be available for that player.

5) The information collected on individual players will be strictly confidential and will only be made available to the participants and/or a medical practitioner on request. This information may form part of the management decision in individual cases. However, the researchers will not be held accountable for medical decisions made by medical practitioners or participants on the basis of that information.

6) Data arising out of this project will be used for thesis and publication purposes only by the collaborating universities.

Signed: _____ **Date:** _____

Name: _____ **E-mail address:** _____

Contact Telephone Number(s): _____ _____

RHODES UNIVERSITY
DEPARTMENT OF PSYCHOLOGY

BRIEF TO RUGBY/HOCKEY/CRICKET PLAYERS AND SWIMMING TEAM MEMBERS REGARDING CONCERNS ABOUT PARTICIPATION IN CONCUSSION RESEARCH

We believe that it is in your best interest to participate in this concussion monitoring and risk prevention project, although participation is voluntary.

1. The participant has the right to withdraw from the entire project or any part thereof. Withdrawal from the project will not prejudice him in any way in terms of his position in team sport.

2. Withdrawal from the project must occur in writing. The participant must complete the withdrawal form below.

3. We wish to emphasize that the project is neither invasive nor harmful to the participant's physical, mental and or emotional well being. For research purposes, the identity of the participants will be kept strictly confidential and individual data will be made available for clinical purposes only with the participant's permission.

4. By not participating in the project, in the event of a concussion no base-line scores or concussion follow-up by the researchers will be available for that player.

5. Should the player participate in a sport where there is not a great head injury risk, his participation is still of crucial benefit to the research. This is in order to make comparisons between players who are exposed to sports concussion, and those who are not exposed. Moreover, should the participant sustain a head injury for any other reason, any deterioration in cognitive functioning would be more accurately assessed in relation to baseline data derived from the study.

WITHDRAWAL FORM

I, _____ hereby wish to withdraw from participating in the university's concussion project. I am aware of the possible negative consequences to my well-being in declining computer-based monitoring in respect of concussion.

SIGNED: _____

DATE: _____

PRE-SEASON QUESTIONNAIRE

CONFIDENTIAL

First Names: _____ Surname: _____

Date of Birth: _____ Age: _____

Highest educational qualification: _____

Degree for which you are currently registered? _____ Current Year of study: _____

Contact telephone number during university term: _____ E-mail address: _____

A. BACKGROUND INFORMATION

Last school attended: _____

Height: _____ m Weight: _____ kg

Right handed: ☐ Left-handed: ☐ (please tick)

Country of birth: _____ First Language: _____

Second Language: _____ Years speaking second language: _____

Please tick if any of the following are relevant to you:

- ☐ You have received speech therapy
- ☐ You have attended special classes or remedial classes
- ☐ You have received occupational therapy
- ☐ You have repeated any grades at school (please specify)
- ☐ You have repeated any subjects at university (please specify)
- ☐ You have been diagnosed with ADD or Hyperactivity
- ☐ You have been diagnosed with a learning disability

What winter sport(s) do you play?

SPORT	POSITION	WHAT TEAM WERE YOU IN LAST YEAR?	HOW MANY YEARS HAVE YOU PLAYED AT THIS LEVEL?

How many times have you sustained a concussion (ie. Felt dazed, dizzy or confused, however briefly, or unconscious)? _____

If you have sustained a concussion, please complete the following:

CONCUSSION	YEAR	REASON FOR CONCUSSION	SYMPTOMS EXPERIENCED *(please tick)*			
			LOSS OF CONSCIOUSNESS *IF YES, STATE DURATION*	CONFUSION	MEMORY DIFFICULTIES FOR EVENTS IMMEDIATELY AFTER INJURY	MEMORY DIFFICULTIES FOR EVENTS IMMEDIATELY BEFORE INJURY
1						
2						
3						
4						
5						
6						
7						

Please indicate whether you have experienced the following:

	YES	NO
Treatment for headaches by physician		
Treatment for migraine headaches by physician		
Treatment for epilepsy/ seizures		
History of meningitis		
Dependency on alcohol		
Dependency on drugs		
Treatment for alcohol abuse		
Treatment for drug abuse		
Treatment for psychiatric condition (depression, anxiety etc.)		

B. CURRENT SYMPTOMS AND CONDITIONS

Hours of sleep last night _____

Current medications _____

Average weekly alcohol consumption _____

Average daily alcohol consumption _____

APPENDIX C: Vocabulary

VOCABULARY

NAME: ..... AGE: .....years.....months DATE: .....

ITEM	RESPONSE	SCORE
1		
2		
3		
4 Start		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		

TOTAL RAW SCORE = ...

APPENDIX D: Picture Completion

PICTURE COMPLETION NAME ..... AGE ..../...../05

ITEM	RESPONSE	SCORE
1		
2		
3		
4		
5		
6 Start		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

TOTAL RAW SCORE = ...

APPENDIX E: 31-Item Post-Concussion Symptom Questionnaire

31-Item Post-Concussion Symptom Questionnaire

Name:..... Age:.....

Please tick the appropriate column which indicates the degree to which you are currently experiencing the following:

	Not experiencing			Somewhat		Severe	
	0	1	2	3	4	5	6
Headache							
Nausea							
Vomiting							
Poor Appetite							
Balance Problems							
Dizziness							
Fatigue / Tiredness							
Trouble Falling Asleep							
Sleeping More Than Usual							
Sleeping Less Than Usual							
Drowsiness							
Sensitivity to Light							
Sensitivity to Noise							
Difficulty Hearing							

	Not experiencing			Somewhat			Severe
	0	1	2	3	4	5	6
Irritability							
Aggression							
Sadness							
Nervousness							
Feeling More Emotional							
Numbness / Tingling							
Feeling Slowed Down							
Feeling Mentally Foggy							
Difficulty Concentrating							
Difficulty Remembering							
Visual Problems (Blurred Vision)							
Speech Problems							
Anxiety Problems							
Restlessness							
Social Withdrawal							
Depression							
Sexual Problems							

9. LIST OF TABLES: