An Investigation of Mild Traumatic Brain Injury in Club-Grade Rugby: A New Zealand Study

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Psychology at Massey University

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2002

Mild traumatic brain injury (MTBI) in sports is a relatively common phenomenon, particularly where a high degree of physical contact is a central feature of the sport. While many of the MTBI's incurred by athletes may be innocuous, some result in negative outcomes that are more persistent and disabling. It is important, therefore, to ensure that sporting groups not only have adequate knowledge about the incidence and severity of MTBI and of the factors that typically surround its occurrence, but that they also have adequate guidelines regarding appropriate assessment, management and treatment of this phenomena.

Despite numerous studies having been conducted with elite/professional or school grade players in high-contact sports such as American gridiron football and rugby league, very little research has been conducted in the area of club-grade rugby, and to-date, there has been no detailed examination of MTBI incurred at this level. The present investigation sought to rectify this situation.

The proposed investigation, incorporating male rugby players participating in a regional club-grade competition, took place in two distinct phases. In the first phase of the research, three questionnaires were administered to players and to those monitoring the sport (i.e., coaches, team management, and referees). The results revealed a high rate of MTBI (14.4%), of which 20.7% of concussions involved a loss of consciousness (LOC). Identified risk factors included: (1) being under 21 years of age; (2) being a forward player, in particular a flanker; (3) the second half of a match; (4) frequent involvement in tackles; and (5) having a history of more than two MTBI. While a relatively high rate of mouthguard use was identified, it unfortunately did not reflect the compulsory use required by mandatory rugby laws. Attitudes relating to mouthguard use indicate that more education surrounding the proven benefits of mouthguard use in MTBI prevention is required at this level.

Slightly more than half of the MTBI reported in the current investigation failed to receive any attention, with players involved at the top club-grade level (i.e., Senior I) more likely to have their injury go unrecognised than players in lower grades. Such findings are attributed in part to the subtlety of MTBI symptomology, but more importantly, to an apparent reluctance on the part of players to report these symptoms. While the majority of those monitoring club-grade players reported basic first aid training/qualifications, the need for more specific training in the assessment and management of MTBI is evident on the basis of the research findings. A general lack of knowledge regarding recommendations for periods of abstinence after MTBI (as advised by governing sporting bodies) was also demonstrated, highlighting another area requiring further attention.

Phase II of the research involved the administration of three neuropsychological measures sensitive to deficits in information processing speed (Symbol Digit Modalities Test, Digit Symbol-Coding Test and Speed of Comprehension Test) in an attempt to monitor the rate of recovery after MTBI. However, on the basis of players reluctance to report (a phenomenon which appeared endemic at this level), the objectives in relation to this phase of the research were not achieved.

The apparent failure of the latter research phase effectively highlights just one of a number of methodological problems associated with conducting research with this particular population, of which other difficulties also primarily relate to the collection of data (i.e., less-than-ideal testing conditions, missing data, etc.). On the basis of the research findings, continuing education and relevant training in relation to MTBI is advocated for all those involved at the club-grade level, particularly in relation to symptom recognition, potential adverse outcomes, protective factors and appropriate assessment and management techniques. Despite the challenges this area presents for research, continued exploration is recommended with careful consideration given to the methodological issues raised in the current investigation.

ACKNOWLEDGEMENTS

There are a number of people whom I would like to sincerely thank for their contribution to the formation of this thesis. Firstly, I would like to acknowledge the commitment and dedication afforded to this project by my primary supervisor, Professor Janet Leathem. Janet, your encouragement, guidance and extensive knowledge in the field of neuropsychology has proved invaluable over this course of study. Thank you also for your support on both a professional and personal level. My sincere thanks also to Associate Professor John Podd, my second supervisor, for his expertise and much respected advice. I would also like to extend my gratitude to Dr. Ross Flett, who offered his time selflessly to assist with the statistical analyses undertaken in this research, and whose enduring patience was greatly appreciated.

In particular I would like to express my sincere appreciation to the players, referees, coaches and members of team management who gave of their valuable time – this research would certainly not have been possible without your co-operation. Thank you also to the Manawatu Rugby Football Union for their tolerance and support. I would especially like to acknowledge the financial contribution afforded by the Neurological Foundation, which enabled the present study to be undertaken. Thank you also to the School of Psychology for their support, both professional and financial, over the course of this project.

Thank you also to my fantastic friends, in particular to those who have shared a similar journey – your support has been truly valued. Finally, I would like to thank my wonderful family for their enduring love and support over the years. In particular I would like to thank my parents, for their unwavering belief in my abilities especially in times of my own doubt. My achievement is also yours.

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Introduction

The decision to conduct research in the area of rugby-related mild traumatic brain injury (MTBI) was influenced by observations drawn from the literature, international interest and anecdotal reports. Section 1.1 sets out the rationale for the current research based on these observations, while an overview of the topics subsequently addressed within the introductory chapters (Chapters 2-5) and the chapters associated with the present study (Chapters 6-11) is presented in Section 1.2.

1.1 RATIONALE UNDERLYING THE RESEARCH

Rugby union is a team sport that involves a high degree of physical contact, skill and tactical variation (Williams & Hunter, 2001). It is played in 104 countries throughout the world (Collinson, 1984) and is extremely well popularised in New Zealand, so much so, that it is considered by many to be New Zealand's national sport (Bird et al., 1998). Rugby has received widespread support in this country with approximately 200,000 individuals (Dalley, Laing, Rowberry, & Caird, 1982) involved at the school, club, provincial and international levels.

In a contact sport such as rugby, the potential for injury is high. In New Zealand, rugby union accounts for the highest rate of injury in sport (22.4% - 60.5%) and has the highest fatality rate (1.35 deaths per 100,000 participants per year) (Hume & Marshall, 1994). In terms of its financial toll, accident information revealed that rugby-related injury accounted for 23% of new claims in 1998, totaling $8.8 million, with males aged between

15 – 29 years accounting for half of this cost (Accident Rehabilitation and Compensation Insurance Corporation [ACC], 1998). These rugby-related statistics showed that injuries to the head, incorporating cerebral concussion, contusions and fractures, comprised 1.9% of all injury sites, and accounted for 2.2% of new cost claims and 2.9% of ongoing claims. While the proportion of injuries to the region of the head appears small, the cost of new claims for head-related injuries totaled $3,932,000 - a cost exceeded only by other central nervous system (CNS) injuries (spine, neck), shoulder and knee injuries (ACC, 1998).

Cerebral concussion, a subset of mild traumatic brain injury (MTBI) (McCrory, 2001), is the most common of sports-related brain injury (Maroon, 1999) and the most poorly documented (Hoy, 1987). Knowledge of the insidious nature of MTBI led to the assumption that symptoms and sequelae associated with such an injury may not be recognised or reported by individuals involved in this sport. On this basis and in conjunction with the high rate of injury exhibited in rugby, it was expected that the incidence of MTBI in this sport could be higher than formal statistics have previously indicated. A review of the literature by this researcher revealed a number of significant points.

Firstly, in the realm of sport-related injury research, sports such as American gridiron and rugby league have received much of the attention internationally, with rugby union by comparison being somewhat neglected. This oversight was bought to the attention of those in attendance at the 1997 International Neuropsychological Society (INS) conference - an omission that has provided some impetus in the formulation of the current research proposal.

Secondly, the literature tends to focus on a broad spectrum of site-specific injuries. While many of these investigations addressed the rate of injury sustained to the region of the head, neck and face, few clearly distinguished between a 'head injury' and an injury resulting in trauma to the brain. This distinction is further complicated by the inconsistent use of terminology defining MTBI.

Thirdly, the method of data collection employed by much of the research in the area has been retrospective in nature, with a large proportion of data drawn from hospital admissions or from those who came to the attention of medical personnel. On this basis and in combination with anecdotal reports of deeply ingrained attitudes held by rugby players toward injury, it was anticipated that the incidence of MTBI would be underreported.

Lastly, athletes participating in previous investigations have been gathered from elite/professional sports teams or from school or college teams. In New Zealand, a substantially large proportion of those active in rugby participate at club grade level, reflecting largely uncharted territory with respect to research in this area.

On the basis of these observations it became apparent that the literature neglected specific investigations into the rate of MTBI evidenced within club grade rugby. It was expected that by concentrating on brain injuries of this severity, some benefit could be derived for players in terms of education - improving recognition, monitoring and assessment of MTBI at the level of club grade rugby.

1.2 OUTLINE OF THESIS

The five subsequent chapters introduce research in the area of sport-related traumatic brain injury (TBI), with specific emphasis on rugby-related TBI. Chapter 2 addresses: issues pertaining to the use of terminology in sport-related research; the pathophysiology of TBI and the mechanical forces specifically implicated in sport-related MTBI; the sequelae associated with MTBI; and the measurement of MTBI severity. Chapter 3 reviews issues of data collection in the realm of sports injury research and presents the most recent literature pertaining to MTBI rates in a variety of contact sports, with an emphasis on rugby from both an international and national research perspective. Chapter 4 introduces current practices recommended for a brief sideline assessment of MTBI and more thorough neuropsychological assessment, as well as reviewing the numerous guidelines for return to play after a concussion. Chapter 5 introduces aspects associated with the prevention of sport-related TBI, reviewing risk factors associated with rugby-related injury and detailing injury prevention techniques. Chapter 6 synthesises the literature relevant to the current research programme and details the objectives of the investigation relating to each of two research phases.

The remaining chapters in the thesis incorporate the methodology, results and discussion associated with the current investigation. Chapter 7 details the hypotheses, formulation and procedures associated with the administration of three research questionnaires which constitutes Phase I of the research. Chapter 9 presents the methodology employed by the second phase of the research involving brief neuropsychological assessment to aid in monitoring recovery from MTBI. Chapters 8 and 10 detail the results obtained from each of these research phases. The final chapter discusses these findings, reviews the methodological difficulties and limitations of the current study, and incorporates recommendations for future research.

CHAPTER TWO

Overview of Traumatic Brain Injury

The first section of this chapter covers the issues pertaining to terminology use raised briefly in the introduction and advocates a stance for the appropriate utilisation of the terms head injury, brain injury, mild/minor head injury, mild/minor traumatic brain injury, and concussion. Section 2.2 reviews the pathophysiology of TBI and the mechanical forces typically involved in sport-related MTBI. The symptoms evident after a brain trauma (i.e., physical, behavioral, and cognitive sequelae) are reviewed in Section 2.3, along with the duration of recovery from MTBI. The fourth section introduces the syndromes associated with MTBI – post-concussive syndrome (PCS) and second impact syndrome (SIS), and also reviews the cumulative effects of MTBI. As a consequence of problems inherent in the inconsistent use of terminology, numerous classification systems to grade the severity of sport-related brain injury have emerged. Section 2.5 reviews some of the more well recognised and widely adopted of these systems, developed in an attempt to establish diagnostic reliability for concussion of varying degrees of severity. The main points highlighted in this chapter are summarised in Section 2.6.

2.1 INJURY TERMINOLOGY

2.1.1 Head Injury vs. Brain Injury

A basic premise underlying sound methodological research is that it is based on constructs that have a sound operational definition. This is not the case in sport-related brain injury research where the terms used to describe mild craniocerebral trauma are varied and inconsistent. A major confusion arises in the literature primarily through the interchangeable use of the terms 'head injury' and 'brain injury'. Lindsay, McClatchie, and Jennett (1980) define head injury as including "linear or depressed fracture, intracranial haematoma or contusion, or diffuse injury" (p.789), while McCrory, Dicker, and Maddocks (1992) use the same term to describe skin lacerations, soft tissue or bone injury, and brain injury. In the context of sports injuries, Bailes (1999a) uses head injury to incorporate epidural, subdural, or intracerebral haematoma, diffuse axonal injury, subarachnoid hemorrhage, cerebral contusion, and concussion. On the basis of the aforementioned descriptions head injury appears to imply a broad definition encompassing both extracranial and craniocerebral trauma. The dilemma faced in adopting the term 'head injury' in its broadest sense is that extracranial trauma may have no neurological consequences at all (Thurman, Branche, & Sniezek, 1998).

In contrast, the term 'brain injury' is more often applied when neurological effects are evident. Traumatic brain injury may produce:

> ... a disturbance of consciousness resulting in an impairment of cognitive abilities or physical functions, but can result in a disturbance of behavior or emotional functioning. The disorders may be temporary or permanent and may cause partial or total functional disability or psychosocial maladjustment (Gerstenbrand & Stepan, 2001; p. 95).

Distinguishing between 'head injury' and 'brain injury' is especially difficult in mild cases. Reitan and Wolfson (1999) point out that while most people could claim to have experienced a 'mild head injury' (MHI) if criteria incorporated any bump or blow to the head, not everyone experiences an injury to the brain, and fewer still sustain structural brain damage. Hence, it is advocated that the term head injury be reserved for those injuries in which only extracranial trauma is apparent.

2.1.2 Mild Traumatic Brain Injury (MTBI)

MTBI is defined by the Mild Traumatic Brain Injury Committee as:

> ... a traumatically induced physiological disruption of brain functions as manifested by *at least* one of the following: (1) any period of loss of consciousness (LOC) of 30 minutes or less; (2) any loss of memory (no longer than 24 hours) for events immediately before or after the accident; (3) any alterations in mental state at the time of the accident (i.e., feeling dazed, disoriented, or confused); or (4) focal neurological deficits that may or may not be transient (Kay et al., 1993; p. 86)

MTBI may occur in "the absence of any observable or unequivocal diagnostic evidence of brain tissue damage" (Reitan & Wolfson, 1999; p. 62), although research has reported significant structural damage is possible in cases of MTBI (Cantu, 1996a; Newcombe, 1996; Tellier et al., 1999). Regardless of whether structural brain damage is apparent, alterations of consciousness often in conjunction with the presentation of post-traumatic symptoms is sufficient to indicate mild/minor TBI (Marion, 1999).

Hallmark features of MTBI include a LOC (Ruff & Jurica, 1999), confusion and amnesia (Marion, 1999). The main features of confusion include heightened distractibility, an inability to maintain a coherent stream of thought in addition to difficulty carrying out a sequence of goal-directed movements (Kelly & Rosenberg, 1997). The amnesia experienced is typically characterised by a disturbance of memory for a period immediately after the event, referred to as post-traumatic amnesia (PTA) (Lucas, 1998). There may also be a retrograde amnesia experienced, which constitutes a loss of memory for the events preceding the trauma. These features can occur immediately after a trauma to the head or several minutes later (Kelly & Rosenberg, 1997). For example, in the absence of a LOC, research has found that a blow to the head can cause pronounced temporary impairment of recent memory within 3 – 20 minutes after the injury without other neurological signs (Lynch & Yarnell, 1973).

2.1.3 Concussion

Concussion is defined by the Committee on Head Injury Nomenclature of the Congress of Neurological Surgeons (1966) as a clinical syndrome evidenced by "transient post-traumatic disturbance in neural function such as alteration in consciousness, disturbance of vision, or equilibrium" (p. 36). According to Echemendia and Julian (2001), some confusion exists regarding the length of time symptoms must be present to receive a diagnosis of concussion, as the Congress of Neurosurgeons definition would indicate that if symptoms appear, even momentarily, a diagnosis is warranted.

While the term 'concussion' is often used interchangeably with MTBI with some degree of confidence, some argue that these terms are not synonymous and that concussion should be considered a subset of MTBI (McCrory, 2001). Less appropriately, based on the argument presented earlier, is the view that concussion is a 'type' of MHI (Hinton-Bayre, Geffen, & Geffen, 1997; Erlanger, Kutner, Barth, & Barnes, 1999). The overlap and interchangeability of the terms 'mild/minor head injury' and 'concussion' serves to add to the confusion that already exists in the literature. For example, Wilberger (1993) utilises the definition of concussion supplied by the Congress of Neurosurgeons to describe the term 'minor head injury'. For research purposes, Rimel, Giordani, Barth, Boll, and Jane (1981) produced a definition of concussion describing it as an acceleration/deceleration injury producing a LOC or diminished consciousness for a period no longer than 20 minutes, a Glasgow Coma Scale (GCS) score greater than 12, and negative neuroimaging on examination. PTA also was required to be present but last less than 24 hours. This particular definition has since been used to describe MHI (Kibby & Long, 1997; Guskiewicz, Riemann, Perrin, & Nashner, 1997). Guskiewicz et al. (1997) appear to argue that MHI is a subset of concussion. They state that the term MHI should describe any grade 1 and grade 2 concussion[1], with concussive injuries greater than grade 2 indicative of a more severe injury.

2.1.4 Position Advocated for the Current Research Programme

Nowhere is the inconsistent use of terminology describing diminished neurological functioning more apparent than in sport-related brain injury literature. The terms 'concussion' and 'mild head injury' are viewed either as distinct entities, denoting separate events along a continuum, or alternatively (and more frequently) are used interchangeably describing the same sequelae. The utilisation of the term 'mild head injury' has been widely adopted by those conducting sport-related research and is often adopted in preference to the term 'mild traumatic brain injury'.

The following stance is advocated in relation to the terminology adopted for this research. Theoretically the term 'mild head injury' should be abandoned, but it has served a practical purpose in sport-related research (Wills & Leathem, 2001; see Appendix A). The use of this term is justified in part on the basis of the difficulty of detecting underlying brain damage in many head injury cases (Bernstein, 1999). Additionally, the term 'concussion' is often value laden. Previous research has indicated that players do not typically associate the symptoms of loss of awareness or transient amnesia with concussion, and in some instances even fail to recognise that a LOC is indicative of concussion (Gerberich, Priest, Boen, Straub, & Maxwell, 1983). Based on these arguments the terms 'mild head injury' and 'head injury' have been utilised throughout the data collection phase of this research to obtain as much information as possible, as the term denotes a broader definition of injury sustained both to the head and brain.

Once a brain injury has been indicated, either by a LOC or an alteration of consciousness evidenced by confusion, amnesia, disorientation, or the presence of

[1] The severity criteria relating to Grade 1 and Grade 2 concussions is addressed in detail in Section 2.5.

postconcussive symptoms, the terms 'mild traumatic brain injury' (MTBI/mild TBI) or 'concussion' will be used. While it can be argued that concussion should be considered a subset of MTBI, providing a distinction between the two for the purposes of this research appears unnecessary.

Additionally, in presenting literature where the terms 'mild/minor head injury' have been employed, these terms will be italicised when evidence indicates MTBI is a more appropriate designation.

2.2 PATHOPHYSIOLOGY

2.2.1 Pathophysiology of TBI

Brain injury is typically classified as being either open or closed (Lucas, 1998). Open brain injury has the potential to cause direct injury to brain tissue due to the skull being crushed or penetrated by a foreign object (Cantu, 1992; Lucas, 1998). In contrast, a closed brain injury does not expose the contents of the skull, and may result from either direct or indirect forces. Richardson (1990) argues that the primary mechanism of damage for closed brain injury arises from a blunt (direct) impact, which occurs as a consequence of a forceful blow or fall. This impact produces deformation of the skull in conjunction with transient brain compression (Parker, 1990). There are three main mechanisms by which such a blow may cause TBI (Wallesch et al., 2001). Firstly, the impact of brain tissue with the overlying skull produces maximal injury to the brain beneath the point of impact (a coup lesion) with damage also possible directly opposite the site of cranial impact (a contrecoup lesion)(Cantu, 1992). The lesions produced are typically focal, with relatively small or well-differentiated areas of localised damage (McFarland & Macartney-Filgate, 1989, cited in Lezak, 1995[2]), of which contusions (bruises) are a primary feature (Lucas, 1998). The second mechanism is that of diffuse axonal injury (DAI), which is considered the major cause of post-traumatic neurological and neuropsychological impairment (Wallesch et al., 2001). The final mechanism of TBI in response to a blunt impact is secondary injury as a consequence of "oedema and space-occupying haemorrhages" (Wallesch et al., 2001; p. 402)

Indirect forces, such as a whiplash-type injury, are also an important feature of closed brain injury, occurring as a consequence of rapid acceleration and deceleration without direct head contact with any object (Parker, 1990; Kelly & Rosenberg, 1997). The mechanisms of acceleration (particularly rotational) and deceleration injures the brain primarily through shearing and tensile forces (Cantu, 1992), resulting in diffuse damage and widespread disruption of neurological functioning (Parker, 1990). A shear-strain model proposed by Barth et al. (1983) suggests that acceleration/deceleration forces produce axonal tearing and neuronal degeneration in various tracts of the brain stem accounting primarily for neural damage and subsequent behavioural dysfunction in MTBI.

2.2.2 Epidemiology & Pathophysiology of MTBI in Sports

Brain trauma accounts for an estimated 2 million incidents each year in the United States (Kaplan & Saddock, 1998). Motor vehicle accidents (MVA's) represent the major cause of closed brain injury amongst adults up until 65 years of age (Richardson, 1990) and accounts for nearly 50% of all *mild head injury* (Bernstein, 1999). Falls, occupational accidents, sports-related injuries, and assaults comprise the remaining injuries (King, 1997; Kaplan & Saddock, 1998; Bernstein, 1999). While Marion (1999) states that sports-related brain injury accounts for less than 5% of all reported TBI, others claim that sport accounts for approximately 20% of head trauma estimated to occur annually in the United States

[2] This source directs the reader to an abstract, for which the full text article could not be located.

(Erlanger et al., 1999). Sport-related injuries are the leading cause of medically attended brain injury for children under 15 years of age, while among 15-24 year-olds sports-related *head injuries* increase in incidence but are second in frequency to MVA's (Sosin, Sniezek, & Thurman, 1996).

Much of the pathophysiology research in MTBI has been conducted with animal subjects, with few studies having systematically documented the mechanisms of injury in athletes, except to report how injuries appeared to occur (Macciochi, Barth & Littlefield, 1998). In contrast to MVA's where the high velocity of impact produces severe brain injury (Civil, 1986), the velocity of impact experienced in sport as a consequence of falls and collisions is inherently different, with most sports-related TBI a product of low velocity impacts. The three main mechanisms through which sport-related MTBI is sustained are: (1) a direct impact or compressive force; (2) acceleration or tensile forces; and (3) shearing or rotational forces (Echemendia & Julian, 2001). Powell (1999) argues that the most important mechanism for sport-related MTBI is an impact or compressive injury that produces movements of the brain inside the skull leading to tissue damage. However, MTBI is equally reported to emerge as a consequence of indirect acceleration forces (Cantu, 1992; Ingersoll, 1993; Macciocchi et al., 1998).

Traditionally the localisation of lesions has been attributed to the site of impact (King, 1997). For example, coup lesions are considered a result of trauma to the front of the head, while coup or contrecoup lesions are produced by an impact to the side, or back of the head (Ingersoll, 1993). Little research has investigated whether one region of the head more commonly sustains direct impacts in comparison to others, although McIntosh and McCrory (2000) reported that the temporal-parietal area was most frequently struck in sports such as rugby league, rugby union, and Australian Rules football. In general, focal contusions and DAI have been shown to primarily affect the temporal and frontal lobes (Gentry, Godersky, & Thompson, 1988).

2.3 SEQUELAE ASSOCIATED WITH MTBI

As a consequence of the forces described in the previous section, certain neuropsychological sequelae may emerge, evidenced by "persistent emotional, cognitive, behavioural, and physical symptoms" (Kay et al., 1993; p. 87). Damage to the brain is more likely to exist if a trauma to the head is accompanied by a loss of awareness of current surroundings, and in some cases a LOC, with a wide variety of subjective symptoms being reported as an individual recovers full awareness (Lucas, 1998). Recovery to baseline levels of functioning may be variable, as although many of the symptoms associated with MTBI dissipate quickly, some may persist for weeks, months, or even a year.

2.3.1 Physical Symptoms of MTBI

The presence of a headache has traditionally been given much emphasis as an important indicator of concussion. The headaches experienced are typically diffuse and are aggravated by physical exertion as well as anxiety and stress (Wilberger, 1993). Headache was reported by 93% of concussed Australian Rules football players (Maddocks, Dicker, & Saling, 1995) and 72% of American football players (Barth et al., 1989) and accounted for the most commonly reported symptom in both studies. However, McCrory (1997) notes that as many as 20% of athletes report exercise-related headache, highlighting the fact that this symptom may not be confined solely to concussion. Other immediate symptoms of concussion include the presence of dizziness or vertigo, lack of awareness of surroundings, and nausea or vomiting (Cantu, 1992). Gerberich et al. (1983) argue for a combination of symptoms as being characteristic of MTBI including "auditory, visual or olfactory hallucinations, a sensation of being dinged, and poor co-ordination of body movements" (p. 1371).

2.3.2 Behavioral Changes Characteristic of MTBI

Behavioral symptoms such as irritability, anxiety, depression, insomnia, and rapid/excessive fatigue may be present for several days to weeks after mild brain trauma (Lucas, 1998). A three-centre study conducted by Levin et al. (1989) revealed that in addition to headache and dizziness, fatigue was one of the three most common complaints by patients who had sustained MTBI. Such behavioral changes have also been noted in sports. An investigation involving 100 concussed high-school American football players revealed that fatigue was the most frequently reported behavioral symptom, encountered by 75% of players, with irritability and anxiety each experienced by 40% of players (Wilberger, 1993).

2.3.3 Cognitive Deficits Associated with MTBI

Cognitive deficits associated with concussive injuries occur in the areas of information processing speed, attention and concentration, reasoning, visuospatial processing, memory (Barth et al., 1983), speech/language, and executive functions (Gerstenbrand & Stepan, 2001). Such deficits can have significant implications for athletes as they may contribute to impaired decision making, decreasing an athletes ability to evade potentially risky situations, and hence increase the possibility of incurring further injury (Ingersoll, 1993). A reduction in information processing speed, for example, affecting both the amount and rapidity at which information can be processed, may also affect aspects of attention, making athletes appear slow, distractible, forgetful, and inattentive (Gronwall, 1989). Evidence of persistent impairment after a concussive injury has been demonstrated in relation to visuospatial attention (Ceremona-Meteyard & Geffen, 1994), which in sports is particularly concerning as such functions influence a player's ability to respond quickly to spatial events. Hence, impairment may increase a player's risk of injury.

Deficits of memory are among the most common neurocognitive complaints as illustrated by one study where 59% of *minor head injury* patients complained of such difficulties 3 months post injury (Rimel et al., 1981). This specific deficit has important implications for an athlete, as while their ability to perform is unlikely to be impeded as a direct consequence of memory failure, difficulty remembering assigned tasks could place them in potentially dangerous situations (Ingersoll, 1993).

2.3.4 Recovery of Function

That the majority of MTBI's result in good recovery is virtually uncontested (Bernstein, 1999). Typically, the symptoms associated with the initial impact resolve within 2 to 30 minutes (Gentilini, Nichelli, & Schoenhuber, 1989), although in the presence of a LOC may take up to 24 hours (Rutherford, 1989). However, for some individuals deficits may persist. Follow-up studies have revealed variable findings with rates of recovery ranging from 5 – 10 days (Barth et al., 1989) to 1 year post-injury (Rutherford, Merrett & McDonald, 1979). However, the natural history for cognitive recovery from MTBI is toward spontaneous improvement within 3 months of injury (King, 1997).

An investigation of recovery from *mild head injury* in a non-athletic population identified that compromised memory functioning was evident within 1 week of the trauma (Ruff et al., 1989). However, within a month, patients had recovered both verbal and visual memory functioning to a level comparable to research controls. Leininger, Gramling, Farrell, Kreutzer, and Peck III (1990) reported that a subgroup of *minor head injury* patients continued to experience post-concussive symptoms for 1 month or more post-injury, in addition to performing significantly lower than uninjured controls on several measures examining reasoning, information processing, and verbal learning. Hugenholtz, Stuss, Stethem, and Richard (1988) revealed that the symptoms in over half of those with *mild concussion* had resolved by the end of the second week, although 23% of patients continued to report symptoms 1 month post-injury. These researchers reported that impaired information processing might persist in such patients for several months after the injury. Rimel et al. (1981) reported that only 16% of patients were symptom-free 3 months post-injury, with 79% of *minor head injured* patients continuing to experience persistent headaches at this time.

With respect to athletes' recovery of function from MTBI, the literature typically indicates a more rapid resolution of symptoms in contrast to non-athletes. An examination of *mild head injury (MHI)* sustained in American college football players revealed that in comparison to controls, players with *MHI* demonstrated cognitive dysfunction and increased symptoms, although these sequelae resolved rapidly, with recovery evident within 5 – 10 days post-injury (Barth et al., 1989). It was noted that while the self-reported symptoms (e.g., headache, dizziness, memory difficulties) appeared to resolve at a slower rate than the neurocognitive impairment, they too had largely dissipated by the tenth day post-injury. Research involving more than 300 amateur rugby players suffering at least one *mild head injury* showed over 60% of those injured reported headaches post-injury, although in 80% of these cases symptoms had resolved within 48 hours (Cook, 1969). The rapid resolution of symptoms evidenced was attributed in this investigation to the athletes' high motivation for recovery. This rationale is concerning as an athlete's desire to resume activity is unlikely to reflect a spontaneous and complete recovery of function. In contrast with these findings, Wrightson and Gronwall (1980) reported that one in five rugby players indicated symptoms associated with concussion persisting 90 days after treatment, although all of the injured players had returned to work after an average absence of 4.7 days.

2.4 SYNDROMES AND CUMULATIVE EFFECTS OF MTBI

2.4.1 Postconcussive Syndrome (PCS)

In a small but significant number of athletes, a constellation of persistent physiological, behavioral, and cognitive symptoms associated with MTBI together form what is referred to as a post-concussive syndrome (PCS) (Bernstein, 1999). According to Rutherford et al. (1979) approximately 15% of *mild head injury* sufferers continued to complain of postconcussive symptoms 1 year after injury.

Headaches and dizziness are considered the most prominent physiological symptoms to feature in this syndrome (Wilberger, 1993), while memory and concentration deficits are reported as being the most common cognitive complaints (Binder, 1986). Additional components of PCS include those that typically feature relatively soon after an individual has recovered from PTA (Grant & Alves, 1987) such as fatigue, irritability (Cantu, 1996b), impaired information processing skills, increased anxiety, emotional lability (Barth et al., 1983), sleep disturbances, and tinnitus (Cantu, 1992).

Unfortunately, as with the head/brain injury conundrum, there is little agreement in the literature on a precise definition for PCS (Bernstein, 1999), and its etiology and maintenance has generated much debate (Gunstad & Suhr, 2001). PCS has most often been conceptualised as a psychological disturbance in order to explain why an otherwise 'normal' individual experiences such symptoms (Wilberger, 1993). More recently the possibility of a specific neuropathological contribution to postconcussive symptoms has been raised, with evidence of neuronal loss and microscopic lesions in the brain stem being identified in even mild instances of brain injury (Barth et al., 1983; Gaetz, Goodman, & Weinberg, 2000). In patients experiencing persisting dizziness post-injury, up to 50% have abnormalities on brainstem evoked potential studies, while MRI scans have also shown abnormalities prevalent in frontal and temporal regions of *minor head injury* patients (Wilberger, 1993).

2.4.2 Second Impact Syndrome (SIS)

Second impact syndrome results when an individual sustains a second trauma to the brain before symptoms associated with an initial brain injury (most often mild in nature) have fully resolved (Cantu, 1992; Wilberger, 1993; Cantu & Voy, 1995; Kelly & Rosenberg, 1997). The second impact, in which consciousness can be retained (Wilberger, 1993), may lead to rapid cerebral swelling as a result of cerebrovascular congestion or a loss of cerebrovascular autoregulation. Consequently, there is a marked increase in intracranial pressure (Kelly & Rosenberg, 1997) which invariably leads to brain herniation and coma (McCrory, 1997).

The concept of this syndrome, first described by Schneider in 1973 and again, a little over 10 years later by Saunders and Harbaugh (Cantu, 1992), rests solely on the interpretation of anecdotal reports, with no case-control studies having been conducted to identify SIS risk factors (McCrory, 1997). However, examination of numerous case studies by Cantu and Voy (1995) has gone some way to reveal an established trend, giving some merit to SIS as an accepted entity. In the majority of these cases athletes have been shown to firstly experience residual post-concussive symptoms, including visual, sensory, or motor changes and difficulty with thought and memory. Secondly, after receiving a second blow the athlete would typically lapse into a coma with, as a consequence of brain herniation, massively increased intracranial pressure, and edema resulting in brain stem collapse (Cantu & Voy, 1995). Despite appropriate treatment, this condition carries a high mortality rate (McCrory, 1997).

2.4.3 Cumulative Effects of MTBI

While the current rate of brain injury occurring in sports can be estimated, the proportion of these brain injuries that are repeat injuries is not very well known (Wilberger, 1993) although the risk of repetition does appear to be high in many sports (Kelly & Rosenberg, 1997). In an investigation involving injured college football players 24% reported having a recurrent injury to the head or neck in the same season as the original injury (Albright, Mcauley, Martin, Crowley, & Foster, 1985). Gerberich et al. (1983) reported that of 3,063 high-school American football players 14% reported having experienced at least one previous episode of unconsciousness. A comparatively higher rate of repeat concussion was found in a study conducted by Bird et al. (1998) with 30% of those sustaining rugby-related concussion reporting a previous injury to the head, severe enough to warrant medical attention. It is generally accepted that once the first injury is sustained, the chance of the individual being subject to future brain injuries is four-to-six times greater (Kelly & Rosenberg, 1997; Marion, 1999).

In addition to placing an individual at greater risk of further injury, the likelihood of serious sequelae increases when MTBI is repeated (Kelly & Rosenberg, 1997). Gronwall and Wrightson (1975) identified significant and sustained neuropsychological abnormalities in individuals after a second MTBI in contrast to controls suffering only one MTBI. These authors later state that long term effects become more evident with repeat concussions, with memory and concentration deficits, personality changes, and diminished abilities becoming more evident to the individual, family, and friends (Wrightson & Gronwall, 1983). Carlsson, Svardsodd and Welm (1987) reported that cumulative effects of repeated brain trauma are likely to play a significant role in the development and persistence of post-concussive syndrome, having identified a strong correlation between the extent of post-concussive symptoms and previous brain injury.

While repeated concussions can cause long-term functional impairment for some individuals, knowledge of these effects for athletes are less well known (Nelson & Schoene, 1995a). A pilot study conducted by McCrory, Maddocks, and Dicker (1995) examining the cumulative effects of MTBI revealed that athletes do not *necessarily* suffer significant impairment as a consequence of multiple concussions. This study was limited, however, with respect to the number of players sustaining multiple injuries ($n = 6$) and the relatively short period of time over which they were monitored (5 years). More recently, Shuttleworth-Edwards, Border, and Radloff (in press) carried out an investigation with South African national and school level rugby players, revealing detrimental effects were more apparent for the older (national) players attributed to longer more intensive exposure to play and the additive effects of multiple brain trauma. Definitive conclusions regarding the effect of multiple concussions on outcome appear difficult to make on the basis of such investigations.

2.5 MEASURING INJURY SEVERITY

2.5.1 Measuring Severity of TBI

The severity of brain injury is typically gauged by evidence of loss of consciousness, duration of post-traumatic amnesia (PTA), and/or ratings on the Glasgow Coma Scale (GCS). The period of time an individual takes to regain consciousness is often used as an indicator of severity (Lucas, 1998), although the reliability of this information is somewhat questionable unless a witness to the injury can give corroborating evidence of duration. In addition, there is no indication in the research literature that longer periods of unconsciousness correlate with more severe concussive injury (Nelson & Schoene, 1995a).

The importance of measuring PTA cannot be understated as it provides a useful index of severity and is one of the best predictors of recovery (Wilson et al., 1999). A general guide to severity and recovery of function is presented in Table 1. This classification system suggests that a mild TBI is indicated by PTA lasting between 5 - 60 minutes, with recovery possible in 3 months or less with the possibility of only a few residual deficits thereafter (Kibby & Long, 1997).

Table 1.

Estimation of severity and duration of recovery as indicated by duration of PTA, based on an adaption by Kibby and Long (1997).

Estimated Severity	*Duration of PTA*	*Recovery (Time)*
Minimal	0 – 5 minutes	1 – 2 weeks
Mild	5 – 60 minutes	2 weeks – 3 months
Moderate	1 – 24 hours	3 – 12 months
Severe	1 – 7 days	12 – 24 months
Very Severe	7+ days	24 + months

Determining when PTA ends, however, can be difficult. Gronwall and Wrightson (1980) explain that the duration of amnesia is typically indicated by when the patient can recall the hour or day when continuous memory returns, while Lucas (1998) states that the first episodic memories after the accident indicates the end of PTA. These methods are, however, unsatisfactory, as they are retrospective and reliant on the patient's judgement of the point at which memory returned (Gronwall & Wrightson, 1980). On this basis, Wilson et al. (1999) argue that more objective measures of reaction time, backward digit span, a visual recognition test and a speed of processing measure should be used to determine the end of PTA. According to Binder (1986), the validity of PTA duration as a predictor of outcome is considered more uncertain when it is short, leaving McCrory (2001) to caution against the use of PTA to indicate severity of a concussive episode.

Finally, the GCS is the most commonly used clinical method of evaluating severity and predicting neurobehavioral outcome, particularly in relation to moderate and severe brain injuries. The GCS cannot be used retrospectively, having to be administered as early as possible, particularly in MTBI patients where the majority of the symptoms are captured within the first few hours post-injury (Ruff & Jurica, 1999). A score on this scale is obtained from 3 – 15 points (refer Table 2), based on an individual's best verbal, eye-opening and motor responses (Lucas, 1998). A GCS rating of 13 to 15 is considered indicative of a mild brain trauma (Bailes, 1999a).

Table 2.

Scores awarded on the Glasgow Coma Scale, used to determine a mild, moderate, and severe brain injury.

Verbal		
	None	1
	Incomprehensible sounds	2
	Inappropriate words	3
	Confused	4
	Oriented	5
Eye Opening		
	None	1
	To pain	2
	To speech	3
	Spontaneously	4
Motor		
	None	1
	Abnormal extension	2
	Abnormal flexion	3
	Withdraws	4
	Localises	5
	Obeys	6
Normal Score		*15*

2.5.2 Measuring Severity of MTBI in Sports

The three indices of severity reviewed in the previous section are typically incorporated in various ways with post-concussive symptomology, to form classification systems to establish the severity of a concussive injury in sport. To date, approximately 28 severity systems have been published (McCrory, 2001), involving between three to six grades of concussion, ranging in nature from mild through to severe (Roos, 1996).

Four of the most cited systems for classifying injury severity are listed for comparison in Table 3. One of the earliest severity systems was that devised by the Ad Hoc Committee to Study Head Injury Nomenclature of the Congress of Neurosurgeons which divided concussion into three levels (Maroon, 1999). While the Congress of Neurosurgeons guidelines continue to be used extensively (Maroon, 1999), more recent classification systems have been developed.

Table 3.

Four of the most cited classification systems of concussion severity.

	Grade 1 (Mild)	*Grade 2 (Moderate)*	*Grade 3 (Severe)*	*Grade 4*
Congress of Neurosurgeons, 1966	No LOC	LOC with retrograde amnesia	LOC > 5 min	
Cantu, 1986	No LOC < 30 min PTA	LOC < 5 min or 30min< PTA > 24hr	LOC > 5min	
Alves & Polin, 1996	Momentary LOC PTA < 1hour GCS = 15	LOC < 5 min PTA up to 24 hr GCS < 15 for 5 min or less	LOC < 5min 12 <GCS < 15 for up to 1hr	LOC > 5 but < 60 min GCS < 12 for over 5min or GCS < 15 for more than 1hr
AAN, Quality Standards Subcommittee, 1997	No LOC > 15 min symptomology	No LOC Confusion Symptoms < 15 min	LOC	

Cantu (1986) devised a system of classification based on clinical observation of sport-related brain injury. As illustrated in Table 3, this system defines the mildest form of concussion as Grade 1 severity, featuring only a brief period of confusion or PTA and no loss of consciousness. Estimates indicate that approximately 85%-90% of all cerebral concussion falls into this category (Cantu, 1996a; Ruchinskas, Francis, & Barth, 1997). Cantu's classification of a moderate (Grade 2) concussion incorporates a LOC which does not exceed 5 minutes. Although uncommon, a Grade 2 classification may also be appropriate for a player who fails to lose consciousness, experiencing instead a period of extended PTA lasting more than 30 minutes but less than 24 hours (Cantu, 1986). A severe (Grade 3) concussion involves a prolonged period of unconsciousness lasting more than 5 minutes (Cantu, 1986).

In contrast to Cantu's classification system, Alves and Polin (1996) of the Sports Neurosurgery Center of the Virginia Neurological Institute proposed a 4-stage grading system, which incorporated GCS ratings and LOC as the principal assessment tools, deemphasising PTA. While under this system a LOC is an essential requisite only for a Grade 3 and 4 rating of severity, the experience of a momentary LOC may be classed as a mild (Grade 1) concussion (refer Table 3). The same criteria for LOC (i.e., less than 5 minutes) features for Grade 2 and 3 concussions, although these grades are differentiated by GCS ratings.

The American Academy of Neurology (AAN) established a 'practice parameter' for sports-related concussion utilising a 3-grade system (Kutner & Barth, 1998). As shown in Table 3, mild concussion is similar to that described by Cantu (1986) although symptoms must resolve in less than 15 minutes. Persisting symptoms for 15 minutes or more with no LOC is classified as a Grade 2 concussion, while the experience of a LOC under this system is considered a severe (Grade 3) concussion.

With the exception of the GCS, the systems currently available are largely anecdotal, with very few having produced guidelines that are scientifically valid as a result of non-randomised, retrospective research (McCrory, 1997). This has essentially precluded their adoption in clinical settings and the lack of consensus evident in the grading of severity has made decisions regarding the appropriate management of concussion (addressed in Chapter 4) more difficult.

2.6 CHAPTER SUMMARY

As evidenced in the review of terminology in the first section of this chapter, there is no universal agreement of the definition of MTBI. The terms 'mild' and 'minor' have been introduced to define brain injuries in which the duration of PTA and LOC are relatively short, there is minimal structural damage, and GCS ratings are no less than 13 (Binder, 1986). However, the adoption of these terms in conjunction with 'head injury' and 'brain injury' has proved a source of confusion and contention. Their interchangeable use has complicated the distinction that theoretically should be made between craniocerebral and extracranial trauma, and has rendered the evaluation of epidemiological data extremely difficult (Cantu, 1996a). Despite these concerns, the use of 'mild head injury' has served a useful purpose in the sports domain. It has allowed researchers to obtain information pertinent to a broader range of injury, which might otherwise not have been captured with the adoption of more appropriate terms such as 'concussion' or 'MTBI'.

This chapter has reviewed the biomechanical forces involved in producing brain injury, of which direct impact and indirect (acceleration/deceleration) forces typify sport-related brain injury. While for the most part MTBI are benign entities (Wilberger, 1993) with rapid resolution of post-concussive symptoms, there is the potential for adverse long-term consequences. An enduring cluster of physiological and cognitive-behavioral symptoms is considered by the literature to constitute a postconcussive syndrome. While essentially this syndrome is an accepted entity, there is little agreement in the literature as to an appropriate definition or etiological factors involved in the development of this syndrome. Potentially serious consequences are also noted in response to repeat brain injuries, with the most grave of these being a second impact syndrome, of which a fatal outcome is typical.

Severity of MTBI can be measured by a number of indices of which the most common are PTA, duration of unconsciousness, and GCS scores. These measures have been incorporated into classification systems for concussion severity in an effort to provide reliability and consistency with respect to diagnosis in a sport-related setting and serves to consolidate comparisons within the research literature. However, the proliferation of these systems over the last 20 years has done little to advance clinical research into the "incidence of concussion, patterns of recovery, risk of neurosurgical emergencies, and the development of permanent neurologic dysfunction" (Kelly & Rosenberg, 1997; p. 575). To achieve this, the adoption of a single concussion grading scale is essential.

CHAPTER THREE

Rate of Sport-Related Brain Injury

The first section of this chapter reviews the methods employed in sport-related research to obtain brain injury incidence and severity information and the varied manner in which the information from these investigations may be presented. In order to understand the sport of rugby union in the context of collision sports in general, Section 3.2 provides a brief description of American gridiron football, Australian Rules football, and rugby league incorporating game objectives, positions and phases of play, and rates of TBI. This is followed in Section 3.3 by a comprehensive review of the sport of rugby union and its associated rate of brain injury.

3.1 DATA COLLECTION IN SPORTS

Sport-related research may either employ a prospective or retrospective design (Junge & Dvorak, 2000). While a number of investigations relating to sport-related injury are prospective in nature, these are often injury-orientated being reliant on the injury coming to medical attention (i.e., hospital admissions, medical reports, or mortality data). A concern relating to the use of such sources of injury information is that injuries at the milder end of the spectrum, analogous to those sustained in sports, are less likely to come to medical attention and therefore they fail to be recorded. While considered inferior to a prospective study on the basis of inaccuracies associated with recall (Junge & Dvorak, 2000), retrospective studies may provide information relating to those injuries that do not receive medical attention.

In addition to issues of design, problems also exist in relation to how investigations define the injury. One of the most commonly used indicators of 'injury' in sport-related research is that which "led to medical attention" (Lower, 1995; p. 39). For example, Roux, Goedeke, Visser, van Zyl, and Noakes (1987) comment that in rugby, the majority of surveys conducted report injuries seen only at one location such as a medical facility at a rugby field, a hospital, or general practitioner. 'Injury' is also defined as that resulting in time off participation due to an inability to play or practice (Seward, Orchard, Hazard, & Collinson; 1993; Norton & Wilson, 1995; Watson, 1997). Problems in data collection also arise as a consequence of the research in this area tending to focus on injuries in general. Information pertaining to brain injuries may therefore be concealed by their broader classification as injuries sustained to the region of the head, most frequently categorised as injuries to the 'head and face', or 'head and neck'.

For those studies which attempt to identify sport-related brain injury, the criteria provided by the National Athletic Injury/Illness Reporting System (NAIRS) is often adhered to (Albright et al., 1985; Buckley, 1988). This involves the reporting of all injuries to the head, generating symptoms sufficient to necessitate the athletic trainer's attention, whether or not time was lost from competition. Less frequently, the definitions presented in Chapter 2, Section 2.1 may be adopted by sport-related research.

In terms of presenting MTBI rates, concussion is often expressed as a percentage of total injuries or a percentage of injuries to the 'head', 'head and neck' or 'head and face'. Concussion rates may also be reported as a proportion of athlete exposures, most typically defined as "each opportunity for an athlete to get hurt" (Buckley, 1988; p. 53). Hence, exposure to injury may be expressed in a number of ways, including (1) per player hour; (2) per 100 player appearances; (3) per 100 player games; (4) per 10,000 man [sic] hours of play; or (5) as a percentage of players injured per season (Garraway, 1993).

In addition to the more widely accepted systems for diagnosing concussion severity (refer Chapter 2, Section 2.5), for research purposes classification systems may be based on abstinence from play or other clinical determinants. For example, Hughes and Fricker (1994) and Durie and Munroe (2000) defined minor injury as that allowing an athlete to return to play within 7 days, moderate injury as an abstinence from play for 1 – 3 weeks and severe injury as an absence from activity for 3 weeks or longer. Davidson (1987) classified injuries into severe and minor on the basis of clinical grounds. For example, concussions were typically classified as a severe injury, along with dislocations, some fractures, and other injuries resulting in some degree of incapacity. Minor injuries constituted abrasions, small lacerations, and contusions.

3.2 RATE OF SPORT-RELATED BRAIN INJURY

Traumatic brain injury in sports is considered to be a relatively infrequent event and if incurred, is typically at the lower end of the spectrum in terms of severity. Incidence rates for MTBI range from 2% to 10% (Ruchinskas et al., 1997); however, these figures are thought to be underrepresented on the basis of more recent estimates (Echemendia & Julian, 2001). Boxing, the martial arts, rugby, rugby league, American Football, professional horse racing, and ice hockey, have historically been found to incur high rates of brain injury (Hoy, 1987; Newcombe, 1996; Cantu, 1996a).

The current section will focus on three sports that involve a high degree of physical contact and which are similar in style to rugby union. So as to put the sport of rugby into context, each of the game's objectives, positions, and phases of play will be reviewed and where possible an injury profile will be provided as an adjunct to the rate of brain injury sustained in each sport.

3.2.1 American Gridiron Football

Description of the Game

Originating in the United States, gridiron football is well popularised, with reports of approximately 1.7 million youngsters participating in this sport each season in America (Buckley, 1986). It is an aggressive sport where the primary objective is for the offence of one team to carry the ball into the oppositions 'end zone' while the defense of the opposition attempts to stop them (Bird, Black, & Newton, 1997). Players move play forward by kicking or running with the ball, or by throwing it, which is restricted to one forward pass per 'play' (Bird et al., 1997).

The risk of injuries to the head, neck, and spine typically arise as a consequence of illegal play associated with blocking and tackling (Gerberich et al., 1983). Sprains, strains, fractures, dislocations, concussion, and contusions are also frequent in this sport (Bird et al., 1997). The adoption of helmets and heavy padding to the shoulder region is evidence of the attempt to help reduce or absorb the impact from heavy tackles. However, while helmets may aid in the reduction of major head injury, their effect on the incidence and severity of concussion is less clear (McCrory, 2001).

Rate of Brain Injury

American football has traditionally received the most attention regarding the incidence of MTBI. Incurring a concussive injury in college football has been described by some as a persistent but generally infrequent occurrence (Buckley, 1988) accounting for 2% - 5% of all injuries incurred (Buckley, 1986; Ruchinskas et al., 1997). However, the apparent low rate of MTBI may underestimate the true incidence of concussion. Some estimate that there is a 15% risk of *minor head injury* for high school football players annually (Bailes, 1999b), while in a more prominent study (3,063 high school football players) the estimated risk was slightly higher, with 19% reporting a concussive injury (Gerberich et al., 1983). Of those participating in this investigation only 2.4% received a diagnosis of concussion after sustaining a trauma to the head, although an additional 16.6% reported a loss of consciousness and/or a loss of awareness. Buckley (1986) recorded concussion accounting for 75% of head injuries in college football players, while Albright et al. (1985) reported that 87% of injury to the head region was attributed to concussion.

In this sport, MTBI occurs most often in a tackle or a blocking maneuver. Gerberich et al. (1983) reported that 43% of players suffered a concussion while *making* a tackle, and 23% whilst *being* tackled. Blocking was the cause of 30% of concussive injuries in this study, with the players either being blocked or making the block themselves. Buckley (1988) reported that tackles accounted for 61.9% of all concussions recorded - twice as many as produced by blocking maneuvers. The high frequency and rate of concussion sustained in tackles in this study was attributed to the intensity of play.

3.2.2 Australian Rules Football

Description of the Game

Australian Rules Football (ARF) is played by thousands of young Australians throughout the winter months each year, and along with rugby league and rugby union is one of three main football codes in Australia (Shawdon & Brukner, 1994). Each team consists of 18 players with 2 or 3 interchange players. A considerable amount of the physical contact involved in this game is attributed to tackling, which involves holding a player in position of the ball anywhere between the neck and hips, while for players not in possession, firm side-on knocks are utilized. A unique feature of ARF, which adds to the potential for injury, is the 'high mark' in which a player "may use the body of an opponent to propel himself into the air to capture the ball" (Shawdon & Brukner, 1994; p. 59). This maneuver often results in a clash of heads, and "it is said that there is a concussion in every game" (Newcombe, 1996; p. 34).

Orchard, Wood, Seward, and Broad (1998) revealed that ARF players in junior competition reported a higher incidence of injury than those in the professional league; however, these injuries were less severe. According to Seward and Patrick (1992) injuries to the lower limbs predominate for professional ARF players, followed by the head and neck, trunk then upper limbs. At the amateur level, the trend for injury is somewhat similar, although in contrast to professional players the upper limbs incur more damage than the trunk (Shawdon & Brukner, 1994).

Rate of Brain Injury

Concussion was identified as one of the six most commonly occurring injuries in both professional and junior AFL competition (Orchard et al., 1998). Seward et al. (1993) reported that concussion accounted for 3.6% and 9.0% of total injuries in professional and semi-professional competition, respectively. In contrast, concussion suffered by amateur ARF players accounted for 15% of total injuries and 50% of all head and neck injuries (Shawdon & Brukner, 1994). Maddocks, Dicker, et al. (1995) reported that over a 7 year period 28 professional ARF players received a diagnosis of concussion, of which only 11 experienced a LOC. The majority of those losing consciousness did so for less than a minute with only one doing so for more than 5 minutes. The findings of this investigation support comments made by Seward et al. (1993), who claim that the majority of concussion reported in this sport are considered mild and do not cause subsequent games to be missed.

3.2.3 Rugby League

Description of the Game

Rugby league is an extremely physical game, in which each team is comprised of 13 players occupying both forward and back positions. Each team is allowed six tackles or "downs" with the ball (Gibbs, 1993). Once a player is stopped with the ball (by being tackled), play is resumed by tapping the ball back to a teammate who is ready to receive it (Bird et al., 1997). At the completion of each set of six tackles the opposition can take immediate possession of the ball, and their set of six tackles begins (Gibbs, 1993). Points are scored in the game by touching the ball down behind the opponents' try-line or kicking the ball between the posts.

In 1990, ACC statistics revealed rugby league had the highest injury rate of all sports in New Zealand (Lythe & Norton, 1992) – a rate since surpassed by rugby union injuries (ACC, 1998). The most frequent injuries receiving a diagnosis and support from ACC were sprains and strains, followed by dental injuries then fractures, with the most common sites of injury being the knee (Gibbs, 1993), the face, and the shoulder (Lythe & Norton, 1992). The most common self-reported injuries sustained by rugby league players in one investigation were sprains and strains, followed by fractures, and concussions (Norton & Wilson, 1995). Of the injuries that are incurred in rugby league the majority are associated with tackling (Bird et al., 1997; Gissane Jennings, Cumine, Stephenson, & White, 1997).

Rate of Brain Injury

With respect to the incidence of concussive injuries, rates appear to range from 3.5% - 11.8%. Of 141 injuries incurred within three professional rugby league teams across a three-year period, 5.7% were sustained to the head and 3.5% were diagnosed as concussion (Gibbs, 1993). The proportion of concussions recorded in this study was considered an accurate reflection of the incidence rate, as *minor concussive injuries* (where no LOC or no time away from play occurred) had not been included in the original findings (Gibbs, 1994). Gissane et al. (1997) indicated that concussive injuries accounted for 7.1% of total injuries sustained throughout their investigation, with the rate of concussion being higher for forwards (7.6%) than that of backs (6.0%). An investigation of injury profiles of elite level rugby league players produced a comparatively higher rate of concussion (8.5%) (Seward et al., 1993), with a still higher rate of concussive injury (11.8%) recorded by Norton and

Wilson (1995). The latter investigation identified that all concussions were incurred in tackles. Further to this, was the finding that concussions accounted for 29% of the all injuries associated with illegal play and only 9% of those sustained in legal play (Norton & Wilson, 1995). While some investigations have revealed that forwards are more likely to be injured than backs, particularly with respect to head and facial lacerations (Seward et al., 1993; Gissane et al., 1997), others have observed the opposite, with backs sustaining more *head injuries* than forwards (Lythe & Norton, 1992).

3.3 RATE OF BRAIN INJURY IN RUGBY

A more in-depth description in relation to the game of rugby is provided in this section, as certain aspects of the game are important to explain in relation to the current study. In comparison to the sports reviewed in the previous section, the occurrence of MTBI in rugby union has received less attention. Of the modest research conducted in this area, most of it has been directed at school grade and elite professional players, although injuries presenting at medical facilities do not typically record the players grade. The research focuses predominantly on males, although in recent times females have become more prominent in the sport, and this trend is reflected in the literature.

3.3.1 Description of the Game

The game of rugby union involves two teams, each consisting of 15 players classified as either forwards or backs. Forwards tend to be large and powerful individuals involved predominantly with phases designed to win the ball in close aggressive play such as scrums, lineouts, rucks, and mauls (Bird et al., 1997). Backs, in contrast, are typically slighter individuals required to run with the ball or prevent the opposition from running with it (Bird et al., 1997).

Points are scored in this game in the same way as in rugby league. During the course of the game the ball is moved toward the opponent's try line by kicking it or running with it, and if passed, the ball cannot be passed forward (Williams & Hunter, 2001). To stop a team's progress with the ball, the opposing team will attempt to tackle the player in possession of the ball. In addition, various phases of play such as scrums, rucks, mauls, and lineouts may interrupt this running play (Bird et al., 1997). The purpose of these phases is essentially a means of restarting the game after a stoppage or allowing each team the opportunity to gain or re-gain possession of the ball (Williams & Hunter, 2001). These phases also represent specific situations in which heavy body contact is characteristic, leading to an increased risk of injury (Wekesa, Asembo, & Njororai, 1996).

The scrum

The scrum is a set play involving both sets of 8 forwards. Each half of the scrum is comprised of a front row (consisting of 3 players) with the 5 remaining forwards positioned behind the front row in set positions (Bird et al., 1997). The scrum formation involves a low body position and a tightly bound 'pack' achieved by each player wrapping an arm around the body of the person next to them (Williams & Hunter, 2001). Once the two packs have 'engaged', each pushes against the opposing pack whilst the 'half-back' (a back-line player closest to the scrum) puts the ball into the scrum and players from the front row attempt to hook it back with their feet (Bird et al., 1997).

The tackle

Tackles are used to control or restrict an opponent's progress with the ball, achieved through putting the player to ground, lifting them off the ground, or turning them to face the defending team (Williams & Hunter, 2001). Tackles involve enveloping the body or legs of an opponent, with 'head-high' (i.e., above the neck) tackles penalised (Bird et al., 1997).

The lineout

The lineout is a method of restarting play after the ball has gone over the touchline and involves the ball being thrown from the sideline between two parallel rows of opposing forward players (Tomasin, Martin, & Curl, 1989). The forwards jump for the ball and either try to tip it to one of their own players, or catch it.

The ruck/maul

A ruck takes place when the player in possession of the ball is grounded. In many respects the ruck formation is similar to that of a scrum but is less organised and structured (Bird et al., 1997). Once grounded, the ball must be released by the player who then attempts to shield the ball from the opposing team, while making it available to his (or her) own team.

According to Williams and Hunter (2001), the process of a maul is similar to a ruck, except that in a maul the players remain on their feet with the ball in hand. In making the ball available to their own team members, players from both sides form up on opposing sides in an attempt to get the ball and/or push the player with the ball toward the opponents' try line (Bird et al., 1997).

Injury Profile

The most common injuries sustained in rugby union are to the lower limbs, head and neck (or head and face), upper limb, and trunk (Dalley et al., 1982; Collinson, 1984; Davidson, 1987). Spinal cord injury (Garraway & Macleod, 1995), closed brain injury and concussion, joint dislocations, and fractures are representative of injuries at the more serious end of the spectrum (Bird et al., 1998). As with rugby league, the majority of injuries incurred in rugby union are the result of tackling (Sparks, 1985; Roux et al., 1987; Dalley, Laing, & McCartin, 1992; Bird et al., 1998), with forwards thought to be at greater risk of injury in general than backs (Roy, 1974; Sparks, 1985; Dalley et al., 1992; Gissane et al., 1997). These issues of risk are discussed in more detail in Chapter 5.

3.3.2 Description of Rugby Divisions

In New Zealand rugby is played competitively at a number of levels which include: (1) professional rugby at an international level; (2) professional rugby at a provincial level; (3) professional/non-professional rugby at a regional level; (4) club grade rugby; and (5) school-grade rugby. Club rugby is comprised of various grades, ranging from Senior I (the top of the club grade) and rank ordered through Senior II, Senior III, and Senior IV teams. Players may also be graded in response to certain age ranges. For example, Under 21, Under 19, and President's (for those 35 years plus) are grades which adopt an age criterion. However, these are not strictly enforced divisions as a player under 21 years of age may play for a senior team, although the reverse cannot apply unless the player meets the age criteria.

3.3.3 International Research

A number of investigations of rugby-related injury have been conducted overseas, most typically in South Africa, England, and Australia, places where this sport is popular. As seen in Table 4, rates of injury to the region of the head are typically presented in these studies in terms of head and neck injuries and/or head and face injuries.

With respect to rates of injury identified in school grade rugby, an investigation across four seasons of English schoolboy rugby revealed that head and neck injuries comprised 26.8% of total injuries, with concussion (defined as any LOC irrespective of duration) accounting for only 2% of all injuries suffered (Sparks, 1985). The rate of diagnosed concussion was also low (1.1%) in an 18-year study of Australian school grade players (Davidson, 1987), which defined 'injury' as any reported to the school casualty room.

However, a higher concussion rate may have been justified as symptoms of headache, nausea and dizziness, in response to a blow to this region, comprised 14.9% of all injuries, with a high rate of injury to the region of the head and neck (36.6%) also demonstrated (Davidson, 1987).

Table 4.

International research conducted in the area of rugby-related injury, illustrating size of sample population, rate of injury to the region of the head and concussive injuries as a proportion of total injuries.

Investigations	*Grade*	*Total Injuries*	*Head & Neck* (%)	*Concussion* (%)
Roy, 1974	University	300	20.5†	2.0
Adams, 1977	-	647	21.6†	3.2
Myers, 1980	Club	277	52.0	8.7
Sparks, 1985	School	772	26.8	2.0
Davidson, 1987	School	1444	36.6	1.1
Roux et al., 1987	School	495	29.0	12.0
Clarke et al., 1990	Club	114	23.0	10.0
Seward et al., 1993	Elite	243	37.3	5.3
Hughes & Fricker, 1994	Elite	133	17.3†	3.8
Garraway & Macleod, 1995	Club	429	15.6†	4.7
Wekesa et al., 1996	Elite	47	21.0†	2.1
Watson, 1997	School	118	-	6.6

† Represents injuries sustained to the region of the head and face

An investigation of injury incidence in a South African study of 26 highschool rugby teams revealed a far higher rate of concussion (12%) in comparison to previous school grade investigations, with head and neck injuries accounting for 29% of all injuries suffered (Roux et al., 1987). In this investigation, 'injury' was defined as any which prevented a player from participating in rugby for 7 days or more, or that required medical/surgical treatment. A separate definition of concussion was not supplied, although, irrespective of severity, all concussions had to be reported. A review of a variety of sports popularised by schoolboys in Ireland revealed concussion was common only in the activity of rugby accounting for 6.6% of all rugby-related injuries (defined as injuries requiring medical treatment or disrupting play) (Watson, 1997).

As Table 4 illustrates, investigations involving elite/professional players have also produced varying rates of concussion. A study involving elite international players participating in a Rugby World Cup prequalifying tournament, featured a rate of concussion of 2.1%, in which 'injury' was defined as that receiving medical attention (Wekesa et al., 1996). Defining 'injury' as any preventing a player from participation or requiring special medical treatment, Hughes and Fricker (1994) reported 17.3% of all injuries sustained by top level Australian rugby players involved the head, with concussion (not specifically defined) accounting for 3.8% of all injuries incurred. Another Australian study conducted with elite players revealed that the most common injuries (defined as any requiring specific medical treatment or an abstinence from competition or training) were head and facial lacerations (20%) followed by concussion (5%) (Seward et al., 1993).

An early South African investigation conducted by Roy (1974) defined injury as any in which a player requested private medical attention over the period of one season. Drawn largely from university rugby teams, participants reported the head and face sustained 20.5% of all injuries (refer Table 4). The majority of injuries to the head region consisted of lacerations (60%) and facial fractures (13%), with only six players (2%) requesting medical attention as a consequence of concussion. Myers (1980) reported that head and neck injuries accounted for one half of all injuries recorded in an investigation of Australian club grade and representative rugby players. Concussion, defined as an alteration or loss of consciousness, accounted for 8.7% of all injuries sustained by this group of players. Extending their research from schoolboys to adult rugby players, Clarke, Roux and Noakes (1990) identified 114 injuries sustained by 78 players, of which head and neck injuries accounted for 23%. As with their school grade investigation, a similar rate of concussion

(10%) was identified with the adult players. Garraway and Macleod (1995) revealed that 15.6% of all injuries (defined as preventing continuation of activity) sustained by a sample of Scottish club grade players involved the head and face. Concussion accounted for 4.7% of all injuries, yet no specific definition was supplied.

In the only investigation reported here which fails to identify the grade of the injured player, Adams (1977) revealed that of 647 rugby-related injuries attended over a period of 13 months in an English hospital department, 21.6% were sustained to the region of the head. Concussion accounted for only 3.2% of all injuries sustained, despite the relatively high rate of head injury.

In summarising the findings of these investigations, the rate of concussion for school grade rugby appears to range from 1.1% - 12%, for elite/professional players 2.1% - 5.3%, and for club grade rugby, 2.1% - 10%. While similarities exist in relation to the definition of 'injury' adopted by these investigations in that it typically involves abstinence from play for a period or the receipt of medical attention, only two studies have provided a clear definition of concussion. Myers (1980) defined concussion as an injury resulting in an alteration or LOC and Sparks (1985) used a LOC alone to indicate concussion, revealing concussion rates of 8.7% and 2%, respectively.

3.3.4 Research in New Zealand

Investigations carried out in New Zealand have tended to involve both school and club grade rugby players (refer Table 5). In one such investigation, injury (defined as any receiving medical attention and/or missing subsequent games) to the head and neck region accounted for 30.2% of all injuries sustained by 5,108 Canterbury school and club grade players (Dalley et al., 1982). Concussion comprised 9.1% of all injuries, with 82.4% considered to be of mild severity and the remainder, severe (Dalley et al., 1982). A further investigation of Canterbury school and club grade players revealed that of the injuries sustained 25.2% were head injuries, 7.6% were classified as concussion and 0.4% ($n=4$) involved a LOC (Dalley et al., 1992). These authors highlight certain limitations of their investigation as a consequence of inaccurate data gathered, which according to them meant the full scope of the study could not be realised.

Table 5.

The rate of concussive injuries as a proportion of total injuries obtained in investigations of rugby in New Zealand, encompassing school and club rugby.

Investigations	*Grade*	*Total Injuries*	*Head & Neck* (%)	*Concussion* (%)
Lingard et al., 1976	-	1,437	34.5	7.5
Dalley et al., 1982	School & club	1,002	30.2	9.1
Dalley et al., 1992	School & club	921	25.2	7.6
Dixon, 1993	-	2,436		4.7
Gerrard et al., 1994	School & club	583	40.0†	5.0
Bird et al., 1998	Club	602	18.0‡	4.5
Durie & Munroe, 2000	School	270	9.6	0.02

† Represents injuries to regions of the head/skull/inner ear, face/outer ear/eye, and neck.
‡ Represents injuries sustained to the region of the head and face.

The Rugby Injury and Performance Project (RIPP) was designed to assess injury sustained in Dunedin rugby union players and was presented in a number of phases. Phase II of the study involved a survey of injury "experienced in the previous 12 months that required either medical attention or caused the player to miss one scheduled game or practice" (Gerrard, Waller, & Bird, 1994; p. 230). A total of 583 injuries were reported by school and club grade players (both male and female), of which 40% were classified as head, neck, and facial injuries (Gerrard et al., 1994). Concussion (not specifically defined) comprised 5% of all injuries incurred.

Phase V of the RIPP described the incidence, nature, and circumstances of injury experienced by 345 club grade players during a competitive season in Dunedin (Bird et al., 1998). As illustrated in Table 5, a total of 602 injuries were reported of which the head and face sustained 18%. As a proportion of total injuries and injuries to the region of the head and face, concussion accounted for 4.5% and 20%, respectively. The vast majority of concussed players (95%) had received medical treatment, while 41% planned to seek further treatment.

The study involving only school grade players presents a very different picture in to those incorporating club grade players. As shown in Table 5, Durie and Munroe (2000) identified 270 injuries (defined as any period of abstinence from play) over the course of the 1998 season, of which only 9.6% were sustained to the region of the head and neck. The rate of concussion was extremely low (0.02%) in comparison to previous investigations, with only 6 players sustaining concussions of varying degrees of severity.

In an investigation of rugby-related injuries presenting at two Emergency Departments (ED), approximately one third of injuries were sustained to the head and neck, with 7.5% of total injuries being classified as *CNS head injuries* (Lingard, Sharrock, & Salmond, 1976). In a similar investigation of injuries presenting at ED or resulting in admission to a public hospital, an incident rate of 16,637/100,000 participants over 15 years old was identified as a consequence of rugby (Dixon, 1993). Admissions to hospital were principally concussions and *head injuries*, of which concussions accounted for 4.7% of all rugby-related admissions (Dixon, 1993).

3.4 CHAPTER SUMMARY

Difficulties associated with establishing a comprehensive rate of brain injury are an overarching problem in the realm of sport-related research. This is largely attributed to the lack of consistent definition (across sporting activities, age groups, and organisations) inhibiting valid comparisons of data (Thurman et al., 1998) and resulting in wide variation of recorded incidence rates (Hoy, 1987). Thurman et al. (1998) have suggested that standardised definitions for the types of injuries that occur and their underlying causes must be established in order to fulfill these data needs.

A principal example of this situation is the criteria for concussion, for which some investigations required the athlete to have lost consciousness, which has precluded accurate reporting of concussion rates. For instance, some 'superficial injuries' produced symptoms associated with concussion, but were not considered as indicative of this diagnosis, as no loss of consciousness had been experienced (e.g., Davidson, 1987).

The rates of concussion obtained from overseas rugby-related research range between 1.1% and 12%, with the highest rates featured in the investigations involving school grade (e.g., Roux et al., 1987) and club grade (e.g., Myers, 1980; Clarke et al., 1990) players. Comparatively less research has been conducted in New Zealand with rates of concussion in studies involving both school and club grade players ranging from 4.5% - 9.1%. On average, the rates of concussion reported by New Zealand studies appear slightly higher than those obtained by overseas research involving school and club grade players. This may in part be attributed to the sport's popularity and reverence in New Zealand, which may mean the game is taken more seriously by players and proponents alike, prompting much more robust and enthusiastic play and as such, increasing the risk of MTBI.

CHAPTER FOUR

Assessment and Management of Sport-Related Brain Injury

After a concussion has been sustained, the management of such an injury may prove crucial in helping to minimise potential sequelae that may impact on a player's ability to return to sport (McCrory, 1997). This chapter reviews the management of a concussive injury in terms of three closely interwoven issues concerning assessment: (1) immediate management; (2) neuropsychological assessment; and (3) return-to-play guidelines. The immediate management of a TBI, taking place at the field of play invariably on the sideline, is addressed in Section 4.1. A more detailed neurological and medical assessment (addressed in Section 4.2) may be required depending on the severity of the concussive injury, with such an assessment typically conducted in a clinic or medical setting. Section 4.3 presents the third category of assessment which incorporates the process of deciding when it is appropriate to return a concussed player to the field of play - a process assisted by the development of a variety of return-to-play guidelines.

4.1 IMMEDIATE MANAGEMENT: SIDELINE ASSESSMENT

The immediate management of a concussive injury involves a crucial and potentially lifesaving function (McCrory, 1997). Issues and treatment priorities in this stage involve accurate diagnosis and assessment primarily ensuring the player is medically and neurologically stable. McCrory et al. (1992) warn of the dangers of oversimplification in the diagnosis and assessment of concussed players, as the wide variety of clinical features associated with concussion may also be indicative of catastrophic brain injury. The importance of accurate diagnosis is reiterated by McFarland and Macartney-Filgate (1989, cited in Lezak, 1995) who emphasise the need to distinguish symptoms indicative of a diffuse concussive injury from those consistent with focal lesions, as a consequence of the brain's low level of tolerance and potential seriousness of the former.

The immediate management of brain injury involves dealing with varying levels of consciousness. In situations where the player presents as disorientated, unconscious, uncooperative or experiencing a seizure after sustaining a trauma to the head, the basic principles of first aid apply. These principles involve minimising immediate environmental dangers to avoid additional harm to the player (i.e., stopping the game or exercise) (Hoy, 1987), assessing their level of responsiveness (McCrory, 1997), and where appropriate adopting the ABC principles. That is, ensuring the airway is clear, the patient is breathing freely and circulation is adequate (Walkden, 1978; Hoy, 1987; McCrory et al., 1992). In assessing responsiveness, many employ the use of the Glasgow Coma Scale to objectively establish a player's level of consciousness and injury severity (Shultz, Houglum, & Perrin, 2000). Once the player has been stabilized and removed from the field a full medical and neurological assessment is advised, which may warrant skull and cervical x-rays and a head CT or MRI scan (Cantu, 1992).

While often obvious, the brevity of some experiences and the confusion that often surrounds such an injury means that establishing whether the player has experienced a LOC is not always easy. Once removed from the field, questions relating to the incident should try to establish whether the player knows what happened. To establish LOC, a general rule of thumb involves the ability of the individual to remember the blow that dazed them (Vetter, 1989). If recalled, it is unlikely that the player lost consciousness, However, if the player demonstrates a period of retrograde amnesia in addition to having been observed to be motionless after the blow, they should be managed as if consciousness was lost (Vetter, 1989).

Assessment on the sideline should also establish whether the player is oriented to time, place, person and activity. It has been shown that the standard approach of asking orientation items (e.g., day, date, year, time, date of birth, etc.) is unreliable in relation to MTBI, as they assess aspects of memory that remain relatively intact (Maddocks, Dicker, et al., 1995). Questions involving recent memory, such as 'Which ground are we at?', 'Which team are we playing today?', 'Which half is it?', and 'Which team did we play last week?', are considered more useful, being sensitive enough to discriminate between concussed and non-concussed individuals (McCrory, 1997).

At this stage of the assessment process it is vital to establish the presence of symptoms such as headache, blurred vision, or unsteady balance (Vetter, 1989), the experience and duration of amnesia (retrograde and/or anterograde) and any history of recent brain trauma (Sports Medicine New Zealand, 1999). According to Maddocks, Dicker, et al. (1995) the most common clinical appearances of concussion in a sample of ARF players was dazed facial expression and unsteady gait, experienced by 82% and 71% of players, respectively. Evaluation of such symptoms has implications for the appropriate management of the player and their return to the field of play (Kelly & Rosenberg, 1997).

Over recent years, the need to evaluate the immediate effects of concussion in a valid, comprehensive and standardised fashion has resulted in the development of two brief assessment measures - the Sideline Concussion Checklist-B (SCC) (Kutner & Barth, 1998) and the Standardised Assessment of Concussion (SAC) test (McCrea, Kelly, Kluge, Ackley, & Randolph, 1997). These measures quantitatively assess over time the resolution of physiological, neurological, and cognitive symptoms associated with concussion (McCrea et al., 1998; Erlanger et al., 1999; Randolph, 1999). Both measures can be administered in less than 5 minutes and have been designed for administration by team trainers and physicians to injured athletes on the sideline (Randolph, 1999). The SAC has received some preliminary testing with concussed players scoring "significantly below the non-concussed controls and below their own baseline (pre-injury) performance" (McCrea et al., 1997; p. 586), although more extensive testing has been recommended (American Academy of Neurology, 1997).

In situations where persisting or worsening symptoms are evident shortly after the initial assessment, some consider referral to a hospital is warranted (McLatchie & Jennett, 1994), although others may see hospitalisation as unnecessary if symptoms cease within an hour (Cantu, 1992). If hospitalisation is considered unwarranted, close observation should be carried out over a 24-hour (minimum) period to ensure that any neuropathological change associated with the injury can be monitored (Kelly & Rosenberg, 1997; Sports Medicine New Zealand, 1999).

An initial assessment can obviously be carried out if symptoms are visible to those monitoring athletes or if the athlete self-reports. Unlike injuries which are apparent to medical personnel (i.e., broken bones, open wounds, etc.), athletes suffering a MTBI typically retain consciousness and usually can walk from the field of play unaided, despite experiencing a variety of symptoms indicative of neurological disruption. It is important to mention at this point that athletes are often reluctant to report MTBI-related symptoms, for fear of being removed from the sport or having to miss subsequent games. Their reluctance to report such symptoms may therefore result in the injury escaping medical attention. In sports such as rugby where attitudes regarding injury are often staunch, ironically reasons for not reporting MTBI appear to be based around the fear of a number of things. These include fears of being stood down for the remainder of the game, missing subsequent games (Wilberger, 1993), and not wanting removal from the game to appear a sign of 'weakness' (Wetzler, 1997). Additionally, a player's uncertainty regarding the symptoms experienced may prevent them from thinking that anything is wrong. For example, a persistent headache the next day could easily be attributed to one-to-many after-match drinks, while fatigue could be considered a consequence of over-robust play. These underlying issues associated with the reporting of MTBI mean that those monitoring players from the sideline need to be vigilant.

4.2 NEUROPSYCHOLOGICAL ASSESSMENT

Traditionally, MTBI investigators have had to base medical diagnosis of concussion and assessment of recovery on the subjective experience of postconcussive symptoms and indicators such as LOC and PTA. As subjective signs and symptoms may resolve immediately after the injury, neuropsychological assessment is often the only way to detect the subtle underlying pathology associated with concussion (Guskiewicz et al., 1997). As a consequence there has been increasing interest in the use of neuropsychological tests as a means of aiding diagnosis in a sports setting (Maddocks, Saling, & Dicker, 1995). While it is recommended that a formal neuropsychological evaluation of the concussed player be conducted within a few days of the injury, prior to returning to practice or competition (Roberts, 1992), such an assessment should ideally be carried out within 24 hours (Lovell & Collins, 1998).

The first phase of the neuropsychological evaluation should reassess the player's level of orientation (given that it should have firstly been assessed on the sideline), particularly with respect to the details of the game in which the injury was sustained (Lovell & Collins, 1998). The concussed player's memory for events immediately preceding and after the injury is important to establish, with an extended period of PTA prognostic for a moderate to severe brain injury (McCrory, 1997). It is also imperative to ensure that an accurate record of the individual's brain injury history was obtained during the sideline assessment (if conducted) and to assess the presence of subjective behavioral symptoms that may not have been evident at the initial assessment or that have continued to persist. Particular note should be taken of any worsening of symptoms, which may warrant referral to a medical facility for appropriate treatment.

The literature has revealed consistent cognitive deficits associated with MTBI which need to be considered when contemplating the assessment of such an injury. These deficits in cognitive functioning include impaired information processing capacity (Gronwall & Wrightson, 1974), alteration of attention span, memory and concentration (Guskiewicz et al., 1997), and inconsistent performance on complex tasks requiring focused and divided attention (Hugenholtz et al., 1988). According to Lovell and Collins (1998) the following measures have been found to be useful in a sports setting to assess the specific areas of deficit associated with MTBI: Trail-Making Test (Part A & B), Stroop Colour Word Test, Digit Span from the Wechsler Memory Scale-Revised (WMS-R), Rey Auditory Verbal Learning Test (RAVLT), California Verbal Learning Test (CVLT), Symbol Digit Modalities Test (SDMT), Digit Symbol Coding Test of the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III), Controlled Oral Word Association Test (COWAT), Paced Auditory Serial Addition Task (PASAT), Letter and Number Sequencing from the Wechsler Memory Scale, Third Edition (WMS-III), and the Grooved Pegboard Test. It is important to note that this list is by no means exhaustive, being merely representative of measures more commonly adopted in the research literature.

In addition to aiding diagnosis, neuropsychological measures also provide an objective measure of recovery following sports-related MTBI. Measures are typically administered to players prior to the start of the season to establish a baseline of cognitive performance, with repeated administrations post-injury enabling the return to pre-morbid levels of functioning to be followed. As a consequence of the need for repeated assessments, an important consideration in the adoption of measures is whether they exist in multiple equivalent forms, as those that do not are limiting in their usefulness (Lovell & Collins, 1998).

Only a few studies have directly examined the effect of sport-related MTBI on psychometric test performance. In the first major study of its kind, Barth et al. (1989) aimed to establish the utility of neuropsychological assessment measures in a sporting context. In a short test battery (17 minutes) comprised of the Trail Making Test A and B, the SDMT, WAIS Vocabulary subtest, and the PASAT, Barth et al. (1989) assessed concussed gridiron players to find that the SDMT and PASAT were sensitive to deficits associated with MTBI. Since this study, other assessment batteries have been developed for use within different sporting codes. In Australia, a standard test battery comprising of the Digit Symbol, PASAT, Trail Making Test B, and a measure of reaction time was developed for use in a series of prospective studies involving AFL players (Maddocks & Dicker, 1989; Maddocks & Saling, 1991; Maddocks, Saling, et al., 1995). Digit Symbol proved sensitive to MTBI deficits, unlike the PASAT which was insensitive to concussion in this population (Hinton-Bayre, Geffen, & McFarland, 1996). While useful to monitor recovery to baseline levels, McCrory (1997) cautioned that this battery was not designed for use as a diagnostic test for concussion in the acute situation and should be administered only once all postconcussive symptoms have resolved.

Another battery that has earned a reputation for ease and speed of administration in large groups is the Pittsburgh Steelers Test Battery, designed for the American Football team for which the test is named. This battery is comprised of the Hopkins Verbal Learning Task (HVLT) (verbal memory and delayed recall), the Trail Making Test (visual scanning and mental flexibility), the COWAT (word fluency and retrieval task), the Digit Span (attention span), the SDMT (visual scanning, visual-motor speed and 'throughput'), and the Grooved Pegboard Test (motor speed and coordination) (Lovell & Collins, 1998). In an investigation of MTBI in collegiate athletes, a variation of this battery was adopted incorporating the measures of Trail Making Test A, the Digit Span, the Stroop and the HVLT to assess cognitive functioning (Guskiewicz et al., 1997). The Sensory Organisation

Test (SOT), a measure of postural stability, was also included in an attempt to identify athletes experiencing sensory interaction problems during the first few days following MTBI. Unlike previous investigations, MTBI players in this investigation did not demonstrate significantly lower performance on the neuropsychological measures when compared to uninjured controls. The previously established sensitivity of the measures employed were however not questioned, and instead this outcome was attributed to several research limitations including differences in test battery and definition of *mild head injury*.

Hinton-Bayre et al. (1996) used three tests of information processing speed to assess recovery after MTBI - the Digit Symbol, the SDMT and a relatively new measure, the Speed of Comprehension test. All three measures were shown to be sensitive to the subtle effects of MTBI, with the Speed of Comprehension Test more sensitive than either of the other measures (Hinton-Bayre et al., 1996). While a composite of reliable change indices from each of the three tests could differentiate concussed and non-concussed players at the acute stage better than the use of single tests, this score was not found suitable for monitoring recovery from MTBI (Hinton-Bayre et al., 1996). A later follow-up study by these researchers incorporating the same measures revealed that use of a Reliable Change Index (RCI) provided a quantitative basis for decisions regarding return to play (Hinton-Bayre, Geffen, Geffen, MacFarland, & Friis, 1999). A significant decline from baseline scores was evident for concussed players at 1-3 days post-MTBI with no significant difference in performance demonstrated 1-2 weeks later. The RCI criterion derived from non-concussed players scores did not prove as sensitive as the clinical cut-off for impaired performance (RCI < -1.65), although both demonstrated sensitivity to concussion.

Currently no single objective measure has been endorsed as a definitive measure of recovery (Hinton-Bayre, Geffen & Geffen, 1997). However, the adoption of psychometric measures is advocated as it provides quantitative criteria upon which to base return-to-play decisions.

4.3 GUIDELINES FOR RETURN-TO-PLAY

The application of appropriate return to play guidelines constitutes the final category of the assessment phase. As with criteria relating to the classification of brain injury severity, the guidelines relating to a player's return to sport following a concussion is a contentious area, with little agreement regarding the length of exclusion from play. While clinical and neuropsychological assessment appears to allow more objective and scientifically valid means of establishing a players recovery from TBI, opponents argue that the dearth of information surrounding brain injury and recovery of function precludes scientific justification regarding a player's return to play (Vetter, 1989). The shortage of scientific evidence is the primary reason for the development of numerous exclusionary policies. Each is typically characterised by variations in injury severity, immediate history of a similar injury and the presence of symptoms (Hinton-Bayre et al., 1999). Only a handful of these guidelines have established clinical recognition, having been adopted as loose specifications for an athlete to resume play.

One of the earliest established management guidelines was created by the Congress of Neurosurgeons and based on their three-tiered classification of concussion (refer Chapter 2, Table 3). Under these guidelines an athlete with a mild concussion was to be removed from contest for at least several 'plays', returning only when the athlete was neurologically completely normal (Maroon, 1999). A moderate concussion required removing the player from the contest, disallowing a return to the game and restricting further involvement in contact play for at least several days, with a return to competition contingent upon neurological and neuropsychological findings (Maroon, 1999). For a severe injury, in which the duration of unconsciousness extended for more than 5 minutes, hospitalisation and appropriate diagnostic testing was advised.

While the guidelines proposed by the Congress of Neurosurgeons continue to receive extensive use, more recently developed return-to-play systems have attained greater support. The most renowned of these guidelines are those devised by Robert Cantu (1986) and endorsed by the American College of Sports Medicine (ACSM) and those formulated by the Colorado Medical Society, outlined in Table 6. Recently adapted by James Kelly and endorsed by the AAN (Roos, 1996) the Colorado guidelines are considered by some, to be the most notably adopted by key medical and sporting bodies (McCrory, 1997). While this grading scale is reportedly based on scientific evidence and consensus (Kelly & Rosenberg, 1997), some contend that the guidelines do not extend well to a clinical setting. This is supported by research having revealed that clinicians indicated their familiarity with the Cantu guidelines in preference to those offered by the Colorado Medical Society (Roos, 1996).

The predilection for the Cantu/ACSM guidelines is a likely consequence of the original Colorado guidelines having received criticism for their conservatism (McCrory, 1997). While both guidelines utilise the criteria of amnesia and LOC to determine injury severity (from mild to severe), classifications of severity and return-to-play decisions differ quite markedly. As presented in Table 6, the original Colorado guidelines classify any LOC irrespective of duration as a severe concussion proposing a minimum four-week stand-down period. In contrast, Cantu recommends that any short-term LOC (less than 5 minutes) results in a player being returned to play after one asymptomatic week.

Some aspects of the Cantu/ACSM guidelines appear more conservative than those of the Colorado guidelines. As illustrated in Table 6, a comparatively longer abstinence from play for a Grade 1 concussion is advised under the Cantu/ACSM guidelines. However, Cantu (1992) states that in a small number of situations return to competition may be permissible if the player shows no evidence of retrograde amnesia and is asymptomatic at rest and exertion after a suitable observation period. The AAN-endorsed guidelines, while virtually identical to those described in Table 6, have incorporated slight revisions not clearly illustrated in this table, in an attempt to address the issue of conservatism. The revisions include: (1) diagnosis of a Grade 1 as opposed to a Grade 2 concussion hinges on the duration of mental confusion rather than on the presence of amnesia; (2) players sustaining a Grade 1 concussion may return to contest if mental status abnormalities or post-concussive symptoms clear within 15 minutes; and (3) the length of unconsciousness is considered with respect to Grade 3 concussions. Under these revised guidelines an athlete experiencing a brief (seconds) period of unconsciousness may return to competition if asymptomatic for one week at rest and exertion, whilst a prolonged (minutes) loss of consciousness should restrict the player from play for two asymptomatic weeks (AAN, Quality Standards Subcommittee, 1997). McCoy II (1996) argues that while some clinicians may include the experience of a brief loss of consciousness in Grade 2 reserving the classification of a Grade 3 injury for more protracted periods of unconsciousness, 'brief' and 'prolonged' periods of unconsciousness are not well defined.

Under both the Colorado and Cantu guidelines, situations involving repeat concussions require more consideration, with players being advised to refrain from contact or collision sports for at least two seasons or reconsider their participation in their chosen sport and also other contact sports. Both sets of guidelines also advocate that no player should be returned to competition or practice sessions if PTA is present, and that they should only be returned if they are asymptomatic for at least one week (Nelson & Schoene, 1995b). Prematurely returning to contact sports, or any sport in which brain injury is a risk, could lead to a catastrophic outcome, such as permanent disability or death (Kelly & Rosenberg, 1997).

Table 6.

Comparison of the Colorado Medical Society and the Cantu/ACSM guidelines for return-to-play

Severity	*First Concussion*	*Second Concussion*	*Third Concussion*
Guidelines of the Colorado Medical Society			
Grade 1 (Mild) Confusion without amnesia; no LOC	May return to play if asymptomatic† for at least 20 minutes	Terminate contest or practice for the day	Terminate season; may return in 3 mnths if asymptomatic
Grade 2 (Moderate) Confusion with amnesia; no LOC	Terminate contest/practice; may return if asymptomatic for at least 1 wk	Consider terminating season; may return if asymptomatic for 1 mnth	Terminate season; may return to play next season if asymptomatic
Grade 3 (Severe) LOC	May return after 1 mnth if asymptomatic for 2 wks at that time; may resume conditioning sooner if asymptomatic for 2 wks	Terminate season; discourage any return to contact sports	
Guidelines of Cantu/ACSM			
Grade 1 (Mild) No LOC, PTA < 30 minutes	Return if asymptomatic‡ for 1 wk	Return to play in 2 wks if asymptomatic at that time for 1 wk	Terminate season; may return to play next season if asymptomatic
Grade 2 (Moderate) Brief LOC or extended PTA*	Return if asymptomatic for 1 wk	Minimum of 1 mnth; may return to play then if asymptomatic for 1 wk; consider terminating season	Terminate season; may return to play next season if asymptomatic
Grade 3 (Severe) LOC for more than 5 minutes	Minimum of 1 mnth; may then return to play if asymptomatic for 1 week	Terminate season; may return next season if asymptomatic	

† No headache, confusion, dizziness, impaired orientation, impaired concentration or memory dysfunction during rest or exertion.
‡ No headache, dizziness or impaired orientation, concentration or memory during rest or exertion.
* Greater than 30 minutes but less than 24 hours duration (Bailes, 1999a).

While only the better-recognised guidelines have been highlighted, other recommendations also exist varying in content with respect to the degree of conservatism. McLatchie and Jennett (1994) advise a minimum of 48 hours abstinence from the field of play for players experiencing less than 2 minutes of PTA, and 15 days or more of abstinence from competition or training in situations involving more than 2 minutes of PTA and/or persisting symptoms. Jordan (1999) offers a more 'restrictive approach', basing evidence of cognitive impairment on those individuals displaying either confusion *or* amnesia, in contrast to the AAN endorsed guidelines which distinguish between the two. As a consequence, Jordan (1999) advocates that individuals with cognitive impairment should be managed as a Grade 2 concussion, and should not be allowed to return to competition on that same day. In comparison to Cantu's (1986) management of individuals having experienced a brief loss of consciousness (less than 5 minutes), Vetter (1989) recommends that a player should be excluded from practice and competition for a minimum of 3 weeks, only returning if asymptomatic for the final week of this stand-down period. Further, in a situation where the player experiences an extended period of unconscious or has lost consciousness twice within a 6-month period, Vetter (1989) advises that they should be excluded for a minimum of 3 months. A New Zealand Rugby Football Union (NZRFU) directive states that a player suffering a concussion is required to adhere to a suspension of play (including practice) for a minimum period of 3 weeks (Bird et al., 1998).

Given the divergence of opinions the clinician's decision of when to return a player to competition after having lost consciousness, is not an easy one. Numerous factors need to be considered when contemplating such a decision including the player's history of concussion, the level of contact in the sport, as well as amount of contact the player's position is subject to (Nelson & Schoene, 1995b). According to Vetter (1989), a player should also indicate a willingness to return to play, with any player who seems hesitant or not confident in his/her ability to continue, being removed from the competition.

The decision to allow a player to return to play becomes somewhat more difficult when the injured player experiences no definite loss of consciousness and limited symptomology. The term 'bell ringer' has been adopted to describe the consequences of an impact in which players may suffer only a headache or report 'seeing stars' (Roberts, 1992). Under these circumstances, most guidelines concede that a player may be returned to the contest if they have not previously suffered a concussion or 'bell ringer', are fully oriented without obvious neurological symptoms (at rest and exertion), and have full recall of events with no evidence of amnesia (Walkden, 1978; Vetter, 1989; Cantu, 1992; Nelson & Schoene, 1995b). Roberts (1992) states that he allows such players to return to play if they are completely asymptomatic after 5-10 minutes, remain asymptomatic after 15-20 minutes of rest and can repeat evaluation after sideline activity. According to Vetter (1989), if any symptom persist beyond 5 minutes a 3-week exclusion period is appropriate.

Of the numerous return-to-play guidelines and recommendations reviewed in this section, very few have earned clinical recognition and none of these have been empirically supported. However, with the adoption of neuropsychological assessment measures to aid in monitoring recovery it is anticipated that reliance on such guidelines will diminish.

4.4 CHAPTER SUMMARY

Appropriate management of a concussive injury incorporates three interwoven stages of assessment – assessment at the sidelines, a more detailed neuropsychological assessment (if of a severity that warrants it), and assessment of functioning prior to returning to play. Sideline assessments should begin by establishing the level of consciousness and the presence of a life-threatening condition. In the absence of such a condition and if the player is conscious, the assessment should establish LOC, type and severity of symptoms, orientation to time, person, and place and a MTBI history (Shultz et al., 2000). Neuropsychological assessment should incorporate measures sensitive to deficits in functioning typically associated with MTBI (i.e., attention, information processing, memory, concentration, etc.) and which exist in multiple equivalent forms to more reliably monitor recovery from concussion.

In the absence of neuropsychological testing, return-to-play guidelines provide the best 'estimate' regarding abstinence from play for concussion of varying degrees of severity. Many of these strategies feature arbitrarily established criteria, "based on theoretical considerations and limited clinical investigations" (Jordan, 1999; p. 892). The primary danger arising from such guidelines is that many assume a concussed player will be medically safe to return to play as soon as the arbitrary time period has passed.

Unfortunately, as Roos (1996) highlights, there is no simple way to determine the seriousness of an injury or whether a player has fully recovered. The use of more standardised screening protocols and the adoption of neuropsychological assessment measures go some way to aiding the appropriate management of such injuries and the monitoring of recovery. However, in the absence of these measures the guiding policy should be that an athlete who still has symptoms or signs of concussion should not return to play (Sports Medicine New Zealand, 1999).

CHAPTER FIVE

Prevention of Sport-Related Brain Injury

Efforts towards the prevention of MTBI should ideally focus on two aspects. The first aspect pertains to the reduction of risk at the time of an injury and reducing the risk of subsequent injury (Powell, 1999). As Chapter 4 has largely addressed this issue, it will not be re-examined here. The second aspect relates to primary prevention - preventing the injury in the first instance. In order to accomplish this, knowledge of factors that may increase the risk of a particular injury is imperative. Section 5.1 presents a review of many of the risk factors associated with MTBI in rugby union (although the inclusion of a small proportion of research that addresses other rugby codes should be noted). Again, as rugby-related research has tended to focus on general injury, identified risk factors associated specifically with MTBI are minimal. However, it is assumed that MTBI is, in many respects, likely to be incurred under similar conditions to those of non-MTBI related injuries. Once potential risks are recognised, consideration of these in relation to preventative measures can be addressed. Section 5.2 reviews the areas of rule changes, coaching techniques, use of protective equipment and improved conditioning which are considered pertinent to the prevention of MTBI in rugby.

5.1 RISK FACTORS ASSOCIATED WITH RUGBY

Whilst certain factors associated with sport-related activities are recognised as having little impact on the potential of an athlete to sustain MTBI, others have been shown to increase the athlete's likelihood that such an injury may result. This section reviews those factors under which the risk of incurring MTBI is increased.

5.1.1 Grade and Age

An early New Zealand study revealed that the rate of injuries sustained during winter sporting activities of rugby, rugby league, and soccer was related to the player's grade and age, with senior grade and older players more frequently injured (Lingard et al., 1976). Dalley et al. (1982) provided partial support for this earlier outcome, as their investigation of school and club grade rugby revealed that players in the Senior I grade incurred most of the injuries. This finding was attributed to the larger size and strength of the players, the greater vigor, motivation and competition demands, and more consistent and competitive exposure to the game (Dalley et al., 1982). However, with respect to age, the early finding has since gone largely unsupported as more recent rugby-related studies have reported younger players incur more injury than their older counterparts. A South African investigation identified that while injuries in general were shown to increase across age groups, the peak rate of injury was associated with players under 19 years of age (Roux et al., 1987). In New Zealand, a similar trend has been observed with injuries found to be most common in the 16-20 year age group, although similar numbers were also found in the 21-25 year age group (Dalley et al., 1992).

The predisposition for younger players, in particular those under 19 years of age, to incur a greater number of injuries has also been identified in different sporting codes. Estell, Shenstone, and Barnsley (1995) revealed this trend in a cross-sectional investigation of an elite rugby league club and attributed it to an interaction of three factors reflective of this age group: (1) continual remodelling and realignment of body tissue; (2) a high degree of physical intensity and strength in their play; and (3) "a misplaced sense of confidence" (p. 96) in their skill level. On the basis of this argument, injury incidence is not considered to be as high for older players as they are more physically mature and have greater playing experience, which may prevent them from encountering potentially harmful situations on the field (Estell et al., 1995).

5.1.2 Time of Season

Injuries in rugby have been found to be more prevalent in the early stages of the season as opposed to the later stages. Observations made by Dalley et al. (1992) showed that early season games carried a greater risk of injury with 46% of all injuries occurring in early autumn (April) while only 1% of injuries occurred in spring (September). This same trend was also reported by Garraway and Macleod (1995) and Roux et al. (1987) in their respective investigations of Scottish and South African rugby. Factors thought to contribute to this trend include the relatively low level of match fitness at the start of a season (Sparks, 1985; Roux et al., 1987; Dalley et al., 1982), the keenness and increased vigour of the players (Sparks, 1985; Dalley et al., 1982), and the hard condition of the ground after the summer months (Dalley et al., 1982). Alsop et al. (2000) stated that the decrease in injury over time did not appear to be a consequence of underreporting end of season injuries.

5.1.3 Period of Game

Injuries in team sports predominantly occur during competition as opposed to training and preseason games. Competitive rugby games reportedly produce 71.3% - 80.0% of all injuries sustained (Roux et al., 1987; Dalley et al., 1992; Bird et al., 1998). With respect to injuries sustained during training, the rates vary from 5% (Dalley et al., 1992) to 28.7% (Roux et al., 1987), and for preseason games range from 8% - 12% (Bird et al., 1998; Dalley et al., 1992).

With respect to match play, the majority of all injuries (55% – 61.7%) appear to be incurred in the second half, irrespective of player level (Lingard et al., 1976; Dalley et al., 1992; Wekesa et al., 1996). This finding is typically attributed to the player's experience of fatigue in this period of the game. However, there is also evidence that no difference in injury rate between halves exists. Bird et al. (1998) reported that 46% of injuries were sustained in the first half, and 40% in the second half, with 14% of injury events unclear. On further examination, the study found that injuries occurred evenly throughout the game, replicating a finding of Seward et al. (1993), who also observed no significant difference in injury rate between the first and second half of the match.

5.1.4 Phase of Play

'Phase of play' refers to a particular strategic activity occurring within the course of a game and in rugby these include tackles, scrums, rucks/mauls, and lineouts. As shown in Table 7, the tackle accounts for the highest proportion of general injury (38.7 – 55%) reported in rugby-related research.

Table 7.

Proportions of general injury identified in rugby investigations as a consequence of different phases of play.

	Phase of Play (%)					
Investigations	*Tackle*	*Scrums*	*Rucks*	*Mauls*	*Lineout*	*Other* †
Sparks, 1985	39.6	11.9	18.7	6.9	1.4	21.5
Roux et al., 1987	55.0	8.0	-	18.0	1.0	18.0
Dalley et al., 1992	38.7	6.2	10.3	15.2	2.1	27.5
Garraway & Macleod, 1995	49.0	8.0	15.0	2.0	-	-
Bird et al., 1998	40.0	7.0	17.0	12.0	-	24.0

† Includes phases of play not known, in addition to open play (Sparks, 1985), foul play (Roux et al., 1987) running, pile-up, kicking ball, up and under (Dalley et al., 1992) and back play (Bird et al., 1998)

Concussion is, as a consequence, also most likely to result from a tackle. Roux et al. (1987) reported that 48% of concussions were associated with tackling, while Bird et al. (1998) revealed 64% of concussions were a consequence of this phase of play. Data obtained by the Rugby Injury and Performance Project (RIPP) showed that the head/neck/face region suffered the greatest proportion of injury (22%) resulting from a tackle situation, while concussion comprised 8% of all injuries sustained in this manner (Wilson, Quarrie, Milburn, & Chalmers, 1999).

Most studies reported that rucks/mauls accounted for more injuries in general than the scrum (Dalley et al., 1992), with the safest phase of play appearing to be the lineout. Not shown in Table 7 are those injuries sustained through contact with another player. Dalley et al. (1992) reported that 75% of injuries incurred were as a result of player-to-player contact, while only 14% of injuries were received through contact with the ground.

5.1.5 Position

The potential risk associated with specific player positions is a source of contention for much of the research conducted in this area. Table 8 provides a review of investigations identifying those positions in rugby union which feature the most and least risk of injury.

Table 8.

Positions in rugby union which are associated with the highest and lowest risk of incurring injury.

	Highest Risk		*Lowest Risk*	
Investigations	*Position*	*Injury Rate* (%)†	*Position*	*Injury Rate*(%)
Roy, 1974	Number 8	14.0	Halfback	9.0
Roux et al., 1987	Number 8	13.0	Lock	6.0
Davidson, 1987	Fullback	8.6	Prop	5.7
Bird et al., 1998	Locks	-	Halfback & First-five-eighth	-

† Adjusted percentage – corrected for unequal numbers of players occupying different positions.

There appears little indication within the literature that any one position is consistently more or less at risk than another, although Table 8 presents two studies identifying the Number 8 position as the one at greatest risk of injury (Roy, 1974; Roux et al., 1987), while the halfback features twice as the position associated with the least injuries (Roy; 1974; Bird et al., 1998). Sparks (1985) identified little variation in the rate of injury as a consequence of player position, with halfbacks and wingers being only slightly more vulnerable than other positions. While not presented in Table 8, the rate of injury in both Christchurch studies (Dalley et al., 1982; Dalley et al., 1992) was highest for props and flankers, with the latter of these studies identifying second-five-eighths and wingers to be the most commonly injured positions in the back-line.

While there is an apparent lack of consensus regarding the risk associated with specific player positions, the finding that forward positions sustain more injury than those in the back-line is more consistent (Roy, 1974; Sparks, 1985; Dalley et al., 1992; Wekesa et al., 1996; Gissane et al., 1997). However, some research in this area provides a less convincing argument. For example, Gerrard et al. (1994) found that forwards on average suffered 2.2 injuries each across a 12-month period in comparison to backs (averaged 1.8 injuries), with this difference not achieving statistical significance; Davidson (1987) states that forwards are not more prone to injury than backs, although cautions that this finding may be reflective of the investigation's focus on school rugby which exhibits "quite a reasonable degree of safety" (p. 120).

Position in Relation to Phase of Play

The distinct roles of forwards and backs are often reflected in the phase of play in which injury is incurred. Injury to forwards typically results from forceful collisions and being stomped, kicked, or trodden on (Bird et al., 1997). According to Dalley et al. (1982) the positions of hooker, prop, and lock are more frequently injured in scrums, rucks, and mauls. In contrast, the backs appear to sustain injuries more often as a result of tackling and open play (Dalley et al., 1982; Bird et al., 1997).

Position in Relation to Injury Site

While some argue that rugby injuries to the head and face comprise the most frequently injured regions of the body (Roy, 1974; Sparks, 1985; Davidson, 1987; Dalley et al., 1992; Hughes & Fricker, 1994), there is much evidence to the contrary. Garraway & Macleod (1995) revealed that injuries to the lower limbs, specifically the knee, accounted for 41% of all injuries, while injuries to head, neck, and face were the regions next most frequently affected, accounting for 15.6% of all injuries. Clark et al. (1990) identified that injury incidence was greater for both lower (44%) and upper (27%) limbs than injuries to the head and neck (23%), while Wekesa et al. (1996) produced findings showing that injuries to the head (21.3%) and the regions of the upper (23.4%) and lower (23.4%) leg were relatively equally affected.

Dalley et al. (1992) reported that *head injuries* were comparatively evenly spread across players irrespective of position, although fullbacks and halfbacks were identified as having a higher incidence of *head injury*. Roux et al. (1987) obtained mixed results, with concussive injuries found to be most common in the positions of Number 8 and fullback. As would be expected, more consistent results regarding the pattern of brain injury have emerged when comparing forwards and backs. Roy (1974) identified that two-thirds (65.5%) of head and facial injuries were suffered by forward players, while Seward and colleagues' (1993) revealed that head and facial lacerations and concussion were the most common injuries in each of three Australian rugby codes, particularly amongst the forwards. Gissane et al. (1997) reported that 62.9% of identified concussions in league player were suffered by forwards, with this trend explained by the fact that those occupying forward positions were more likely to be involved in extra collisions and had greater physical involvement than players forming the back-line.

5.1.6 Foul Play

According to Roy (1974), the majority of head and facial injuries could be classed as unnecessary rugby injuries, attributed either to foul play (i.e., being punched or kicked), or 'over-robust play', marked by excessive enthusiasm and determination on behalf of the players. Reports of foul play vary in the literature. Dalley et al. (1992) reported that illegal or foul play did not contribute to any of the head and face injuries incurred in the investigation. Bird et al. (1998) reported foul play accounted for 13% of all injuries, and 17.4% of concussions, while in what seems an excessively high rate, Roux et al. (1987) attribute 32% of all concussive injuries to foul play.

5.2 PREVENTION OF SPORT-RELATED BRAIN INJURY

Over the last 20 years the rate of serious brain injury has fallen dramatically, particularly in collision sports such as American football and rugby league (Cantu, 1996a). Rule changes (e.g., outlawing spear tackling), introduction of equipment standards and enforcing the use of protective gear, better conditioning of the neck, and improved on-field medical care (reviewed in Chapter 4) are some of the factors that have been attributed to this reduction. In contrast to the musculoskeletal system, the brain is unable to be conditioned to accept trauma. Rather, trauma to this region may leave the brain more vulnerable to future injury (Gerberich et al., 1983). This section reviews four of the five main areas that Cantu (1992) suggests should be introduced to prevent the occurrence or reoccurrence of TBI in sport (the fifth area relates to on-field management, addressed in the previous chapter).

5.2.1 Rule Changes

Rule changes may need to be introduced in order to reduce the potential for brain injury, particularly if there is clear-cut evidence of a mechanism being solely responsible for such an occurrence (McCrory et al., 1992). For example, in 1976 a ruling was enacted that made illegal "any initial impact of the helmeted head when tackling or blocking" (Clarke, 1998; p. 7) in both school and college level American football. This ruling led to a noticeable reduction in head-related fatalities, corresponding to the diminished use of the head as a battering ram and spear tackling.

The Australian Rugby Football Union (and the NZRFU) have taken measures to decrease "forces at scrum engagement, interrupting play once a player is on the ground, encouraging participants to play 'the ball' not 'the man' and preventing dangerous tackling" (Hughes & Fricker, 1994; p. 249). Dangerous tackling is penalised at the referee's discretion, with high tackling prohibited and late tackling more strictly enforced (Tomasin et al., 1989).

5.2.2 Coaching Techniques

Injury prevention should incorporate educating players on ways to protect the head. One method of reducing injuries among players is to ensure that skills such as tackling and scrummaging are taught correctly (Collinson, 1984; Tomasin et al., 1989; Powell, 1999). It is considered the responsibility of coaches to ensure that these skills are correctly taught and that the positions players are selected for are appropriate for their build (e.g., hookers and front row players should have a short strong neck) and level of skill (Collinson, 1984).

Coaches also play an important role in reducing foul play and should be seen not to condone the illegal actions of their players on the field. To this effect, Roy (1974) claims that "the coach's influence in forming the attitude of his [sic] players is of paramount importance" (p. 2325).

5.2.3 Protective Gear

Clear support for the use of mouthguards in sports such as rugby has been indicated in the scientific literature. Investigations have provided evidence that mouthguards are effective in protecting against orofacial injuries (Chapman, 1985) and more importantly, offer protection against concussion and injuries to the cervical spine (Chalmers, 1998).

Rates of mouthguard use in rugby and other collision sports are varied, although the general trend reflected an increasing number of players electing to use mouthguards even before mandatory laws were enforced. Dalley et al. (1992) reported that on average 66.4% of their 1989 rugby sample wore mouthguards during competitive games, although the rate of use declined in response to age group. Lower rates of mouthguard wearing were evident in those over 30 years of age (54.6%), while those in the 21 – 25 year age group exhibited the highest rate of use (67%). Gerrard et al. (1994) revealed a much higher rate of mouthguard use (85%) in their investigation involving club and school grade rugby players. A more recent investigation involving AFL players of varying levels of performance identified mouthguard wearing rates in competition of 89% for elite players, 71% for those in organised competition (equivalent to club level), and 64% for those under 18 years (Banky & McCrory, 1999). During training, rates of use for each of these groups were 40%, 21%, and 1%, respectively.

A number of studies (e.g., Jennings, 1990; Bird et al., 1998) have shown that the majority of players of collision sports who have sustained concussion have not been wearing a mouthguard at the time of injury. In a survey of club grade rugby players in England, 48% reported having been concussed at some stage during their career and 71% indicated not wearing a mouthguard at this time (Jennings, 1990). Bird et al. (1998) revealed that 72% of players who had sustained a concussive injury were wearing neither a mouthguard nor headgear. Hughes and Fricker (1994) found that only 31.2% of players sustaining an injury to the head region had not been wearing mouthguards.

Many studies have revealed a high degree of acceptance regarding the efficacy of mouthguards with the majority of players surveyed indicating regular use (Stokes & Chapman, 1991; Chapman & Nasser, 1993). Investigations of international players' attitudes to mouthguards in rugby have shown that many players at this level would be reluctant to play without a mouthguard. Stokes and Chapman (1991) surveyed the All Black test squad and found that all members of the squad believed mouthguards protected against injury, with 47.6% of squad members indicating that they would not play without a mouthguard and 38.1% stating they would be reluctant to do so. Chapman and Nasser (1993) identified that of the 84% of players in their investigation who regularly wore a mouthguard, the percentage of players who would not play without a mouthguard ranged from 27.3% to 54.6%, far outweighing those who would be willing to play without it (4.6% - 15.8%).

The quality of the mouthguard is important in preventing against concussive injuries. Maximum protection and safety is afforded by mouthguards custom-made by dentists (Chapman, 1985; Kerr, 1986; Chalmers, 1998). Non-custom mouthguards (i.e., stock and mouth formed) are plagued by problems associated with being poorly fit, such as being easily dislodged, causing gagging and interfering with speech, swallowing, and breathing (Banky & McCrory, 1999).

The most common reasons for the use of headgear are preventing scalp and facial lacerations and minimising the risk of concussion by reducing the magnitude of the force of impact (Wilson, 1998). According to Gerrard et al. (1994), New Zealand rugby players attributed their use of protective gear to the prevention of injury (57%), previous injury (53%), and on the basis of medical advice (21%). Rates of headgear use and controlled studies of headgear effectiveness have not been well documented (McIntosh & McCrory, 2000). Gerrard et al. (1994) reported that 20% of players in their investigation used headgear, while according to McIntosh and McCrory (2000), the rate of adoption of headgear in players under 15 years of age is around 60%. Whilst improved protective headgear, properly fitted and maintained, has been claimed to reduce the incidence of *head injury* (Cantu, 1992), as yet no sport-specific helmets have been shown to be beneficial in sports such as ARF and rugby union (McCrory et al., 1992). A more recent study concluded that the current commercially available models are unlikely to reduce concussion or more severe *head injury* as impact energy attenuation performance is poor in comparison to other helmet types (McIntosh & McCrory, 2000).

5.2.4 Improved Conditioning of Athlete

Another area pertinent to primary prevention emphasizes the need for improved conditioning of an athlete's body, especially of the neck (Cantu, 1992). As stated earlier, most injuries occur early in the season or in the later stages of a match when fatigue becomes an issue (Tomasin et al., 1989). Strengthening exercises to develop both neck and shoulder muscles are recommended from school age (Collinson,1984; Tomasin et al., 1989; Cantu, 1992) as strong neck muscles in good tone may help reduce the effect of a blow to the head (Wrightson & Gronwall, 1983). While Estell et al. (1995) report that weight training may assist a player in minimising the number of minor injuries to the body by being able to absorb a greater impact, they caution that the player's perception of a 'tougher' body may increase the likelihood of a more severe injury.

5.3 CHAPTER SUMMARY

Primary prevention in sports requires the knowledge of factors that may increase athletes' risk of injury. In rugby, these factors include being young (i.e., 16 – 20 years), competing at a senior level, and occupying a forward position. Injuries also appear to occur most frequently in the early season games, the second half of a match, tackles and as a consequence of foul play. Of contention is whether these factors are valid indicators of risk as a consequence of the somewhat equivocal nature of the data gathered in this area. Despite this concern, the general trends that have been established in relation to these particular areas are worth calling attention to.

In order to avoid a MTBI in the first instance, primary prevention strategies should address: (1) rule changes; (2) the responsibility of coaches; (3) the importance of using protective gear (particularly mouthguards); and (4) improving a player's overall conditioning. In instances where a MTBI has been not been prevented, it is advised that the circumstances resulting in the concussion be analysed. Where repetitive brain injuries are evident, Lovell and Collins (1998) recommend assessing whether the reoccurrence of such injuries are a consequence of poor playing technique, ill-fitting or poorly maintained equipment, or poor neck strength.

CHAPTER SIX

Formulation of the Proposed Research

The first section of this chapter provides a summary of the literature reviewed to this point, so as to place the current investigation into context. On the basis of this literature review and in conjunction with the author's own observations and assumptions, a number of research objectives were formulated. The proposed research consists of two phases – the first involving the administration of three questionnaires designed for the purpose of the study, and the second incorporating the administration of neuropsychological assessment measures. Sections 6.2 and 6.3 present the objectives associated with each of the respective phases.

6.1 SUMMARY OF LITERATURE REVIEWED

Issues associated with the varied and inconsistent use of terminology and the definitions accompanying these terms has meant that drawing firm conclusions about TBI-related aspects within the realm of sports is somewhat of a challenge. The interchangeable use of the terms 'head injury', 'brain injury', 'mild/minor head injury', 'mild/minor brain injury' and 'concussion' have proved confusing and have led to complications when making comparisons across research studies. The importance of a unified definition for MTBI and its appropriate use in clinical and research settings emerges as a high priority.

Contact sports such as American gridiron football, Australian Rules football, rugby league, and rugby union are considered high-risk with respect to incurring both general injury and MTBI specifically. Rates of incidence of MTBI in many of these sports range from 2% – 22%. In New Zealand, where the sport of rugby union is well popularised, rugby is a major contributor to sport-related deaths, presentation at emergency departments, hospitalisations, and healthcare costs (Hume & Marshall, 1994). While the incidence, nature, and circumstances surrounding rugby injury has been described both internationally and nationally, few studies have specifically examined the incidence of rugby-related MTBI, and in this country, only one investigation (Bird et al., 1998) has dealt exclusively with club grade players. Of the rugby investigations reporting MTBI, rates of incidence vary, with overseas research appearing to generate a lower MTBI rate on average than rates evidenced in this country (4.5% - 9.1%). Figures also vary as a function of the population from which they are drawn, with MTBI rates obtained from elite/professional teams appearing lower than that of club grade and some school grade teams.

In sport, the mechanisms of injury associated with MTBI are reported to occur equally as a product of direct impact or indirect acceleration/deceleration forces, producing either focal or diffuse damage. Physical, behavioural, and cognitive deficits may emerge as a consequence of such damage, with the hallmark features of MTBI including a LOC, confusion/disorientation, or amnesia (Kelly & Rosenberg, 1997). While many of the symptoms associated with MTBI are relatively short-lived with spontaneous improvement typically noted within 3 months of the injury (King, 1997), some sequelae such as headache, dizziness, memory, and concentration deficits may continue to persist for up to a year post-injury. Such a constellation of persisting symptoms is referred to as a post-concussive syndrome (Bernstein, 1999) and is experienced by approximately 15% of those suffering MTBI (Rutherford et al., 1979).

While the presence of these persisting symptoms is important to assess, it is even more important to ensure that a second TBI is not suffered prior to the resolution of symptoms associated with the primary injury. Should this occur, the ensuing sequelae constitute a phenomenon referred to as second impact syndrome, and while rare, the outcome is typically fatal. Aside from the potential for such a syndrome, an athlete has a four-fold increase in risk for future TBI after suffering an initial brain trauma. Cumulative effects of repeated brain injury have been noted, increasing the severity and duration of the sequelae suffered.

On the basis of these risks, appropriate assessment at the time of injury is advocated to ensure the safety of the player. The immediate management of a suspected MTBI should incorporate minimising environmental dangers to avoid additional harm to the player, assessing their level of responsiveness, and adopting the first-aid principles of ABC where required. Establishing whether a player lost consciousness is important, as is assessing their orientation and experience of post-traumatic symptoms. A full medical and neurological assessment may be warranted in more severe cases, in conjunction with a head CT or MRI scan (Cantu, 1992).

The use of appropriate classification systems to gauge injury severity and aid decision making associated with returning an athlete to play is also important to consider. In the realm of sport-related research a number of systems for measuring brain injury severity have been developed, largely based on evidence of LOC, duration of PTA and/or GCS ratings, and rating the severity of injury from very mild to severe. As a consequence of variations evident within these systems a number of different exclusionary policies have been produced, with little agreement regarding the length of time a player should abstain from play after incurring a MTBI. Despite the apparent lack of consensus, all adhere to the general rule of thumb, which states that in times of uncertainty, no athlete should be returned to play if they are symptomatic.

As these return-to-play guidelines are considered somewhat arbitrary with little scientific support, neuropsychological assessment is increasingly utilised to aid diagnosis and, importantly, to assist in monitoring the rate of recovery from TBI. Assessment measures are typically selected on the basis of their sensitivity to assess areas of functioning affected by MTBI and on the availability of multiple equivalent forms, to ensure that the monitoring of an individual's recovery to baseline levels is reliable. Despite some developments, research in this area remains relatively new, with more exploration required to establish measures appropriate for use in a sporting context.

Risk factors associated with MTBI in rugby union are somewhat equivocal with respect to age, experience, and the individual positions held by players. However, it is widely accepted that players occupying forward positions in general, are more at risk of injury than those in the backs, and that in contrast with other phases of play, involvement in tackles place a player at greater risk. With respect to the prevention of MTBI in sport, the focus has been on regulation changes, improving coaching techniques, use of protective equipment, and improving the overall conditioning of the athlete.

6.2 FORMULATION OF PROPOSED RESEARCH - PHASE I

Phase I of the research was designed to investigate a number of different areas associated with MTBI in club rugby, employing the use of three questionnaires (the RPQ, HMQ and AMQ, discussed later in Chapter 7) to address the following objectives.

6.2.1 Rate of Brain Injury and Relationship to Other Injury

A review of the available literature revealed that the investigation of rugby-related injury at the club grade level had received little attention compared to studies involving school and elite/professional rugby players. Additionally, these studies typically focused on a broad range of injury, as opposed to a more concentrated inquiry of MTBI. Therefore, a primary objective of this research was to investigate the rate of MTBI sustained by players at club level, allowing for comparisons with pre-existing rates evidenced in rugby in addition to more crude comparisons with rates in other collision sports.

Another objective associated with determining the incidence of MTBI was to identify the rate of repeat brain injury, to establish whether players with a history of MTBI were more at risk of incurring future brain injury than those with no prior history. As previous research has indicated that delayed reaction times and poor decision making associated with brain injury may predispose an athlete to an increased risk of general injury (Ingersoll, 1983; Gronwall, 1989), it was the intention of the present study to identify whether this phenomenon was evident in this particular population. Establishing the rate of non-MTBI related injury would also provide a basis for presenting a MTBI rate, enabling comparison with previous studies.

6.2.2 Severity of Brain Injury

As a consequence of the biomechanical forces associated with sport-related TBI and in conjunction with previous reports of severity in the literature, it was anticipated that the brain injuries sustained in club grade rugby would constitute injuries at the mild end of the spectrum (i.e., MTBI or concussion). As different classifications of severity exist for such injuries (as indicated by concussion severity guidelines) which warrant different management, it was considered important to establish the severity of concussion experienced at this level. Once established, this would allow for comparisons to be made with elite/professional and school grade rugby teams.

On the basis of the retrospective nature of the questionnaire and the lack of corroborating evidence, establishing the reliability of respondents' reports of concussion severity was expected to be difficult. Severity of a MTBI was therefore to be determined in one of three ways: (1) by the number of symptoms endorsed; (2) by reports of a LOC; or (3) by reports of diagnosis by respondents. In the absence of information pertaining to duration of PTA, the number of symptoms experienced by a respondent was considered of value in indicating the severity of a concussion. In accordance with Roberts' (1992) criteria, the recall of only dizziness and/or headache in the absence of a LOC or a diagnosis of concussion was to be considered indicative of a *verymild* concussion – a bell-ringer (refer Table 9). While a somewhat arbitrary division, the recall of at least three or more symptoms (excluding LOC) was to be classified as a *mild* concussion, while injuries with only one or two symptoms (excluding headache and/or dizziness) would fall into a *very mild – mild* severity category, as shown in Table 9. The latter division was formed on the basis that the presence of a symptom such as memory impairment[3] would likely be indicative of more severe injury than the presence of headache or dizziness alone. In accordance with Cantu's (1986) guidelines, a moderate concussion is indicated by a LOC, a phenomenon more likely to be recalled by the player than the subtle symptoms of MTBI. Therefore, in the present study a LOC would be considered a definitive indicator of a *moderate* severity injury.

Table 9.

Classification of concussion severity for the purposes of current research based on the presence of symptoms and LOC, ranging from very mild to moderate severity

Classification of Severity	*Sequelae Associated with Injury*
Very mild	Dizziness and/or headache, no LOC
Very mild - mild	1 symptom (not including headache or dizziness) <u>or</u> 2 symptoms (1 may be either headache or dizziness), no LOC
Mild	3 or more concussive symptoms, no LOC
Moderate	LOC <u>or</u> diagnosis of concussion by medical professional

[3] Lynch and Yarnell (1973) claim that memory impairment may occur in the absence of any LOC or other symptoms.

In the absence of direct reports from medical professionals a respondent's report of a 'head injury' being diagnosed as concussion by a medical professional, was also to be considered a satisfactory and comparatively reliable indicator of injury severity. On the basis that those losing consciousness or experiencing persisting symptoms would receive or seek medical attention, it was considered that such an injury would most likely reflect a *moderate* severity injury.

6.2.3 Player- and Game-Related Variables Associated with Brain Injury

The issue of risk is an important consideration in sports where an individual's welfare is often endangered. Establishing a reliable profile for the way MTBI is incurred in a sport has implications for the teaching and practice of correct technique in addition to initiating regulation changes in an attempt to reduce brain trauma.

Age and Grade of Player

Unlike school grade and elite/professional teams, club rugby is somewhat unique in the fact that the grading system encompasses a broad range of ages and playing abilities. Accordingly, the current research aimed to establish whether certain age groups or levels of ability were potentially at greater risk than others on the basis of three assumptions. Firstly, as a consequence of youthful enthusiasm, lack of experience, and an attitude of indestructibility, younger players are more likely to incur MTBI than older players. Secondly, in lower grade competition a player's risk of MTBI is increased due to a more lax enforcement of regulations by those in charge of play, effectively resulting in a less adequately controlled game. Thirdly, players are at greater risk of incurring a MTBI if correct skills and techniques, aiding in the prevention of brain injury, are inadequately taught or poorly communicated by an inexperienced coach – a situation considered more likely within the lower grades.

Position of Player

Prior research has established that forward positions are more at risk of injury in general than those positions forming the back-line. The role undertaken by forward positions frequently incorporates a wider range of high-risk phases of play (i.e., rucks, scrums, and mauls) than those occupying back-line positions. One of the objectives associated with this line of investigation was to replicate this earlier finding in addition to establishing whether particular positions place a player at greater risk.

Period of the Game

Research to date suggests that the second half of a match is more likely to produce MTBI as a consequence of increasing levels of fatigue, which correspondingly leads to an increased risk of injury. An objective of the current research was to obtain evidence at club rugby level that higher rates of MTBI occur in the second half of competition.

Phase of Play

Different phases of play in rugby are associated with varying elements of injury risk, of which the tackle is consistently attributed the highest degree of risk for both general injury and MTBI specifically. An objective of this study was to establish a hierarchy of risk in relation to the phases of play in club rugby.

Receipt of Injury and Foul Play

The manner of receipt of MTBI, whether through normal passages of play such as contact with another player, contact with the ground, or as a consequence of foul play is important to establish in relation to club grade rugby.

6.2.4 Use of Protective Gear

Mouthguards

The wearing of mouthguards by players during competition, irrespective of grade, became mandatory, enforced by the NZRFU in 1997. Since this regulation came into effect, little published information exists regarding the level of adherence to this new law. It was therefore essential for the present investigation to establish whether rates of mouthguard use exhibited by players in club competitions concur with rates identified in earlier studies. In addition, this study sought to provide information as to the rate of mouthguard use during training sessions.

In the absence of mandatory laws enforcing mouthguard use, research has identified a high level of acceptance and wearing rates both by elite international players as well as by club grade players, although the evidence is less convincing in the latter case (Chalmers, 1998). Athletes' levels of acceptance regarding the wearing of mouthguards is thought to be reflected by their beliefs as to its benefits, indicated by their reluctance or refusal to play without a mouthguard (Stokes & Chapman, 1991; Chapman & Nasser, 1993). Although use in this country is mandatory, it was considered important to establish players' attitudes regarding the wearing of mouthguards. The utility of mouthguards in preventing concussion and dental injuries was also to be examined from the perspective of coaches, team management, and referees.

Mouthguard quality has been reported to impact on the level of protection it offers, with inexpensive, ready-made mouthguards and mouth-formed versions (shell-liner and 'boil and bite' mouthguards) being unlikely to provide the same protection afforded by custom-made mouthguards (Chalmers, 1998). On this basis, one objective was to establish the quality of mouthguards selected for use by club grade players and determine whether any variations in quality were noted between grades.

Headgear

The literature offers three standpoints in the debate surrounding the ability of headgear to provide protection against brain injury. The first is a largely misconceived and now infrequently endorsed notion that this piece of equipment aids in the prevention of TBI irrespective of the force of impact to the head or body. The second view is one that is highly sceptical, believing that irrespective of the velocity of impact, headgear is of no use at all. The third standpoint, supported by the present research, errs on the side of caution arguing that headgear is of little preventive use when faced with high-velocity impacts, although it may aid in the prevention of injuries at the mild end of the spectrum. It is this latter stance which provides the rationale for the current study supporting headgear use by players.

Based on these equivocal perspectives, the rate of headgear use during competition and training sessions by those in club rugby was of considerable interest. As with mouthguard use, players' attitudes toward wearing headgear was important to examine. Support for the unreasonable belief that headgear would prevent against all TBI was to be assessed with players, coaches, team management, and referees in addition to examining the reasons underlying a player's decision to wear headgear.

6.2.5 Levels of Recognition, Assessment and Management

Was Attention Received and When?

That MTBI frequently escapes medical attention in numerous sports settings is widely acknowledged. On this basis, there was the potential for this to be an issue of 'epidemic' proportions in club rugby, attributed in part to the subtlety of MTBI symptomology, but also to the lack of familiarity and knowledge of such symptoms at this level. The degree to which this assumption is correct was to be examined in the current research by comparing the number of MTBI's reported by respondents with the number receiving attention. It was also considered important to determine the point at which attention was received (i.e., during the course of the game or at a later point when persisting symptoms prompted a player to obtain medical assistance).

Level of Recognition

The level of knowledge of MTBI symptomology and sequelae held by those monitoring players was important to assess, as was establishing the extent that individuals conducting assessments at this level understood that a LOC is not required for a diagnosis of concussion.

Who Attended the Injured Player?

There is an inherent expectation that an injured player should receive attention from a person competent in the assessment and management of injury. Whilst those competing in elite/professional rugby are attended by those competent to provide medical assistance, this scenario is less likely for those competing at club level. However, within the club grade system itself, senior teams tend to receive a greater proportion of club funding and non-club sponsorship than teams in the lower grades, and consequently may be able to employ qualified medical personnel. In the absence of trained medical personnel attached to a team, the Order of St. John's (an organisation involved in the training of first aid) supply personnel to monitor club rugby games (Personal communication, Kevin Dewn, May 2000). However, members are often only able to attend the more serious injuries, while minor injuries are left for those involved with the team to tend to or alternatively are neglected. On the basis of this information, it was assumed that lower grade teams would be less likely to receive appropriate medical attention and more likely to be attended by coaches, members of team management, or referees. Of concern to this research was whether these individuals possessed sufficient knowledge for the appropriate assessment and management of MTBI.

Level of Competence of Assessor

To establish whether any continuity in the assessment of a MTBI existed, the procedure or protocol respondents followed when confronted with an unconscious player was examined. It was expected that those monitoring club grade players would have knowledge of five basic steps to manage such a situation, which includes: (1) ensuring there are no immediate environmental dangers which may lead to further injury; (2) assessing responsiveness; (3) checking for spinal or neck injuries; (4) adopting the ABC (airway, breathing, circulation) principles if considered necessary; and (5) ensuring a full medical and neurological examination occurs.

Another means of establishing competence was through evaluating the frequency of use of standard assessment tools. The Glasgow Coma Scale (GCS) is a standard assessment measure for concussion, often adopted by those with more extensive medical training (e.g., St. John's personnel). The respondents' use of this measure and other assessment tools would assist in establishing their level of competency and help to identify the utility of such measures within this domain. The assessment of orientation to time, place, person, and activity was also to be examined to ensure that this was undertaken reliably (i.e., asking orientation items that assess recent memory as opposed to aspects of memory that remain intact after MTBI). The information obtained in relation to these issues may be used to support future recommendations advocating the adoption of standardised assessment procedures in addition to ensuring adequate training for those conducting initial injury assessment.

Reporting and Recording

Currently the onus for the reporting and recording of any injury requiring the player to leave the field of play resides with the coaches/managers of a team in addition to the attending referee. In the event of such an injury a 'Serious Injury Report Form' (SIRF) is to be completed and submitted to the local union. However, the regional rugby union reported that the utilisation of this form was infrequent and inconsistent. As these reports assisted with the composition of ACC statistics, it was considered important to examine why this was the case.

While the responsibility for monitoring club grade players who have incurred a concussion appears to lie with team management, it was of interest to determine where those involved felt such responsibility should rest. Associated with this issue, and having implications for return-to-play decisions, was determining whether coaches were aware of players' MTBI history and whether team management felt they should be party to this knowledge. Assessment of these issues may prove to lend weight to recommendations allowing coaches to request disclosure of a player's MTBI history, especially important in cases where a player has suffered an injury of a severity warranting medical attention and/or exclusion from participation.

6.2.6 Adherence to Regulations and Recommendations

Stand-Down Period

According to NZRFU directives, a concussion (as indicated by a LOC) is subject to a minimum 3-week stand-down period. Adherence to this stand-down period is generally strictly enforced for those whose involvement in the sport is professional and there is some evidence of its support at club level, with Bird et al. (1998) revealing that 86% of MTBI cases in their investigation were subject to this 3-week stand-down period. Determining the level of adherence to this mandatory ruling for those in club rugby was crucial, due to the potentially harmful implications of a concussed player returning to play prior to resolution of symptoms. Of specific concern to the present study were those players who did not observe this regulation after sustaining a concussion of *moderate* severity and whether this would have implications for repeat MTBI.

These issues were also important to examine from the perspective of those controlling the return of players to the game. In competition situations where the injury sustained appears minor (with a few discreet symptoms) the onus for allowing a player to continue often falls on the coach, referee, and/or team management. Adherence to return-to-play guidelines by such individuals for concussion of varying degrees of severity was important to establish, as was the rationale underlying the decisions made by these respondents.

Abstaining from the Sport

In such a high physical contact game it is not unusual for individuals to be advised by a medical professional to abstain from participating in the sport as a result of either a severe concussion or multiple brain traumas having been incurred. Guidelines currently recommend that those players sustaining two severe concussions or scan abnormalities of brain injury should terminate a season (Cantu, 1986). However, should the player sustain four concussions in a season, they should abstain from playing the sport indefinitely and avoid other contact sports (Wrightson & Gronwall, 1983). Of concern with respect to this latter situation were anecdotal reports that, invariably, players who had been advised to discontinue their participation would continue despite the risk of incurring more severe brain injury, or even death. As such information is largely unsubstantiated it was important to investigate the number of players currently participating in club grade rugby who had previously been advised by a medical professional to refrain from playing contact sports.

6.3 NEUROPSYCHOLOGICAL ASSESSMENT - PHASE II

Within the realm of sports, one of the key issues in the management of MTBI is when to allow an athlete to resume participation (Hinton-Bayre et al., 1999). While many exclusionary policies have been developed to aid the decision-making process, the majority are arbitrary with little or no empirical support (Roos, 1996). These policies may therefore underestimate or overestimate the time an individual may require to recover after a MTBI.

While the NZRFU's recommended exclusionary period might be regarded as a sensible time frame to ensure cognitive recovery after concussion, this recommendation does not take into account differences in brain injury severity as indicated by the duration of unconsciousness and/or PTA. This exclusionary time frame also ignores variations in the rate of recovery as a consequence of individual differences. It matters not whether these differences exist in relation to physiology, anatomy, or psychology. Theoretically, two players receiving an impact of the same velocity, to the same region of the head, will experience differences in symptom type, severity, and duration. As a consequence of such variability between cases, the use of psychometric measures as objective indicators of recovery after MTBI is recommended by several researchers (Hoy, 1987; Wrightson, 1992; Gronwall, 1992; Hinton-Bayre et al., 1996; Hinton-Bayre et al., 1999).

To date, only a few studies have prospectively examined psychometric test performance in relation to the rate of recovery after MTBI (reviewed in Chapter 4), with none having assessed this phenomenon in relation to a New Zealand rugby-playing sample. The current study sought to replicate in part the research conducted by Hinton-Bayre et al. (1996) and Hinton-Bayre et al. (1999). In addition to other measures of cognitive functioning, both investigations employed three specific psychometric measures sensitive to information processing speed deficits: (1) SDMT; (2) Digit Symbol; and (3) Speed of Comprehension Test (Silly Sentences).

6.3.1 Practice Effects

While practice effects were noted by Hinton-Bayre et al. (1996) in relation to the Silly Sentences and Digit Symbol test, the SDMT was not significantly affected. The researchers recommended that practice effects could be controlled by a minimum of two pre-season measures, with the player's highest score acting as a baseline (pre-injury) comparison score. However, the 1999 investigation showed that not all practice effects could be sufficiently controlled in this manner, with non-injured players' scores on Silly Sentences improving during a mid-season assessment to a level significantly higher than their baseline performance.

The current investigation sought to examine whether practice effects were evident in relation to these measures across four assessment sessions (pre-season I and II, mid-season, and post-season), incorporating the use of both the average pre-season score and the highest pre-season score as a baseline comparison. Use of the latter score has been found to produce no significant differences in performance by the non-MTBI group in the 1996 study, while the 1999 investigation demonstrated that use of the highest pre-season score did result in significant differences. It was the intention of the current study to clarify this particular finding.

6.3.2 Monitoring Rate of Recovery

While Hinton-Bayre et al.'s 1996 study examined recovery of function to pre-baseline levels with group analyses, Hinton-Bayre et al. (1999) demonstrated the sensitivity of these three tests to measure individual variations, incorporating the use of the Reliable Change Index (RCI). The use of the RCI allowed measurement of the magnitude of 'clinically meaningful change' for the individual through examination of pre- and post-injury scores (Hinton-Bayre et al., 1999). This index takes into account the effect of practice that had obscured concussion-related deficits in the 1996 investigation where group analyses were used.

The magnitude of change experienced by a MTBI player would be assessed in the current investigation through use of the RCI and compared to that of non-MTBI players. An additional objective was to examine the extent of deficit and rate of recovery associated with players with a history of MTBI in contrast to those with a singular injury. This was an area not addressed by previous prospective studies.

The hypothesis associated with the objectives outlined for Phase I of this investigation are addressed in the next chapter, while those for Phase II are detailed in Chapter 9.

CHAPTER SEVEN

Method – Part I

Three questionnaires – the Rugby Players Questionnaire (RPQ), the Headgear and Mouthguard Use Questionnaire (HMQ), and the Assessing and Managing Head Injury Questionnaire (AMQ) - were contrived to fulfill the objectives relevant to Phase I of the research. Section 7.1 introduces the Phase I hypotheses which endeavor to replicate previous research, provide greater clarity to equivocal findings, and address areas not previously investigated. Section 7.2 covers information relevant to the development of the questionnaires, provides justification for the questions incorporated, and reviews adjustments made to certain versions of the RPQ. The third section of this chapter provides demographic information pertaining to the respondents involved with each questionnaire, while the procedures adopted for the administration of each are covered in Section 7.4. The final section of this chapter, Section 7.5, addresses the statistical procedures undertaken to analyse the data gathered.

7.1 RESEARCH HYPOTHESES

The hypotheses formulated for Phase I of the current research are delineated and listed below under headings which correspond to the earlier stated objectives.

7.1.1 Rate of Brain Injury & Relationship to Other Injury

- The rate of MTBI at the club grade level of competition will be higher than rates previously reported by studies (both national and international) involving either school or elite/professional grades.

- A player incurring three or more MTBI's prior to a season will be more susceptible to MTBI within that season than those either having a history of 1-2 MTBI's or having no prior history.
- Players experiencing MTBI during the season will be more likely to sustain injury to other regions of their body than those with no MTBI.

7.1.2 Severity of Brain Injury

- The rate of MTBI involving a LOC will be higher in club rugby than rates obtained by previous investigations involving elite/professional or school grade teams.
- All MTBI featuring a LOC will have received a diagnosis of concussion by a medical professional.

7.1.3 Player- and Game-Related Variables Associated with Brain Injury

Grade and Age of Player

- More MTBI will be sustained by those in the 16-20 year and 21-25 year age groups than by those aged 26 years or older.
- Those in the Lower Grades (i.e., Senior II, III, IV, Under 21, and Under 19) will be more likely to sustain MTBI than players in the Senior I grade.

Position of Player

- Forwards will sustain more MTBI's than backs; however, backs will sustain more severe injury (i.e., *moderate* concussion) than forwards.
- Individual positions associated with forward play will sustain more MTBI than individual positions comprising the back-line.

Period of the Game

- More MTBI will be incurred in the second half of a match as opposed to the first.

Phase of Play

- More MTBI will emerge from phases of play in which the head region is at risk of sustaining physical impact (i.e., rucks, mauls, and scrums) as compared to phases where contact with this region is less likely (i.e., lineout).
- The tackle will be the phase of play associated with the greatest number of MTBI.
- Back-line players will sustain more MTBI as a consequence of tackles than forwards.

Receipt of Injury and Foul Play

- The majority of MTBI will result from contact with the body of another player.
- Rates of MTBI arising as a consequence of foul play will be greater at club level than at the elite/professional or school grade level.

7.1.4 Use of Protective Gear

Mouthguards

- The rate of mouthguard use in competition will reflect previously obtained rates, with the rate of use during training sessions being lower than in competition.
- More players will indicate their *reluctance* to play without a mouthguard in competition than *refuse* to play without one.
- The majority of players will believe that mouthguards are beneficial in preventing dental injury.
- The majority of players, coaches, team management, and referees will believe that mouthguards are beneficial in preventing against concussion.
- The majority of players will use mouth-formed mouthguards in preference to the more expensive custom-made version.

Headgear

- More forwards will wear headgear than backs, as a consequence of the protection it offers in scrums, rucks and mauls.
- More players will claim to be *reluctant* to play without headgear than those who will *refuse* to play without headgear.
- The majority of players, coaches, team management and referees will have realistic beliefs regarding the utility of headgear to aid in the prevention of concussion.
- Headgear use will more often reflect a personal choice or advice from medical personnel than recommendations from the player's family or from their coach/team management.

7.1.5 Establishing Levels of Recognition, Assessment and Management

Was Attention Received and When?

- *Moderate* concussions will be more likely to receive attention than *very mild* to *mild* ones.
- Attention for MTBI will primarily occur during the match at the field of play.
- Senior I players will be more likely to receive attention during the course of the game than Lower Grade players.
- MTBI will not be reported primarily on the basis that the injury was considered mild and not worthy of attention.

Level of Recognition

- Those monitoring Lower Grade players will be less likely to recognise MTBI (indicated by the number of reported MTBI not receiving attention), than those monitoring Senior I players.
- The majority of those monitoring players will know that 'concussion' can be sustained with or without a LOC.

- Hallmark features of concussion such as headache, confusion, and amnesia will be better known by those monitoring players than features such as nausea/vomiting, blurred vision, etc.

Who Attended to Injured Player?

- Senior I players will receive attention primarily from qualified medical personnel (i.e., doctor, St. John's personnel).
- Lower Grade players will receive attention primarily from coaches/team management.
- *Moderate* severity concussions will primarily receive attention from qualified medical personnel.
- *Very mild* to *mild* severity concussions will mainly receive attention from coaches/team management.

Level of Competence of Assessor

Respondents having obtained medical or first aid qualifications will be:

- more prolific in the Senior I grade than in other grades.
- younger than those without such qualifications, perhaps reflective of changing attitudes toward injury management and prevention.
- more likely to follow standard assessment protocol for managing an unconscious player than those without these qualifications.
- more likely to use the GCS than those without qualifications.

7.1.6 Adherence to Regulations and Recommendations

Stand-down Period

- The rate of concussion during the season will be higher for those who rarely, if ever, reported observing the mandatory stand-down period.

Of those monitoring club grade players, most would:

- return a player to the game if they were only experiencing a headache after a blow to the head.
- not return a player to the game if they experienced a LOC after a blow to the head.
- advocate the mandatory 3-week stand-down if a LOC was suffered.
- advocate that the player abstain from play for a season if they experienced two concussions involving a LOC during the course of one season.

Abstinence from the Sport

- There will be a small number of players who will have ignored the advice of medical professionals to abstain from playing rugby indefinitely, evidenced by their continuation in the sport.

7.2 FORMULATION OF QUESTIONNAIRES

The adoption of questionnaires to obtain information pertinent to injury is consistent within sports research. For the purposes of the current study, questionnaires were considered the most effective and efficient means of gathering information from a relatively large sample within a constrained time period. Based both on a review of the literature and assumptions about the target population, the characteristics of brevity, simplicity, and ease of reading were essential prerequisites in the development of the three questionnaires. In contrast to many of the more recent investigations employing a prospective design, the administration of the RPQ was to be retrospective, in an attempt to capture information regarding the incidence of MTBI that was not dependent on medical records or hospital admission. In addition, the less structured nature of the club grade itself (in contrast to elite/professional and school grade teams) precluded the use of a prospective design, primarily as a consequence of the difficulties in ensuring the recording of injuries would be maintained throughout the data collection period.

Table 10 provides a summary of the objectives to be achieved through the construction of each questionnaire.

Table 10.

Summary of objectives to be achieved through the administration of the RPQ, HMQ and AMQ.

	Questionnaires		
Objectives	*RPQ*	*HMQ*	*AMQ*
Rate of MTBI	✔		
Severity of MTBI	✔		
Player & Game Related Variables	✔		
Use of Protective Gear			
Frequency of use	✔	✔	
Attitudes regarding utility		✔	✔
Quality of gear		✔	
Levels of Recognition, Assessment and Management			
Level of recognition	✔		✔
Level of competence of assessor			✔
Was attention received and when?	✔		
Who attended to injured player	✔		✔
Reporting and recording of injury	✔		✔
Adherence to Regulations and Recommendations			
Stand-down Period	✔		✔
Abstinence from the Sport	✔		✔

7.2.1 The Rugby Players Questionnaire (RPQ)

The RPQ (refer Appendix B) was administered at one point across each of three consecutive seasons to capture information from rugby players competing at the club grade level. For ease of responding this two-page questionnaire included 28 questions that were either dichotomous or required the respondent to affix a letter or number to indicate their answer.

Three versions of the RPQ were developed to reflect the season being targeted (refer Appendix B). While the 1998 and 1999 versions were essentially identical, adaptations made to the 2000 questionnaire meant the number of questions increased to 30. Alterations to this later version involved the elimination or rephrasing of questions that had previously produced inadequate or difficult-to-interpret data. It also incorporated new questions to investigate an issue raised part way during the study.

Demographic Information

Respondents were asked to record their name and the rugby club they currently played for, to ensure those completing more than one version of questionnaire were identifiable. Respondents were also asked to indicate how many years they had spent playing club rugby. These questions remained relatively static across all three versions, although the 1999 and subsequent 2000 version required slight alterations to the querying of 'years of club grade experience'. This alteration involved the inclusion of an additional sentence emphasising that they should enter the number of years playing club grade not including school-grade rugby.

Rate of Brain Injury and Relationship to Other Injury

The definition of concussion adopted for the RPQ reflects a widely recognised description focusing on a disturbance of neural functioning (see Appendix B). It requires the injury to result in 'at least dizziness, disturbed vision, confusion and/or a loss of consciousness' (Newcombe, 1995), incorporating symptoms endorsed by the American Academy of Neurology, Quality Standards Subcommittee (1997) as indicative of concussion. As discussed in Chapter 2, Section 2.1.4 the term 'head injury' was utilised in the construction of these questionnaires in a bid to avoid the value laden connotations associated with the terms 'concussion' and 'MTBI'.

To establish the rate of MTBI respondents were asked to record the number *of head injuries* they had received playing rugby during the target season (current) and prior to the target season (history). Responses were recorded on Likert-type scales, ranging from 'None' to '4 or more' to establish current MTBI, and 'None' to '15 or more' to obtain the respondents MTBI history. As the latter scale required consideration of injuries sustained much earlier in time, respondents were required only to provide an approximation of the number incurred.

To identify the existence of a relationship between the rate of MTBI and the frequency of non-MTBI related injury, respondents were asked to indicate the number of injuries sustained to eleven other regions of the body during the target season. In the 2000 RPQ, the use of an accepted definition of 'injury' was incorporated (an additional question) to establish the disparity between the injuries reported in response to the question above and those injuries requiring medical attention and/or requiring them to miss competition for at least one week.

Severity of Brain Injury

Many of the questions adopted to determine the severity of MTBI replicated those used by Gerberich et al. (1983). As in this earlier study, players were asked whether they had suffered a LOC ("Did you lose consciousness following a blow to the head?") and to indicate their experience of eight concussive symptoms associated with MTBI ("Did you have any of the following symptoms/problems after a blow to the head, even though you may not have been unconscious?"). Respondents were also given the option of including symptoms that were not listed.

The 1998 and 1999 versions incorporated a question to establish symptom duration, which asked whether any of the symptoms respondents had indicated were being experienced at present. While this question was initially incorporated to help establish MTBI severity, it was eliminated from the 2000 version on the basis that an accurate estimate of duration could not be established as the date of injury was not recorded. Responses could not therefore be considered a reliable indicator of severity and were not incorporated in any subsequent analysis. As an additional indicator of severity, respondents were asked to identify how many of the *head injuries* sustained throughout the season had been diagnosed by a medical professional as concussion.

Player- and Game-Related Variables Associated with Brain Injury

To obtain information pertinent to injury patterns and risk factors associated with MTBI, questions adopted by other sports research were incorporated in the RPQ. These questions included identification of the players' age and grade (Lingard et al., 1976), position (Roux et al., 1987; Dalley et al., 1982; Albright et al., 1985; Seward & Patrick, 1992), whether the injury occurred during a match or training session (Roux et al., 1987), during the first or second half (Lingard et al., 1976; Wekesa et al., 1996), the phase of play during which the injury was sustained (Dalley et al., 1982; Norton & Wilson, 1995; Bird et al., 1998), and the way in which the injury was received (i.e., regulation manoeuvres or foul play) (Norton & Wilson, 1995). Respondents were provided with a variety of possible answers in relation to each of these questions of which they were required to select one option.

Use of Protective Gear

Previous research has examined the relationship between TBI and mouthguard (Dalley et al., 1982; Dalley et al., 1992; Norton & Wilson, 1995) and headgear use (Norton & Wilson, 1995). Due to the retrospective nature of the RPQ, the accuracy of players' recall regarding their use of protective gear at the time injury was questionable. Hence, respondents were asked to indicate their frequency of mouthguard use ('always', 'sometimes', or 'never') during the target season in matches and training sessions. This line of questioning was also adopted to examine the use of headgear, but pertained only to match situations.

Levels of Recognition, Assessment and Management

Respondents completing the 1998 and 1999 RPQ were asked to identify the person (if any) who attended to their injury(s) (coach, referee, St. Johns personnel, or a member of team management) and indicate where this attention was first received. Response options included: (1) whether the *head injury* was first attended during the game/training session; or (2) on completion of the game/training session at either: (a) the rugby grounds; or (b) a doctors surgery or hospital.

Three questions were introduced into the 2000 questionnaire to determine why players sustaining a MTBI may not receive attention. The first newly introduced question required respondents to record the number of 'current season' *head injuries* that had received some form of attention. If respondents had not received attention they were directed to the second question where the selection of one of three reasons for the injury not being reported was required. These reasons (in multi-choice format) included: (1) the injury being considered too minor to report; (2) the player choosing not to report despite persisting symptoms; and (3) the absence of persons to attend the injury despite the player's willingness to report it. The opportunity to record other reasons for attention not being received was also given. If respondents indicated the second of these three reasons, they were directed to the third new question that was designed to investigate their reason for not reporting. Responses associated with this question included: (1) not wanting to be removed from the game; (2) not wanting to risk missing future games (Lovell & Collins, 1998); (3) not wanting to appear 'soft'; and (4) thinking the injury was not severe enough to report. Again respondents were given the opportunity to record any other reasons not listed.

As knowledge of a player's MTBI history is essential to consider regarding return-to-play decisions, respondents were asked to indicate whether their coach was aware of previous *head injuries* they had sustained.

Adherence to Regulations and Recommendations

Players were asked whether the 3-week mandatory stand-down period was observed for any of the *head injuries* sustained during the target season. The 1999 version also asked whether this period of abstinence had been enforced for *head injuries* sustained prior to the target season, although this question was abandoned for the 2000 RPQ as the information obtained was not considered reliable.

Respondents were also queried as to whether they had ever been advised not to play rugby by a medical practitioner or neurologist due to *head injury*. Although the question intended to identify those having been advised of a permanent exclusion from rugby, the question was interpreted by some as referring to a temporary exclusion. The misinterpretation of this question resulted in its rephrasing for the 2000 version, to read "Have you ever been advised not to play rugby ever again by a medical practitioner or neurologist as a result of head injury?".

7.2.2 The Headgear and Mouthguard Use Questionnaire (HMQ)

The HMQ (refer Appendix C) was designed to obtain information pertinent to players' attitudes regarding the use of headgear and mouthguards. The questionnaire consisted of 15 questions, the majority requiring a 'Yes', 'No', 'Always', 'Sometimes', 'Never', 'Maybe', or 'Don't know' response by way of a tick box.

Respondents were asked: (1) whether they had ever sustained a *head injury* whilst playing club grade rugby; (2 – 5) how often they used headgear and mouthguards (Always, Sometimes or Never) during both competition and training; (6 – 7) whether they believed mouthguards could: (a) help prevent dental injuries; and (b) aid in the prevention of concussion; (8) whether they believed headgear could aid in the prevention of concussion; (9 - 12) if they would be *reluctant* to play and/or *refuse* to play without either piece of protective gear; (13) the type of mouthguard worn from one of three options: (a) Boil and

Bite; (b) Custom-made; or (c) Other (allowing for details to be supplied); (14) the make or brand of headgear used; and (15) the reason they opted to wear headgear.

7.2.3 The Assessing and Managing Head Injury Questionnaire (AMQ)

The AMQ (refer Appendix D) was developed to gather information from coaches, members of team management, and referees, to establish their ability to attend and manage MTBI. The formulation of this questionnaire involved consideration of some of the issues raised by the RPQ, with many of the questions incorporated in the questionnaire based on a policy statement formulated by Sports Medicine New Zealand (1999). In an effort to generate more consistent practices, recommendations pertaining to the recognition, assessment, and management of a brain-injured player were established by Sport Medicine New Zealand after consultation with the NZRFU Medical Advisory Panel and expert reviewers from both New Zealand and Australia.

The AMQ consisted of 24 questions of which the majority featured tick boxes to indicate the respondent's choice. The remaining questions were open-ended, requiring a brief written response.

Demographic Information

Respondents were asked to indicate their age, gender, current role (e.g., coach, referee, team management, etc.), grade(s) involved with, and the person viewed as most frequently providing attention to a 'head-injured/concussed' player during competition.

Use of Protective Gear

Respondents were asked to indicate (Yes, Maybe, No) whether the use of mouthguards and headgear aided in the prevention of concussion.

Levels of Recognition, Assessment and Management

To establish the level of recognition of MTBI, respondents were asked to record the signs and symptoms they considered indicative of a concussion and indicate whether or not a LOC is required for a diagnosis of concussion. To establish competency, they were asked to supply: (1) their highest recognised medical or first aid qualification; (2) their degree of familiarity with the GCS (whether they had heard of the measure, if they had ever used this measure, and their frequency of use of the measure); (3) their use of other measures to assess a player's conscious state; and (4) their normal practice in attending an unconscious player. With respect to assessing orientation, respondents were asked to indicate the questions they would use to assess a player's level of confusion after a blow to the head. The multi-choice format provided options that: (1) were not considered reliable (What day of the week is it? What year is it? What is your date of birth?); (2) were recommended (What ground are you at? What team are you playing? What is the score? etc.); (3) combined both sets of questions; and (4) indicated a lack of support for the use of either set of questions.

The AMQ also investigated opinions regarding: (1) whether team management should have knowledge of a player's *head injury* history; (2) where responsibility should lie for the monitoring of *head injured* players; (3) whether there should be an independent report form for recording *head injury* to record factors such as LOC, time player was unconscious, symptoms experienced; and (4) whether improvements could be made to the current system of *head injury* reporting. Respondents who regularly completed the Serious Injury Report Form (SIRF) were asked to indicate their level of satisfaction with this form, and if dissatisfied, to state why.

Adherence to Recommendations and Regulations

On the basis of previous research utilising case studies to examine return to play recommendations (Roos, 1996), the AMQ incorporated two vignettes. The first described a player who, after a blow to the head, experiences two symptoms for a period of 3-4 minutes in addition to a slight but persistent headache, while the second involves the same symptoms but incorporates a LOC. In response to these vignettes respondents were asked to indicate whether they would allow the player to return to the game (Yes, Maybe, No). If 'No' was selected, respondents were asked to state why, and when the player should resume participation. If 'Maybe' was selected, respondents were asked what factors would influence their decision to allow or disallow the player to return to competition. The circumstances that would warrant a player being stood-down for three weeks and alternatively for one year, were also assessed.

7.3 RESPONDENTS

7.3.1 The Rugby Players Questionnaire (RPQ)

The 1998 Administration

Coaches and club-captains of five clubs participating in the Manawatu Rugby Football Union (MRFU) club grade competition gave consent for their members (approximately 600) to be approached with respect to the administration of the RPQ. In total, 174 questionnaires were completed, although 38 of these were eliminated from the final analysis due to either incomplete data (n=11), the respondent not having played rugby in the 1998 season (n=3) or having participated in school not club grade during the previous season (n=24).

At the time of the RPQ's administration the 136 respondents ranged in age from 17 – 37 years (M=23.0 years). A comparatively equal number of volunteers (29 – 34 players) were drawn from four of the five clubs, with 11 players acquired from the remaining club. For the purpose of presenting demographic information, each grade was re-categorised into three groups: (1) Senior I players; (2) Senior II, III and IV players; and (3) Colts (a term used to collectively describe Under 21 and Under 19 players). Of the 136 respondents, 39.7% were involved at Senior I level with this same proportion of players participating in the Under 21 and Under 19 grades (refer Table 11). The remaining respondents (*n*=28) competed at Senior II, III, and IV level. While variations existed between grades in relation to the length of time players were involved in club rugby (refer Table 11), on average, respondents recorded 5.1 years of club grade experience.

Table 11.

Number of players, average age and years of playing as a function of grade and season investigated.

Grade	*Target Season*	*Total (N)*	*% of Total Players*	*Years of Age (M)*	*Years Playing (M)*
Senior I	1998	54	39.7	25.6	6.9
	1999	43	52.4	23.4	5.4
	2000	68	43.0	25.2	7.3
Senior II, III and IV	1998	28	20.6	24.0	5.8
	1999	34	41.5	25.0	6.4
	2000	45	28.5	24.8	6.8
Colts	1998	54	39.7	19.8	2.8
	1999	5	6.1	20.0	3.4
	2000	47	29.7	19.8	2.6
Total	1998	136		23.0	5.1
	1999	82		23.9	5.7
	2000	158		23.5	5.8

The 1999 Administration

At the end of the 1999 season four clubs (consisting of 14 teams) agreed to participate in the second administration of the RPQ with questionnaires distributed to approximately 280 club members. Unfortunately, completed questionnaires from one club were lost on their return via mail, leaving only 83 questionnaires retrieved from the remaining clubs, with one case being excluded due to data being incomplete. The 82 volunteers from these three clubs ranged in number from 21 - 37 and comprised only Senior I, Senior II, and Under 21 grade players.

At the time of the second RPQ administration, respondents ranged in age from 18 – 36 years (M=23.9 years). As Table 11 illustrates, 52.4% of the respondents had competed at Senior I level, 34 participated at Senior II level, and the remainder (6.1%) competed in the Under 21 grade. A relationship between age and years of experience was evident, with Senior II players identified as the eldest and correspondingly having one more year of experience in club grade (M=25 years of age; 6.4 years) than the Senior I players (M=23.4 years of age; 5.4 years). Overall, the 1999 respondents averaged 23.9 years of age and 5.7 years of club grade experience.

The 2000 Administration

The final administration of the RPQ involved a total of 10 clubs (approximately 960 players) from which 159 respondents completed the questionnaire. Only one case was excluded from this sample due to incomplete data. Volunteers from each of the clubs ranged in number from 7 – 18, and comprised of players primarily from Senior I, II, and Under 21 grades, although a few volunteers from other grades were also obtained.

Respondents at the time of the third administration were aged between 18 – 37 years. Table 11 shows that 43% of respondents participated at Senior I level across the 2000 season, with comparatively equal numbers of respondents being involved in the Senior II, III, and IV grades (29.5%) and Colts grades (29.7%). In contrast to the 1999 administration, Senior I players were on average the eldest and had the most playing experience (M=25.2 years; 7.3 years). Across the 2000 sample, respondents averaged 23.5 years of age and 5.8 years of club grade experience.

Total Sample (1998 – 2000)

When viewed as one sample incorporating respondents across the three years, Senior I players comprised 43.7% of all respondents, in contrast to Senior II, III, and IV players (n=107) and Colts players (n=106), accounting for 28.3% and 28% of all players respectively. Respondents in this sample had an average age of 23.4 years and an average of 5.5 years of club grade rugby experience.

7.3.2 The Headgear and Mouthguard Use Questionnaire (HMQ)

Four teams from two local clubs completed the HMQ during Phase II of the current study. The demographic information, displayed in Table 12, was obtained as a consequence of respondents' participation in the second research phase not as an outcome of completing the HMQ. In total, 49 club grade players completed this questionnaire of which 22 came from one club and 27 from another. As seen in Table 12, the majority of respondents (65.3%) were members of Senior I teams, with only 9 Colts players and 8 Senior II team members.

Table 12.

Number of players, average age, years of education and time playing sport as a function of grade.

Grade	*Total (N)*	*% of Total*	*Age (M)*	*Years of Education (M)*	*Hours Playing Sport (M)*
Senior I	32	65.3	23.4	6.1	8.3
Senior II	8	16.3	22.6	3.9	6.9
Colts	9	18.4	18.2	5.1	7.2
Total	49	100.0	22.0	5.5	7.9

Respondents ranged in age from 17 – 33 years (M=22.0 years), with Senior I players being older on average (M=23.4 years) than either Senior II or Colts players (refer Table 12). Those comprising Senior I teams recorded the longest periods of education (M=6.1 years), with Colts players averaging slightly less time in either secondary or tertiary education (M=5.1 years), attributed primarily to their youth. The average time participants spent each week engaged in sport-related activities (including rugby) was similar across the

Senior II and Colts grades (refer Table 12) with Senior I players clearly spending the longest duration (M=8.3 hours) in sporting activities.

7.3.3 The Assessing and Managing Head Injury Questionnaire (AMQ)

The AMQ was distributed to 26 coaches, 2 trainers, 6 managers, and 5 physiotherapists involved in the regional club grade rugby competition. Copies of the questionnaire were also sent to all 40 club grade referees from the Manawatu Rugby Referees Association.

Table 13.

Respondents average age and grade involved with as a function of their role within club rugby.

Role of Respondent	*Age* (*M*)	*Senior I* (*n*)	*Lower Grade* (*n*)	*Total* (*N*)
Coach	39.9	3	8	11
Trainer	51.0	1	0	1
Manager	44.5	1	1	2
Physiotherapist	34.0	2	1	3
Referee	39.1	5	16	21
Total	39.5	12	26	38

As seen in Table 13, just under half of the 79 questionnaires distributed were returned (N=38). Respondents ranged in age from 22 – 56 years (M=39.5 years) with the vast majority being male (n=36). Physiotherapists represented the youngest age group (M=34 years), followed by referees and then coaches (refer Table 13). As a function of role, referees completed 55% of AMQ's with just under a third of completed questionnaires (29%) returned from coaches.

The category of 'Lower Grades' was introduced to encompass those in a grade lower than Senior I level or those indicating involvement in more than one grade (excluding

Senior I). As Table 13 illustrates, respondents involved with the lower grades completed 68% of the questionnaires, with the remainder returned from those involved with Senior I rugby.

7.4 PROCEDURE

Written consent for the proposed research was first obtained from the Manager of Rugby Services of the NZRFU, prior to approaching the regional rugby organisation. Preliminary discussions were then held with the Chief Executive Officer (CEO) and the Rugby Development Officer (RDO) of the MRFU regarding both phases of the research. This section outlines the procedures followed in executing Phase I of the current research after approval was obtained from the MRFU.

7.4.1 The Rugby Players Questionnaire (RPQ)

The 1998 Administration

The first RPQ was to be administered prior to the commencement of the 1999 season in order to assess MTBI's incurred during the previous season. To identify any problem areas with the questionnaire, a pilot version was administered in January of 1999 prior to pre-season training to prospective members of a Senior I club grade team. These respondents were asked to complete the questionnaire and provide comments regarding the ease of completion, clarity of questions, and whether any alterations needed to be made to general format and structure. Very few alterations were required, apart from additional clarification of one or two questions and deletion of one item deemed unnecessary.

After making the necessary alterations, permission to approach the players competing in the Manawatu club grade rugby competition was sought from the coaches at this level.

Contact was made with coaches in one of two ways: (1) via letter; or (2) through attendance at an injury prevention seminar. After contact details had been obtained from the MRFU, Senior I coaches were sent a letter outlining the objectives for Phase I of the research and inviting their participation (refer Appendix E). Alternatively, coaches from a variety of grades were approached during each of three ACC Injury Prevention Seminars run in conjunction with the MRFU. A brief outline of the study and justification for Phase I of the research was presented to those in attendance, and contact details for those willing to participate were gathered at this point.

Coaches willing to take part in the research were phoned within 1 – 3 weeks from the point at which the initial contact was made to arrange a time suitable for the administration of the RPQ. As training sessions were typically held twice a week on either Tuesday, Wednesday or Thursday nights during the season, it was considered feasible to administer the RPQ either prior to the scheduled training session or at its completion. Questionnaires were administered to players either in the clubrooms, changing rooms, or on the training field itself.

Information sheets (refer Appendix F) were supplied to all those present, outlining the overall objectives of the study, with a copy of the RPQ, a clipboard and pen, provided only to those players willing to participate. Before filling out the RPQ, players were again briefly informed of the study's purpose and their attention was drawn to a number of aspects pertinent to the questionnaire. Firstly, respondents were informed that their consent was implied in the completion of the questionnaire. Secondly, the definition of head injury adopted by the study was explained in order to ensure their understanding of the term. Respondents were also told that the questionnaire required only a tick, letter, or number to be placed in each box to indicate their response in accordance with the requirements of each question. Players were encouraged to ask questions regarding any aspect of the questionnaire, with clarification provided by the researcher. On completion of the questionnaire respondents were asked to return clipboards and pens and hand the completed questionnaire to the researcher.

The 1999 Administration

The administration of the second RPQ was conducted within the final three weeks of the 1999 season. Problems with the administration of this questionnaire were encountered, primarily as a consequence of the time of season. Poor weather conditions and darkness prevented the administration of the RPQ to players on the training grounds, enabling administration only when clubrooms or changing rooms were available. Access to respondents was also made difficult in that training sessions were often cancelled due to poor weather conditions, and lower ranked or graded teams often abandoned practices due to poor attendance often as a consequence of having been eliminated from the competition.

In response to these difficulties, alternative strategies were arranged to gather data. Of the 14 teams receiving the RPQ only four teams completed the questionnaire in the researcher's presence – three completing the RPQ in clubrooms, while the fourth team filled out the questionnaire in their changing rooms. Questionnaires for the 10 remaining teams (including one women's team) were supplied to each of the coaches to distribute to their players. Four of these teams were to return the completed RPQ to the coaches to be picked up by the researcher the following week. The six other teams were to return their questionnaire to the researcher in freepost envelopes provided. Of the questionnaires distributed, 60 were obtained from the teams either receiving direct administration or whose coaches were responsible for collecting the questionnaires after completion, with only 23 questionnaires returned by post. None of the returned questionnaires had been completed by women players.

The 2000 Administration

The administration of the third RPQ was procedurally quite different from previous administrations. Based on the previous season's low rate of return due in part to administration difficulties, it was decided to send the RPQ to each player's residential address. Contact details for players involved in club rugby had previously been unattainable. However, a meeting with the MRFU prior to the end of the 2000 season resulted in this information being made available. As a consequence of the volume of information provided by the MRFU, it was decided that as with the second administration, the administration of the third RPQ would encompass only the Senior I, Senior II, and Under 21 grades drawn from 10 clubs. The questionnaires were distributed three weeks prior to the end of the season to the residential addresses of 691 players.

As there was concern that this method of distribution would prompt a low response rate from players, based on the assumption that players would feel less obliged to complete the questionnaire in the absence of both the researcher and coaches, an incentive was offered to encourage participation. Players were informed in an accompanying cover letter that each questionnaire completed and returned would result in three dollars being allocated to their club of which the accumulated amount would be converted into sporting vouchers. The cover letter also drew attention to the definition of head injury adopted by the RPQ and to aid clarification, provided an example of what did not constitute a head injury. Questionnaires were to be returned in a freepost envelope supplied.

Five days prior to players receiving the RPQ, coaches and club-captains involved with each of the 10 clubs were sent a letter (refer Appendix G) regarding the research and informing them of the distribution to players in their club. The letter explained the incentive being offered to players and requested that coaches and club-captains alike made players aware of the impending survey and encourage them to complete and return the questionnaire. Two weeks after the distribution of RPQ's club captains were re-contacted by either mail or phone in order to provide information as to the funds that had been accumulated for their club and to request that players continue to be encouraged to complete and return the questionnaires.

7.4.2 The Headgear and Mouthguard Use Questionnaire (HMQ)

The HMQ was administered during one of four assessment sessions involved in Phase II of the research (employing neuropsychological assessment measures). The questionnaire was attached to the top of the participant's standard assessment battery response booklet and featured a code number, allocated to all those involved in the second research phase. Prior to filling out the HMQ, respondents were informed of the meaning of the term *head injury* in accordance with the requirements of the research. They were then instructed to complete the questionnaire prior to the commencement of the neuropsychological assessment component of the research. On completion, the questionnaires were returned with the response booklets to the researcher.

7.4.3 Assessing and Managing Head Injury Questionnaire (AMQ)

The AMQ was distributed to coaches, members of team management, and referees involved in club grade rugby in different ways. Two weeks after the third RPQ was sent out, coaches of selected club grade teams received the AMQ at their residential address (contact details obtained from the MRFU). Accompanying the questionnaire was a cover letter (refer Appendix H), which provided justification for and an explanation of the current study and requested (if willing to participate) the completion and return of the AMQ in the freepost envelope provided. The letter also stated that completion and return of this questionnaire would receive remuneration in the same form as that awarded to the players (i.e., sporting vouchers).

In addition to the completion and return of the AMQ, coaches were also asked to complete a form detailing contact information for members of their management team (trainers, managers, physiotherapists, or personnel operating in a similar medical capacity). Once contact details had been supplied, the AMQ, cover letter, and freepost envelope were distributed to each member of team management listed, with the same incentive for the completion and return of the questionnaire extended. As with the RPQ, a detailed record was kept of all individuals having been sent the AMQ and those having been returned.

Contact details for all referees involved in club rugby within this region were obtained through correspondence with the Manawatu Referees Association (MRA). The request for these details included a provision that in the event that this information could not be supplied (due to privacy issues) the MRA distribute the AMQ's on the researcher's behalf. However, this proved unnecessary with the association providing contact detail for 40 club grade referees. As with the distribution of the AMQ to members of team management, referees were sent a cover letter (refer Appendix I) and a copy of the questionnaire to complete and return in the freepost envelope provided, although, unlike the other respondents, no incentive was offered.

7.5 DATA ANALYSIS

As a consequence of the relatively small samples obtained across each of the three seasons, the information gathered by the RPQ was considered best treated as one data set. Incorporating those who indicated competing in school grade rugby in the 1998 season (n=24), 400 RPQ's were considered suitable for analysis. However, in treating the information as one data set, some consideration was required for those respondents completing more than one RPQ over this period ($n = 68$), as this would complicate analyses involving historical variables (i.e., MTBI history).

On the basis of these observations the data were considered in four distinct groups: (1) including all data (Sample A); (2) excluding school grade players (Sample B); (3) excluding those completing multiple questionnaires (Sample C); and (4) excluding both school grade players and those completing multiple questionnaires (Sample D). For ease of reading and to clearly differentiate each group, in subsequent chapters these groups will be referred to as Sample A, Sample B, and so on. The majority of analyses involving the RPQ exclude school grade players (as they are not part of the club grade), except when examining attitudes to certain issues (headgear and mouthguard use). Those completing more than one RPQ were not excluded if variables being analysed were constrained within a specified time frame (one season) as this information could not conflict with information respondents had provided in earlier or later questionnaires. Therefore, unless specified otherwise, the analyses conducted can be assumed to be based on Sample B comprising 376 respondents (see Table 13, Chapter 8).

The analysis of data gathered from this phase of the research employed the SPSS 10.1 for Windows statistical package. As a consequence of data obtained from the administration of the RPQ, the HMQ, and the AMQ, and in response to the research questions, the analysis conducted was predominantly descriptive. For the analysis of categorical data, non-parametric chi square analyses were conducted. Where appropriate, independent sample t-tests and one-way between-groups analysis of variance (ANOVA) were used to explore differences between groups. In situations where the homogeneity of variance assumption was violated, the alternative statistic provided by SPSS for unequal variances (indicated by the Levene Test for Equality of Means) was adopted, provided group sizes were reasonably similar, that is, not more than twice the size (largest/smallest = 2) (Coolican, 1995). The strength of association (or effect size) indicating "the proportion of variance in the DV [dependent variable] that is associated with levels of the IV [independent variable]" (Tabachnick & Fidell, 2001; p. 52), was also to be reported and is roughly indicated by the eta squared (η^2) statistic. While SPSS provides this statistic for ANOVA analysis, it does not provide it for *t*-tests. The formula for determining η^2 is: $t^2 / t^2 + (N_1 + N_2 - 2)$ (Pallant, 2001). The effect size is especially important when examining cases of non-significant findings because such results may be a consequence of insufficient power rather than no real difference between groups (Pallant, 2001).

CHAPTER EIGHT

Results – Part I

This chapter present the results of analyses conducted with data obtained through administration of the RPQ, AMQ, and HMQ, to address the hypotheses detailed in the previous chapter.

8.1 Rate of Brain Injury and Relationship to Other Injury

Current MTBI

Of those comprising Sample B (refer Table 14), 128 (34%) respondents reported 203 injuries in accordance with the MTBI definition during the course of the investigation.

Table 14.

The number of MTBI's, non-MTBI injuries and total injury associated with each of four data samples.

Sample Group	*Respondents* (*N*)	*MTBI*	*Non-MTBI Injuries*	*Total Injuries*
Sample A (all data)	400	222	1305	1527
Sample B (excludes school grade)†	376	203	1206	1409
Sample C (excludes multiple questionnaires)	332	185	1095	1280
Sample D (excludes school grade & multiple questionnaires)	308	166	1029	1195

† Shaded area represents data group most typically used in analyses.

For those in the MTBI group, this figure translated to an average of 1.6 MTBI's per player, while across the whole of Sample B (n =376) the average was 0.5 MTBI's per player.

Of those forming the MTBI group (n=128), 79 players (61.7%) reported sustaining only one MTBI, while 38.3% indicated two or more concussive injuries.

Previous MTBI

To establish history of MTBI, analyses were based on Sample D (refer Table 14). As a consequence of a missing value, the sample comprised 307 respondents, of which 64.3% (n=198) reported sustaining one or more MTBI's prior to the target season. Of those reporting a MTBI history, 58.6% indicated having previously sustained 1-2 injuries and 41.4% reported three or more. Of the latter group, 12 respondents claimed to have suffered 9 or more MTBI's prior to the season under investigation.

Table 15 presents the relationship between a history of MTBI and the incidence of MTBI sustained during the current season. Of those with no MTBI history (n=109), 87.2% (n=95) remained uninjured (i.e., no MTBI) during the target season, while only 68.1% (n=79) and 34.1% (n=28) of respondents with respective histories of 1 – 2 and 3 or more MTBI's, did not suffer a concussion during the season.

Table 15.

Relationship between a history of MTBI and MTBI incurred during the current season.

	Current season concussive injury			
Concussive injury pre-season	*None*	*1*	*2 or more*	*Total*
None	95	9	5	109
1-2	79	31	6	116
3 or more	28	24	30	82
Total	202	64	41	307

Of the respondents with 1 – 2 previous concussive injuries, 26.7% (n=31) incurred one MTBI across the course of the season, while 29.3% (n=24) of respondents reporting a history of 3 or more MTBI's sustained one concussion. Those forming this latter group

(n=82), appeared more likely to sustain multiple injuries, with 36.6% (n=30) of these respondents reporting 2 or more concussions. The proportion of MTBI's sustained by those with varying histories of concussion was found to be significantly different, $\chi^2(4)=78.4$, $p<.0001$.

Relationship to Other Injury

Sample B respondents reported 1206 non-MTBI related injuries[4], which were distributed fairly evenly across the upper (n=606) and lower (n=600) regions of the body. As a proportion of total injuries (refer Table 14), three regions featured similarly high rates of injury: the hand/finger (13.3%), shoulder/arm (13.2%), and ankle (13.1%) regions (refer Figure 1). Injuries to the knee, which are characteristic of this sport, comprised 10% of all the injuries reported, while MTBI's (14.4%) accounted for the greatest proportion of total injuries.

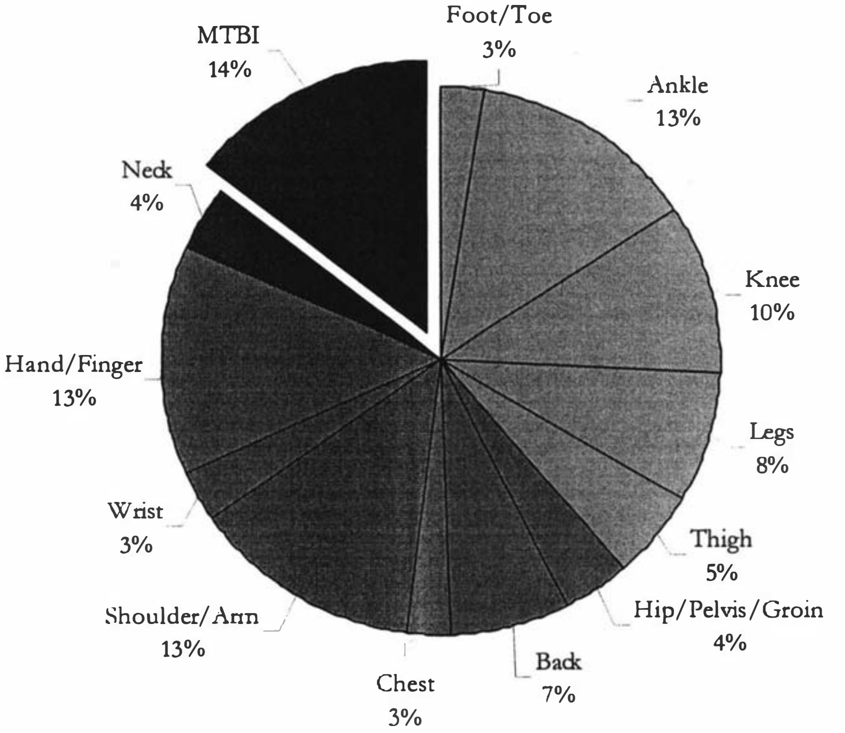

Figure 1. *Representation of the injury distribution, including MTBI.*

[4] This analysis excluded data from one case, considered an extreme outlier. Sample size equals 375.

Independent *t*-tests were conducted to compare the rate of non-MTBI related injury incurred by those having sustained a MTBI during the target season ($n = 128$) with those who did not ($n = 248$). The analysis revealed a statistically significant difference [$t(157.3)=4.27$, $p<.001$, $\eta^2=.05$] between these groups, with more injury on average (4.67 injuries per person) suffered by those reporting a MTBI, than for those who did not (2.61 injuries per person).

The 2000 RPQ incorporated a more precise definition to account for non-MTBI related injury (i.e., receipt of medical attention or a week abstinence from the sport). Of the 157 respondents (one case excluded) completing the third RPQ, 111 players reported a total of 222 non-MTBI related injuries and 69 reported suffering 115 MTBI's. Those forming the MTBI group incurred slightly more non-MTBI related injury on average ($M=1.71$) than those in the non-MTBI group ($M=1.19$), a difference which did not reach statistical significance, $t(95.2)=1.69$, $p=.10$, $\eta^2=.02$.

8.2 Severity of Brain Injury

Loss of Consciousness

Of the 203 MTBI's reported by Sample B, 20.7% ($n=42$) resulted in a loss of consciousness. In accordance with the research criteria (detailed in Chapter 6, Section 6.2.2) these injuries are classified as *moderate* concussions.

Symptomology Experienced

For those reporting MTBI during the target season, the most common symptom experienced was dizziness, accounting for 27.7% of reported symptoms and experienced by 75% of respondents. Headache was the next most frequently endorsed symptom, reported by 71% of respondents and comprising 26.2% of all symptoms. These and the percentages for the remaining symptoms are reported in Table 16.

Table 16

The percentage of symptoms experienced and the proportion of respondents endorsing each symptom.

Symptom	*Proportion of Total Symptoms* (%)	*Respondents Experiencing Symptom* (%)
Dizziness	27.7	75.0
Headache	26.2	71.1
Blurred Vision	14.4	39.1
Fatigue	8.9	24.2
Concentration Difficulties	7.2	19.5
Poor Memory	6.6	18.0
Nausea/vomiting	5.5	14.8
Irritability	3.5	9.4

Diagnosis of Concussion

Of the MTBI's reported by Sample B respondents, 14.3% (*n* = 29) were reported to have received a diagnosis of concussion from a medical professional. When viewed in terms of injury severity, 35.7% (*n* =15) of MTBI's involving a LOC (a *moderate* concussion) received a diagnosis of concussion. The remaining diagnosed concussions were attributed to injuries ranging in severity from *very mild* to *mild*. However, due to the way the RPQ was constructed, the number of diagnoses associated with each of these three categories could not be examined.

Severity Classifications of MTBI

Figure 2 shows the distribution of MTBI severity obtained within the sample, with 24.1% (*n*= 49) of concussions classified as *very mild*, 39.9% (*n* = 81) as *mild*, and 26.1% (*n* = 53) as *moderate*. The remaining MTBI's (9.9%; *n* =20) fell into the category of *very mild* – *mild*, characterised by one or two symptoms not able to be classified as a *very mild* concussion, yet featuring symptoms clearly indicative of MTBI.

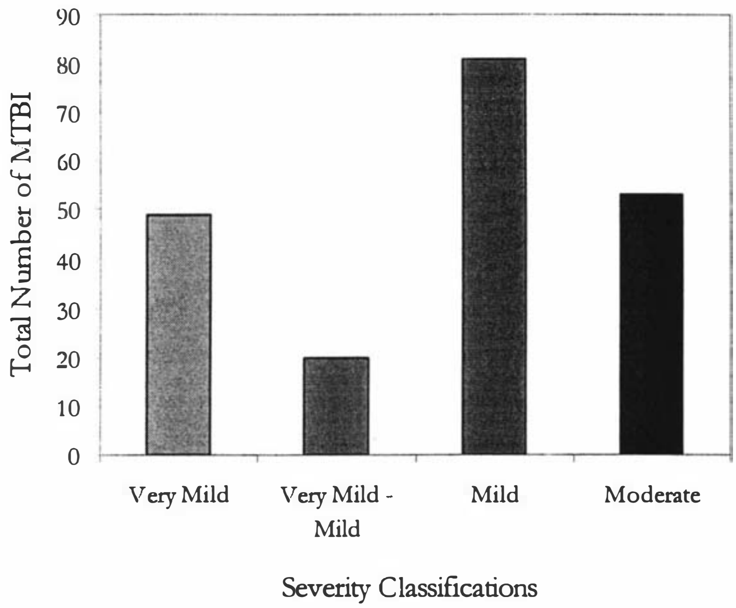

Figure 2. *Severity Classifications of MTBI ranging from Very Mild to Moderate.*

8.3 Player- and Game-Related Variables Associated with Brain Injury

Age and Grade of Player

Table 17 presents the rate of MTBI experienced as a function of each of four age groups for Sample B respondents. A one-way between-groups ANOVA was conducted to examine the impact of age on the rate of MTBI. There was a statistically significant difference in the number of MTBI's sustained during the season by each of the four age groups [$F(3, 372)=5.8$, $p=.001$, $\eta^2=.04$], with those of a younger age associated with a greater number of MTBI. The effect size indicated a small-to-moderate magnitude of difference between the means. Post-hoc comparisons using the Tukey HSD test indicated the mean score for 16-20 year olds ($M=.76$, $SD=.95$) was significantly different from 26-30 year olds ($M=.27$, $SD=.59$), and those over 30 years ($M=.20$, $SD=.41$). The number of MTBI's experienced by those in the 21-25 year age group ($M=.58$, $SD=1.04$) did not differ significantly from the number of MTBI's sustained in the other age groups

Table 17.

The number of Sample B respondents in each of four age groups and the number in each age group reporting at least one MTBI during the target season.

Age Group	*Number of Respondents*		*Respondents Reporting MTBI*	
	N	%	*N*	%
16 – 20 years	107	28.5	52	48.6
21 – 25 years	165	43.9	55	33.3
26 – 30 years	79	21.0	16	20.2
30 years or older	25	6.6	5	20.0

With respect to the average age of respondents as a function of grade, Senior I players ($n = 166$) averaged 24.9 years of age, while those comprising the lower grades ($n = 210$) had an average age of 22.3 years. Examination of MTBI's incurred as a function of grade revealed that 30.7% of Senior I players sustained at least one concussive injury. A slightly greater proportion was identified for those in the Lower Grades (comprising of Senior II, III, IV, Under 21, and Under 19 grades), with 36.6% of respondents within this group reporting at least one MTBI. However, no significant difference in rate was identified between Senior I players ($M = .31$, $SD = .46$) and Lower Grade players [$M = .37$, $SD = .48$; $t(360.5) = 1.21$, $p = .23$, $\eta^2 = .004$].

With respect to the severity of MTBI suffered, of the 78 MTBI's sustained by Senior I players, 44.9% were classified as *mild*, 26.9% *moderate*, 19.2% *very mild* and the remaining 9% of MTBI were considered to be of *very mild – mild* severity. Of the MTBI's suffered by Senior I players, 16 cases involved a LOC. In contrast, the MTBI's experienced by Lower Grade players included 36.8% *mild*, 25.6% *moderate*, 27.2% *very mild*, and 10.4% *very mild – mild* severity concussions. There were 26 cases of LOC experienced in this grade.

Player Position

As seen in Table 18, a higher proportion of respondents occupied forward positions than back line positions, with forward positions incurring more MTBI on average than the backs.

Table 18.

Comparison of forward versus back-line positions with respect to the number of MTBI reported and the number involving a LOC or receiving a diagnosis of concussion.

Position	*Group Size*	*MTBI*		*LOC*		*Diagnosis*	
		n	%	*n*	%	*n*	%
Forwards	202	121	59.9	19	9.4	14	7.4
Backs	174	82	47.1	23	13.2	15	8.6

In comparing the average number of MTBI's sustained by forwards (M= 1.75, SD=.99) and backs (M=1.39, SD=.77) significant differences were revealed[t(124.8)=2.34 p=.02, η^2=.03]. However, there were no significant differences between the LOC experienced by forwards (M= .28, SD=.51) and backs (M=.39, SD= 59); t(115.9)=1.17, p=.25, η^2=.03. MTBI was diagnosed as concussion for 6.9% of forwards and 8.6% of backs, although these differences were not significant (M= .20, SD= 58; M= .25, SD= .44), t(126)=.56, p=.58, η^2=.01.

When the categories of forwards and backs were broken down further, it was revealed that the largest proportion of respondents (16.2%) occupied the position of flanker, with locks (13.6%), props (11.2%), and wing (9.8%) positions also well retained. Table 19 illustrates the rate of MTBI and non-MTBI related injury associated with each position. Flankers incurred the highest rate of MTBI (0.98 MTBI's per respondent), followed by first five-eight's (0.69 MTBI's per respondent), second five-eight's (0.52 MTBI's per respondent), and fullbacks (0.50 MTBI's per respondent). Respondents appearing least likely to sustain a MTBI occupied Center and Number 8 positions (0.29 MTBI's per respondent).

Table 19.

Rate of MTBI and non-MTBI related injury as a proportion of respondents occupying individual positions.

Position Held	*MTBI per respondent*	*Non-MTBI per respondent*
Prop	0.48	2.95
Hooker	0.45	3.32
Lock	0.43	3.33
Flanker	0.98	3.89
Number 8	0.29	4.18
Halfback	0.30	1.55
First Five-eight	0.69	3.23
Winger	0.43	3.41
Second Five-eight	0.52	4.22
Center	0.29	3.33
Fullback	0.50	3.36
Multiple positions †	0.52	2.30

Note: Shaded area represents back-line positions.
†Reflects respondents who reported more than one position.

With respect to the number of non-MTBI injuries (refer Table 19), the positions at greatest risk were the second five-eight (4.22 injuries per respondent) and the Number 8 (4.18 injuries per respondent) positions. Those who incurred the lowest rate of non-MTBI injury were halfbacks (1.55 injuries per respondent).

Period of the Game

Competitive games were responsible for 92.1% (n=187) of MTBI's incurred by Sample B respondents, with only 4.9% (n=10) sustained during training sessions (the remaining 3% were not accounted for). In relation to the MTBI's incurred in competition, 37.4% (n = 70) were sustained during the first half of the game and 41.7% (n=78) in the second half. A relatively large proportion (20.9%) of match-related MTBI's could not be established as having taken place in the first or second half due to respondents being uncertain as to when the injury had been sustained.

Phase of Play

As Figure 3 illustrates, the tackle (being tackled or making a tackle) represents the largest proportion of MTBI's (48.8%), with the second highest proportion incurred in the ruck/maul (29.1%). These phases of play were followed by the scrum (5.9%) and the lineout (1.0%), with 5.4% of MTBI's sustained by other means during the normal passage of play. The remaining MTBI's (13.3%) could not be attributed to any phase of play due to the uncertainty of respondents

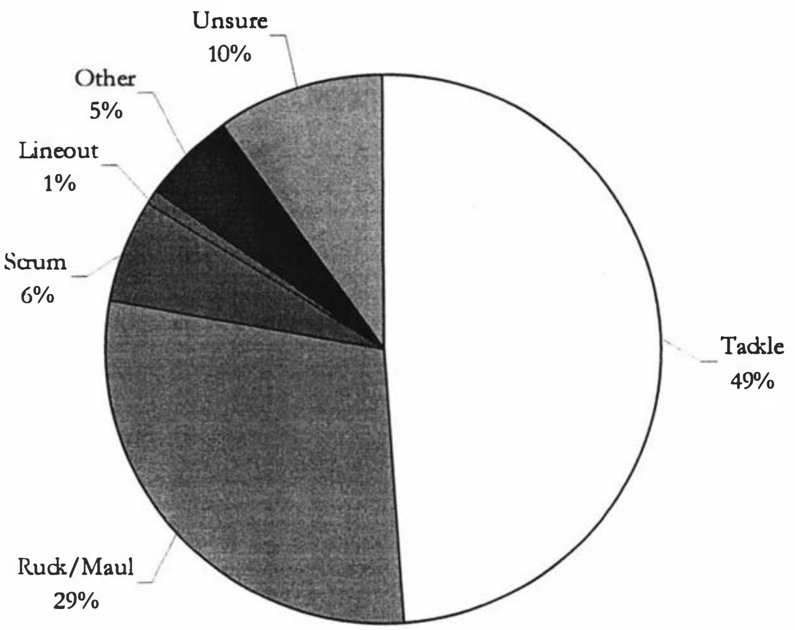

Figure 3. *Phases of play accounting for MTBI*

Differences in rate of MTBI's associated with certain phases of play were noted in relation to the player's position (i.e., forward or back). Of the MTBI's sustained by back-line players, 72% occurred as a consequence of involvement in a tackle. In contrast, forward players received an equal proportion of MTBI's (19.8%) as a consequence of their respective involvement in either a tackle or a ruck/maul.

Receipt of Injury and Foul Play

As Table 20 illustrates, the most common means by which respondents reported the receipt of MTBI's was through contact with the body of another player, accounting for 52.2% of such injuries, with backs (58.5%) more likely to sustain MTBI in this manner than forwards (47.9%).

Table 20.

Receipt of MTBI in relation to position (i.e., forward or back) and as a proportion of total MTBI.

Receipt of Injury	*Player Position*		
	Forwards (%)	*Backs* (%)	*Total MTBI* (%)
Legal Play			
Contact with ground	8.3	20.7	13.3
Contact with body of player	47.9	58.5	52.2
Kicked	9.1	3.7	6.9
Other	1.6	-	1.0
Foul Play			
Punched	9.1	2.4	6.4
Kicked	1.7	6.1	3.4
Uncertain of Receipt	22.3	8.6	16.8

Illegal play (i.e., being punched and kicked) accounted for 9.8% ($n=20$) of MTBI's as opposed to the normal passage of play (i.e., being kicked as a function of involvement in a ruck or maul) which accounted for 6.9% ($n=14$) of MTBI's. Foul play occurred relatively equally across both halves of the match, with only slightly more MTBI's resulting from foul play in the first half (4.9%) than in the second (4.4%). Inferential statistical comparisons between the rate of foul play associated with forwards and backs were not conducted because of the small numbers involved. As shown in Table 20, the remaining respondents (17.8%) reported MTBI's being sustained through other means or reported being uncertain as to how the injury was sustained.

8.4 Use of Protective Gear

Sample A (n=400) was used to establish rates associated with use of mouthguards and headgear, with more specific questions pertaining to attitudes toward use incorporating the HMQ (n=46) and AMQ (n=38) samples.

Mouthguards

With respect to the mandatory wearing of mouthguards the RPQ showed that during competition 87% of players *always* wore a mouthguard during competitive games, 7% used a mouthguard infrequently, and 6% never used one. Mouthguards were used less often during training sessions (32.7%) with 35% stating they *never* wore a mouthguard and 27.3% using one only *sometimes*.

Examination of the rate of mouthguard use in relation to the respondent's grade revealed that 83.1% of Senior I players and 90% of Lower Grade players *always* wore mouthguards during matches. However, chi square analyses identified no significant difference [χ^2 (2)=3.89; p= .14] in the rate of mouthguard use between Senior I and Lower Grade players during competitive games. In contrast, a mouthguard was *always* worn in training sessions by only 34.9% of Senior I players and 31.9% of players in the Lower Grades. Again, no significant differences [χ^2 (2)=3.75; p=.15] were found between these two variables.

The HMQ provided a more detailed investigation of attitudes toward mouthguard use. Just under half of the respondents (48.9%) reported they would be *reluctant* to play without a mouthguard. However, only 21.7% of the sample stated they would *refuse* to play. With respect to these attitudes as a function of grade, no significant difference in *reluctance* to play was evident between Senior I and Lower Grade players [$t(43)=.12$, $p=.91$, $\eta^2=.0003$], nor was such a difference evident between grades in relation to a *refusal* to play [$t(44)=.08$, $p=.94$, $\eta^2=.0001$].

That mouthguards help to prevent dental injuries was supported by 84.8% ($n=39$) of HMQ respondents. In relation to concussion, 67.4% ($n=31$) of HMQ respondents and 86.8% ($n=33$) of AMQ respondents believed that mouthguards could aid in the prevention of concussion. Only one AMQ respondent believed mouthguards could not prevent such an injury.

The most frequently worn make of mouthguard reported by HMQ respondents was a boil-&-bite (71.7%), with 21.7% using custom-made mouthguards and 2.2% using another unspecified type (4.3% indicated 'not applicable' to the question). Differences in the quality of mouthguard worn by those in Senior I rugby in contrast to Lower Grades was examined, with a chi square analysis showing that there was no significant difference between proportions in the two grades [$\chi^2(3)=.77$; $p=.86$].

Headgear

The RPQ examined the extent of headgear use in general, with 56.5% of Sample A respondents reporting they *never* wore headgear. The remaining respondents in Sample A stated they wore headgear only *sometimes* (15.3%), or that they *always* wore headgear during the season (28.3%). There was no significant difference [$\chi^2(2)=1.85$; $p=.40$) in the rate of headgear use between Senior I and Lower Grade players. However, in relation to the use of headgear as a function of position, a statistically significant difference was found, with forwards in Sample A ($M=.87$, $SD=.91$) more likely to use headgear than backs ($M=.45$, $SD=.78$) $t(373.7)=4.87$, $p=.000$, $\eta^2=.06$.

Of those completing the HMQ, 78.3% ($n=36$) indicated either no or some *reluctance* in relation to playing without headgear, with the absence of headgear prompting a *refusal* to play for only one respondent (2.2%). Significant differences were revealed between grade with Lower Grade players (M=.31, SD=.48) indicating a greater *reluctance* to play without headgear than Senior I players (M=.93, SD=.59), $t(43)=2.20$; $p=.03$, $\eta^2=.10$). The effect size for this analysis was large. However, no significant differences were evident between grades with regard to players' *refusal* to compete without headgear [$t(44)=.10$, $p=.92$, $\eta^2=.0002$].

When respondents were asked whether they believed that headgear could protect players from incurring a *head injury*, 65.2% believed it could, 23.9% stated it may sometimes, and 6.5% indicated it could not (4.3% were unsure). Coaches, members of team management, and referees (AMQ) were more uncertain than players about the utility of headgear, with only 36.8% believing headgear could prevent concussion, with 34.2% believing it *may* and 28.9% stating that it would not prevent concussion.

Twenty-six HMQ respondents indicated headgear use and of these respondents 53.8% wore Canterbury brand headgear and 7.7% used the Madison brand. For 80.8% of the respondents, electing to wear headgear reflected a personal choice. One respondent (2.2%) wore headgear for medical reasons, while for another (2.2%) the choice reflected both medical and personal reasons. One respondent (2.2%) reported that the choice to wear headgear was affected by all the options detailed in the AMQ.

8.5 Establishing Levels of Recognition, Assessment and Management

Was Attention Received, When, and Why Not?

The RPQ responses showed that of the 203 MTBI's reported by Sample B, 57.1% (n=116) failed to receive any attention at all. For those MTBI classified as *moderate*, 66.0% (n=35) received attention, while 34.7% (n=52) of *very mild* to *mild* concussions were attended to. As Table 21 illustrates, of those who did receive attention (n = 87), 64.4% were first attended to during the course of the game, 11.5% were attended at the completion of the game at the match venue, and 20.7% at a medical facility (3.4% missing data). With respect to grade, a greater proportion of Lower Grade players received attention during the match in comparison to Senior I players, as illustrated in Table 21. However, in contrast to Lower Grade players, more cases of MTBI incurred by Senior I players were attended at the completion of the game either at the venue or at a medical facility. As a result of the questionnaire format, the point at which different severity injuries received attention could not be examined.

Table 21.

The point at which attention was first received as a function of grade and total MTBI.

	Attention Received (%)			
	During Game	*After Game at Venue*	*After Game at Medical Facility*	*Missing Data* (%)
Senior I Grade	56.7	16.6	26.7	-
Lower Grade	68.4	8.8	17.5	5.3
Total MTBI	64.4	11.5	20.7	3.4

The 2000 RPQ investigated reasons for why a MTBI did not receive attention, with 44 of the 69 respondents sustaining a MTBI during this season providing information pertinent to this question. The majority of respondents (68.2%) indicated that attention was not received because the player considered their injury to have been 'minor' and, therefore, not requiring assessment. Attention was not received due to a lack of appropriate personnel to assess the MTBI in one case and in another case the respondent did not realise they were concussed. Twelve respondents (27.3%) elected not to report the MTBI sustained for a number of reasons, for example, not considering the injury severe enough to report (n=6), not wanting to be removed from the game (n = 1), and a combination of both of the above responses and not wanting to risk future games or to appear soft (n=5).

Level of Recognition

In examining the proportion of MTBI's recognised (as indicated by receipt of attention), 38.5% of MTBI's incurred by Senior I players (n=78) received some form of attention, while in contrast, those comprising the Lower Grades had 45.6% of MTBI recognised by those monitoring these players.

The AMQ revealed the vast majority of respondents (94.7%) were aware that a loss of consciousness was not required for a diagnosis of concussion, with only two respondents believing this to be the case. The symptom that was most commonly reported by 68.4% of respondents as being indicative of a MTBI was that of confusion/disorientation. This was followed by the symptoms of dizziness/loss of balance (57.9%), dilated pupils (44.7%), blurred vision (36.8%), memory loss (34.2%), headache (26.3%), slurred speech (23.7%), vomiting/nausea (15.8%), and lastly, LOC (10.5%).

Who Attended the Injured Player?

According to players, a coach or member of team management attended 49.4% of MTBI, while a doctor examined 32.2%, St. John's personnel 10.3%, with the remaining 8.1% of MTBI's attended by a referee or someone else (unspecified). Coaches/team management attended a comparatively equal number of MTBI cases for both Senior I (46.7%) and Lower Grade players (50.9%). A doctor was reported to have attended 43.3% of Senior I MTBI cases in contrast to 26.3% of Lower Grade cases, while St. John's personnel attended 14% and 3.3% of Lower Grade and Senior I MTBI cases, respectively. Referees attended the remaining injuries (refer Table 22).

For MTBI's of *moderate* severity (i.e., LOC or diagnosis) receiving attention, 48.6% (n=17) were attended by a doctor, 40% (n=14) by a coach/team official, and 8.6% (n=3) by St. John's personnel (2.8% [n=1] missing data). Of those sustaining a concussion of *very* *mild* to *mild* severity, 53.8% (*n* =28) were attended by a coach/team official, 21.2% (*n* = 11) by a doctor, 11.5% (*n*=6) by St John's personnel, 7.6% (*n* = 4) by referees, and 5.8% (*n* = 3) by unspecified individuals, as seen in Table 22.

Table 22.

Who attended MTBI's presented as a function of grade, injury severity, and proportion of total MTBI's.

	Coach/Team Mng. (%)	*Doctor* (%)	*St. John's* (%)	*Referee* (%)	*Other* (%)
Grade					
Senior I Grade	46.7	43.3	14.0	3.3	
Lower Grade	50.9	26.3	3.3	5.3	
Severity					
Moderate Severity	40.0	48.6	8.6	-	2.8†
Very Mild to Mild Severity	53.8	21.2	11.5	7.6	5.8
Total	49.4	32.2	10.3	4.6	3.5

† Figure represents missing data.

According to 60.5% of AMQ respondents, coaches/team management typically assessed MTBI, with 18.4% of respondents reporting that a combination of coaches/team officials and qualified medical personnel (i.e., St. John's member or registered nurse) generally conducted MTBI assessments. St John's personnel were recorded by 7.9% of respondents as the individuals most frequently attending concussed players, with 5.3% reporting a combination of coaches/team officials and referees. One respondent reported that coaches, referees, and St. John's personnel routinely conducted MTBI assessments, with the remaining two respondents not completing this question. Doctors were not reported by this sample to frequently attend a concussed player.

Of those completing the AMQ, 39.5% (*n* =15) indicated that they routinely attended MTBI's. All of the team physiotherapists (*n* =3) and managers (*n* = 2) and 7 of the 11 coaches who completed the AMQ indicated their frequent involvement in the assessment of a concussed player. Only 3 of the 21 referees reported being routinely involved in MTBI assessment, while the one trainer completing the questionnaire indicated others conducted such assessments.

Level of Competence of Assessor

Almost two-thirds of AMQ respondents (65.8%) indicated having received both medical/first aid qualifications and training (refer Table 23). In the absence of qualifications, medical/first aid *training* alone was reported by 15.7% ($n = 6$) of respondents, with 13.2% indicating neither qualifications nor training (5.3% accounted for by missing data).

Table 23.

Number of AMQ respondents with both medical/first aid training and qualifications, with training only, or with neither, presented as a function of the respondent's role and grade involved with.

	Respondents (*n*)	*Qualifications and Training* (%)	*Training Only* (%)	*Neither* (%)	*Missing Data* (%)
Role					
Coaches/Team Officials	17	64.7	17.6	5.8	11.7
Referees	21	66.7	14.3	19.0	-
Grade					
Senior I Grade	12	83.3	2.6	8.3	-
Lower Grade	26	57.7	19.2	15.4	7.7
Total		65.8	15.7	13.2	5.3

With respect to role, 66.7% ($n = 14$) of referees and 64.7% ($n = 11$) of coaches/team officials reported having both medical/first aid training and qualifications, as illustrated in Table 23. Of those indicating their primary involvement with Senior I players, 83.3% reported having both medical/first aid qualifications and training, with one individual (2.6%) having received only training. In contrast, 57.7% of those involved with Lower Grade teams held qualifications and 19.2% had received training.

The average age of those with qualifications was higher (M=38 years) than for those without (M=43 years), although not significantly different [$t(35)=1.71$, $p=0.97$, $\eta^2=.08$], while for those with only training, the age averaged 39 years which contrasted only slightly to the average age of those with no training (M=41 years).

Of the AMQ respondents, 18.4% reported having heard of the GCS, and 10.5% indicated having used this objective measure. An equal number of respondents in the Senior I grade and Lower grade had heard of and used this measure, and all four respondents held medical/first aid qualifications. The frequency of use within a rugby setting ranged from 'hardly ever' (n=1) (reported by a Senior I physiotherapist) to 'never' (n=3). Other means of assessing a player's conscious state proposed by those completing the AMQ were a combination of verbal and physical responses (including the finger-to-nose test and indicating the number of fingers displayed) (29%), responses to verbal questioning (26.3%), and physical responses (18.4%), with one respondent indicating use of neuropsychological measures and another reporting use of a concussion classification system. The remaining respondents either did not use any particular method to assess a player's conscious state (7.9%) or did not complete the question (13.2%).

Five main steps are typically adhered to when dealing with an unconscious player. The following proportion of AMQ respondents endorsed each of these steps as follows: 36.1% would check for spinal/neck injuries; 33.3% would check that airways were clear and if indicated use the recovery position; 7.9% would assess responsiveness; 52.8% would remove the player from the field or ensure he was out of harm's way; and 71.1% would obtain appropriate medical assistance for the player. Upon attending an unconscious player only one respondent (a referee) endorsed four of the five main steps involved in managing such a situation, with knowledge of three steps indicated by 9 respondents, two steps by 18 respondents, and one by 8 respondents. There was no significant difference in relation to knowledge of this procedure as a function of whether or not medical/first aid qualifications were held [$\chi^2(3)=5.56$, $p=.11$].

Reporting and Recording

Only 13 of the AMQ respondents reported using the Serious Injury Report Form (SIRF) supplied by the MRFU and of these, the majority (76.9%) indicated their satisfaction with the form. Three respondents reported the form to be unsatisfactory, because it does not define a serious injury or require detail for those injuries which may not be considered serious at the time of injury, but which 'may strongly influence players' long-term fitness'.

Almost one third (31.6%) of AMQ respondents stated that responsibility for monitoring a concussed player should rest with their coach and team management, while 21.1% of respondents considered that team management and the club should be responsible. The regional union was viewed as responsible by 15.8% of respondents, while others indicated that the club (10.8%), or the club and union (7.9%) should be responsible for monitoring a concussed player. One respondent believed a delegated club official should monitor such players, while another believed responsibility should be shared between the coach, club, and regional rugby union. Two respondents indicated that medical personnel should be responsible, with one other laying responsibility with the referee and team management.

In examining the MTBI group from Sample B (n=128), 43% indicated that their current coach was unaware of their TBI history, with 21.1% indicating that they were uncertain of whether their coach was aware of previous concussions. Almost one third of respondents (30.5%) reported their coach had been informed or was aware of a player's TBI history, with the remaining cases constituting missing data. For respondents indicating a concussion of *moderate* severity, 44.1% reported their coach was not aware of their TBI history, with only 29.4% stating their coach had been informed. Of those with less severe injuries (i.e., *very mild* to *mild* severity), 45.5% indicated their coach was unaware of their history of brain injury, although a third (33%) indicated their coach had been made aware of such injuries.

8.6 Adherence to Regulations and Recommendations

Stand-down Observed

Of the respondents reporting a concussive injury during the course of the season, only 10.9% indicated that the mandatory 3-week stand-down period was always adhered to as a consequence of the injury, or injuries, they received. In contrast, this period was never observed by 66.4% of those suffering MTBI and was observed only sometimes for 15.6% of MTBI respondents (7.1% of responses were missing data).

For those having sustained one MTBI during the target, 69% of respondents did not observe the required 3-week stand-down period, in contrast to 15.5% of respondents who stated this period was *always* observed. In relation to having suffered two or more MTBI within a season, 74.4% of respondents *never* abstained from play for the recommended period, with only 5.1% of players *always* doing so.

The responses to each of the scenarios detailed in the AMQ were somewhat varied. With respect to Scenario I, in which the player continues to experience a slight headache after a blow to the head, 7.9% of respondents reported they *would* allow the player to return to play immediately, 34.2% stated they *may* return the player, while 57.9% stated they *would not* allow the player to resume play. For those respondents comprising the latter group (n=22), 55.5% indicated they would only allow the player to return if they received medical clearance. Some indicated (7.9%) the would return the player to the game after 10 minutes if asymptomatic, while others (27.8%) stated players would receive a 2-3 week minimum stand-down period. One respondent indicated that the decision to return the player to the game rested with team management.

For those respondents who indicated they *may* return the player to the game ($n = 13$), 46.2% indicated their decision would be influenced the severity of the symptoms being experienced, while 38.5% stated that their decision would depend on medical advise. One respondent stated a player would be allowed to return if that player insisted or if there was a need for the player to be returned, while another stated that the onus for returning the player would be based on a team management decision.

In response to Scenario II where the player lost consciousness, all those completing this question stated they would not allow the player to return to the game. The time-frame as to when they would allow the player to resume play varied from a stand-down period of 10 minutes if asymptomatic (4%), 1-2 weeks (4%), 2-3 weeks (12%), 3 weeks or more (44%), after medical clearance (28%) or based on a team management decision (4%). One respondent stated that they would base their decision on a '10 second rule', which is unknown to the researcher.

Conditions under which a 3-week stand-down would be advised by respondents included evidence of a LOC (34.2%), 'a concussion' (10.5%), a heavy blow to the head (2.6%), or stitches to the head (2.6%). Respondents on the advice of either medical personnel (18.4%), or team management (5.3%) would also recommend this period. One respondent (2.6%) indicated that the 3-week stand-down period was a fictitious timeframe and hence they would not use it (23.7% was missing data).

Conditions under which stand-down for a season was advised included the experience of: a LOC irrespective of duration (6.9%); LOC for extended period (i.e., coma) (3.5%); at least two concussions (13.8%); at least two LOC (24.1%) (one respondent specified that these were to occur within a 6-week period); at least three LOC (6.9%); a series of concussions (unspecified number) (6.9%); or on the basis of medical advise (34.5%) or the team's decision (3.5%).

Abstinence from the Sport

It was revealed that 5.3% (n=20) of the 376 respondents had been advised previously by a medical professional such as a general practitioner, neurologist, or neurosurgeon, to discontinue their participation in rugby after receiving a concussive injury. As a consequence of these players having completed the questionnaire (administered only to those registered as a club grade rugby player) it was obvious that this advice had been ignored.

CHAPTER NINE

Method – Part II

The second phase of the research was designed primarily to monitor the rate of recovery from MTBI through the objective use of neuropsychological assessment measures. The chapter commences with an outline of the expected outcomes, followed in Section 9.2 by a review of the assessment measures adopted, their psychometric properties, and the rationale underlying their selection. Demographic information for the participants is detailed in Section 9.3, while the administration process is discussed in Section 9.4 in conjunction with a review of the difficulties encountered during this phase. The statistical procedures undertaken to analyse the data gathered are discussed in the final section of this chapter.

9.1 RESEARCH HYPOTHESES

The primary objective in relation to this phase of the research was to monitor recovery of function from MTBI in the context of club rugby. However, to accomplish this objective satisfactorily, a negligible effect of practice associated with the repeated administration of the assessment measures needed to be demonstrated. The hypotheses relating to this phase of the research are as follows:

- For players suffering a MTBI, deficits in information processing speed will be indicated by reduced scores on each of the three measures employed, or by a significant change in performance on these measures as assessed by the RCI.

Compared to a single MTBI, repeat MTBI's will be associated with:

- a greater magnitude of deficit in information processing speed as indicated by pre- and post-injury scores on each of the three measures.
- a slower rate of recovery to pre-injury levels

It is important to mention at this point the failure of the current investigation to fulfill the primary objective associated with this research phase (i.e., monitoring the rate of recovery from MTBI). The reason for this failure can be attributed to the players' reluctance to report - an issue addressed in more detail in subsequent chapters.

9.2 ASSESSMENT MEASURES

9.2.1 Selection Criteria

The neuropsychological measures adopted for the current investigation were selected on the basis that they were:

(1) sensitive to MTBI deficits, especially learning, short-term memory, verbal retrieval, attention, and concentration;

(2) suitable for evaluating large groups of players, or where group administration was impossible, suitable for inclusion in an individual assessment protocol;

(3) time-efficient - a maximum of 20-30 minutes with each player for a baseline assessment is considered typical in such research (Lovell & Collins, 1998). In order to work within this time frame, tests with administration times of more than 5 minutes were excluded, which also effectively reduced the number of tests able to be administered in total;

(4) available in multiple equivalent forms or be able to withstand the effect of practice, as repeated administrations were necessary;

(5) reliable and valid with respect to detecting deficits in functioning associated with MTBI.

9.2.2 Assessment Measures Selected

The tests incorporated in this assessment phase ensured different aspects of cognitive functioning were to be measured, in particular attention, concentration, information processing, and tracking functions. Tests were administered in one of two batteries, of which the individual battery comprised the Auditory-Verbal Learning Test (AVLT), the Trail-Making Test (Part A and B), the WAIS-III Digit Span subtest, and the Stroop Colour Word Test. The group assessment battery included the Digit Symbol-Coding Test (Wechsler, 1997), the Symbol Digit Modalities Test (Smith, 1982), and the Speed and Capacity of Language Comprehension Test (Baddeley, Emslie, & Nimmo-Smith, 1992) which consisted of two subtests: (1) the Sentence Completion (Silly Sentences) Test and (2) the Spot-the-Word Test. The measures comprising the group battery were identical to those adopted by Hinton-Bayre et al. (1996, 1999).

It had originally been intended that participants in this phase were to receive both batteries. However, the administration of the individual battery was precluded as a consequence of additional time constraints imposed by coaches (attributed to the limited time they had to work with players) and the unwillingness of participants to complete more than the group assessment. The repercussions of this were that only the group assessment battery was conducted. A review of the measures comprising this battery follows.

Digit Symbol-Coding Test (Wechsler, 1997)

Of all the Wechsler Adult Intelligence Scale Third Edition (WAIS-III) subtests, the Digit Symbol-Coding Test (Digit Symbol) is the most sensitive to impairment after TBI, even when damage is minimal (Lezak, 1995). The primary purpose of the Digit Symbol (also known as the Digit Symbol Substitution Test [DSST]), is to assess psychomotor performance which is relatively unaffected by intelligence level, memory, or learning. For this task a key is presented with numbers on top ranging from 1 - 9 and beneath each number is a corresponding symbol. Using this key the participant is instructed to reproduce the symbol that corresponds to the number as quickly and accurately as they can. Motor persistence, sustained attention, response speed, and visuomotor co-ordination all play important roles in a participant's performance in this test (Lezak, 1995).

Digit Symbol is brief (a 2-minute timed test), easily administered in a group situation, and exists in four parallel forms (refer Appendix J) produced by Maddocks and Dicker (1989) and Maddocks and Saling (1991). According to Lezak (1995) this measure has a high test-retest reliability (r = .82 - .88) and it is reported to be the only WAIS-III subtest to correlate with the duration of PTA (Paniak, Silver, Finlayson, & Tuff, 1992). The sensitivity of this test with respect to MTBI has been indicated with a number of sport-related investigations. Impairments in performance on the Digit Symbol were reported 5 days post-concussion for rugby league players (Maddocks & Saling, 1996) and gridiron athletes (Macciocchi, Barth, Alves, Rimel & Jane, 1996). The ability of the Digit Symbol to differentiate concussed from non-concussed rugby league players was demonstrated by Maddocks, Saling, et al. (1995), although its sensitivity is reported to diminish by the sixth month post-injury.

Practice effects for the Digit Symbol have been noted, with Hinton-Bayre et al. (1996) showing improvement in score by an average of 6.6 symbols (11.1%) from the first to the second administration. Jamieson et al. (1998) report that a definite practice effect was noted with repeated administrations of this measure, which was not controlled for by the randomisation of number-symbol associations. Therefore, as maximal improvement occurs between the first and second assessment, it is recommended that no less than two pre-season administrations be conducted (Hinton-Bayre et al., 1996). This ensures an indicator of best performance is obtained, enabling any post-injury deficit to be reliably identified.

Symbol Digit Modalities Test (Smith, 1982)

The Symbol Digit Modalities Test (SDMT) is a measure utilised to assess for deficits relating to attention, primarily assessing complex scanning and visual tracking, although it also employs psychomotor problem solving and visual perceptual abilities (Lezak, 1995). A 90-second timed test, the SDMT reverses the presentation of Digit Symbol, involving the conversion of symbols into written number responses (Smith, 1982). Like the Digit Symbol, the SDMT can be administered in a group situation and features four alternate forms (designed by Hinton-Bayre et al., 1996; see Appendix K). The correlation between the SDMT and Digit Symbol is high ($r = .85$ - $.91$), which has meant that in the past they have been used, and referred to, as interchangeable (Barth et al., 1983). However, an individual's performance on both tests has the potential to result in very large differences. Morgan and Wheelock (1995) examined differences in performance between the WAIS-R version of the Digit Symbol and the SDMT finding that the mean SDMT scores were the equivalent of 2½ - 3 age-scaled score points lower than the Digit Symbol scores. In addition, unlike the Digit Symbol this measure does not appear to be significantly affected by repeated assessment (Hinton-Bayre et al., 1996). These findings support the notion that these measures are conceptually different and, therefore, according to Morgan and Wheelock are not directly interchangeable.

The SDMT is considered to be one of the most sensitive measures to the presence of acute or chronic 'organic' cerebral dysfunction (Smith, 1983) and is considered more sensitive to impairment in diverse neurologic populations relative to the Digit Symbol (Morgan & Wheelock, 1995). Reliability and validity data reveals support for the stability of SDMT score over time ($r = .80$) and the ability of this test to differentiate between clinical and non-clinical groups (Smith, 1982).

The SDMT's qualities of brevity, objective scoring, and sensitivity to cerebral dysfunction has resulted in its considerable use in research (Lewandowski, 1984), often selected as part of a battery of neuropsychological measures to assess cognitive functioning after TBI. Barth et al. (1989) employed the Symbol Digit in a test battery to establish a recovery curve for gridiron football players suffering *mild head injury*. Scores on this measure revealed deficits within 24 hours of the injury, with an apparent recovery in the 24-hour to 5-day interval, with continued recovery taking place in the 5- to 10-day interval. Use of the SDMT by Hinton-Bayre et al. (1996) showed a decline in performance from pre-injury assessment to within 24 - 48 hours after *mild head injury*. Reliable change indices revealed that along with the Digit Symbol, SDMT scores were notably closer to baseline maximum levels 1 – 2 weeks after injury, with these levels not significantly different at the 3 – 5 week retest. In another investigation (employing the Pittsburgh Steelers Test Battery), a drop in performance on the Symbol Digit was reported within 24 hours of sustaining a concussion, with performance returning to baseline levels or above by the post-season evaluation (Lovell & Collins, 1998).

The Speed and Capacity of Language Comprehension Test (Baddeley et al., 1992)

This test, comprising two subtests, was developed to measure the slowing of cognitive processes evident after TBI (Baddeley et al., 1992). The *Speed of Comprehension Test* (Silly Sentences) is considered sensitive to a reduction in information processing speed (Hinton-Bayre et al., 1996). It is a 2-minute timed test consisting of 100 short sentences, of which half are true and half false (Baddeley et al., 1992). The participant is required to place a tick or cross next to each sentence according to whether it is sensible or not (Hinton-Bayre et al., 1996).

Existing in four alternate forms (refer Appendix L), this measure is suitable for multiple administrations to monitor improvements in information processing speed. Parallel-form reliability is acceptable ($r = .88$) (Baddeley et al., 1992) and while a practice effect has been reported (Hinton-Bayre et al., 1996), this can be controlled for with a minimum of two pre-injury administrations. Reliable change indices revealed that in comparison to the Digit Symbol and SDMT, Silly Sentences is more sensitive to deficits in information processing associated with MTBI (Hinton-Bayre, Geffen, & McFarland, 1997).

The *Spot-the-Word Test* is considered a brief and simple means of estimating premorbid intelligence (Baddeley et al., 1993). It involves presenting the participant with 60 pairs of items comprising a word and an invented non-word, and requires the participant to indicate (by ticking) the actual word (Baddeley et al., 1992). As with the previous measures, the Spot-the-Word test is easily administered in a group format, as no verbal response is required.

Proposed as a measure to supplement the more popular National Adult Reading Test (NART), the Spot-the-Word test is considered more resistant to TBI as it provides a number of parallel routes to performing the task (Baddeley et al., 1993). Existing in two parallel forms (refer Appendix M), reliability between Form A and Form B is acceptable (r=.88) (Baddeley et al., 1992) and performance is unaffected by repeated administrations (Hinton-Bayre, Geffen & McFarland,1997). Adequate internal reliability (r=.78 for Form A; r=.83 for Form B) has also been demonstrated (Baddeley et al., 1993) and with respect to its correlation's with similar measures of verbal intelligence produced coefficients of .69 with the Mill Hill Vocabulary Test, and .87 with the NART (Baddeley et al., 1993).

9.3 PARTICIPANTS

The initial design aimed to administer group and individual assessment batteries to five Senior I teams, on the basis that the teams would be similar in age and years of playing rugby. However, the time commitment involved in the assessment phase proved obstructive and ultimately volunteers could only be obtained from two Senior I teams, a Senior II team and a Colts team. In total, 61 players were involved in the first preseason administration (refer Figure 4, Section 9.4) – 39 individuals were recruited from one club and included players from a Senior I, Senior II, and Colts team (referred to as Group I), while 22 players obtained from another club were all members of the Senior I team (Group II). However, for reasons addressed in Section 9.4, only the players from Group II ($n = 22$) completed the remainder of the group assessments. Demographic information for the Group II participants is presented in Table 24 as a function of their MTBI history.

Table 24.

Mean age, years of education, time playing sport, and standard score for the Spot-the-Word test for those in Group II having previously sustained a MTBI and those with no MTBI history.

MTBI History	*N*	*Age (M)*	*Time in Sport (Hrs per week) (M)*	*Education (Yrs) (M)*	*Spot-the-Word* † *(M)*
MTBI	12	23.3	7.6	6.3	8.8
Non-MTBI	10	24.3	8.7	5.9	6.9
Total	22	23.8	8.1	6.1	8.0

† Standard scores for Spot-the-Word test are presented.

Twelve players (54.5%) in Group II reported a history of MTBI. Of this sample, six reported a history of 1-2 injuries in accordance with the definition, while the remainder of the MTBI group revealed having previously suffered 3-5 concussions. Participants were asked to report any MTBI suffered during pre-season training for the current season, of which one case was reported. As the injury did not result in a LOC and there was no evidence of persisting symptoms, the participant was retained in the sample.

As illustrated in Table 24, the participants averaged 23.8 years of age, with those in the non-MTBI group a year older on average than those forming the MTBI group. The non-

MTBI participants also indicated a greater number of hours in sporting activities per week (*M*= 8.7) than those having a previous history of MTBI. An average of 6.1 years of secondary and tertiary education was identified for participants in this sample, with players forming the MTBI group having spent slightly longer in the education system than those in the non-MTBI group. Three ethnic groups were identified in the sample, with 45.5% of participants of European/Pakeha descent, 31.8% of Maori heritage, and 22.7% of Pacific Island origin.

9.4 PROCEDURE

Coaches of Senior I teams who had participated in the 1998 RPQ were approached regarding participation of their players in both the individual and group administered assessment batteries. Despite all efforts, volunteers were not forthcoming in this grade, and as stated earlier, this was primarily attributed to the time commitment that both individual and group assessments warranted. After abandoning the individual assessment component of the research, Senior I grade coaches were re-approached along with coaches from other grades, resulting in the procurement of four teams derived from two clubs. The group battery (approximately 15 minutes) was to be administered at four stages of assessment: a baseline assessment (formed by two preseason administrations), a midseason assessment and a post-season administration (as illustrated in Figure 4). The tests administered at each stage of the assessment phase and the order of presentation are also illustrated in Figure 4. As the equivalence of the alternate forms of the Digit Symbol, SDMT and Silly Sentences measures had been previously established, it was not considered necessary to counterbalance the administration of each form across players and session at baseline. A different alternate form was used for each assessment and was administered in sequential order, that is, Form 1 of each measure was administered at this first assessment, Form 2 at the second (baseline) assessment, and so on. Details relating to each of the assessment stages (baseline, mid-season and post-season) are addressed below. Two independent administrations of the group battery were required to accommodate both clubs involved in this phase of the research, and the procedures followed were identical for each group.

Baseline Assessment

The first preseason assessment was conducted at different times for each club. Group I participants were assessed one week prior to the start of the competitive season, while Group II did not receive an assessment until one week after the start of the competitive season. Both preseason assessments were conducted in respective clubrooms, in the presence of coaches, members of team management, the researcher, and two research assistants. The research assistants distributed to each participant a clipboard, a pen, and a response booklet (comprised of an information sheet, consent form [see Appendix N], and response sheets for each test). The booklet also featured an identification number to ensure monitoring of individuals throughout the season was reliable. Once these items had been distributed, participants were instructed to read the information sheet and detach it from the booklet, to be retained for their reference. After the participants had completed reading the information sheet the researcher summarised the main points, placing particular emphasis on the participants' obligation to report any MTBI suffered. Those willing to take part in the research were then asked to complete the consent form, while those not wanting to participate were asked to wait outside. Instructions for the completion of each measure were read aloud to the participants, with clarification provided as required. Although participants were monitored so that they did not talk amongst themselves, this was difficult to control especially for those in Group I due to its size and the informal

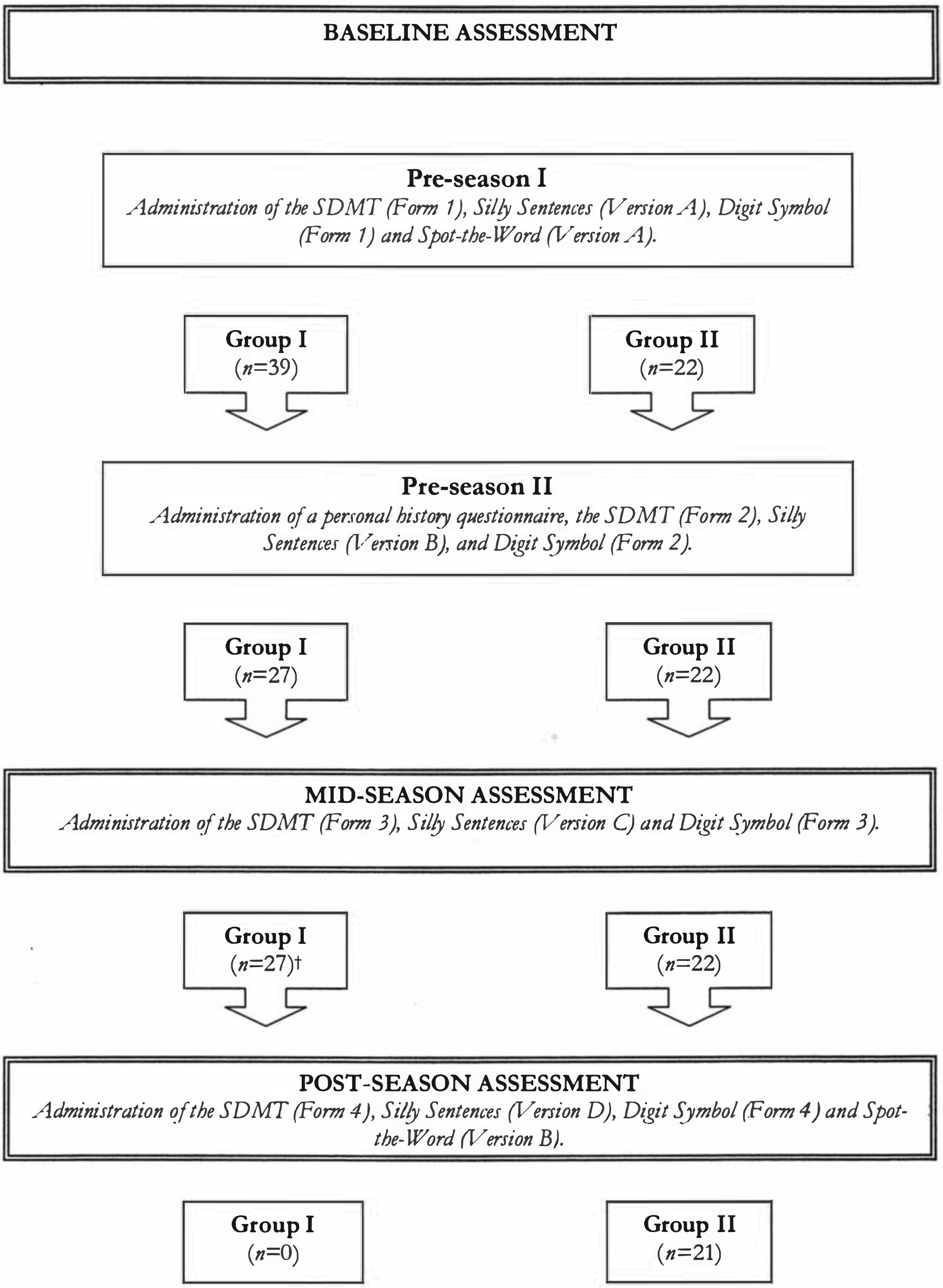

Figure 4. *Flowchart depicting the three stages of the assessment process in Phase II of the research.*

† The 27 participants completing the Pre-season II and Mid-season assessment are not representative of the same individuals. Of the individuals completing the Pre-season I assessment, some did not complete Pre-season II, yet completed the mid-season assessment and vice-versa.

testing conditions (being seated on the floor). On completion of the assessment battery, the participants were asked to return their response booklets to the researcher.

The pre-season II assessment was to be administered within 1 – 2 weeks of the initial assessment. Group II participants received the re-test within one week (5 days) of the initial assessment. However, due to circumstances beyond the researcher's control, Group I participants did not receive the second assessment until 3 weeks later. At this point both groups had played one competitive game each. The second assessment was administered in the respective training-ground changing rooms of each club. As shown in Figure 4, participants were administered a personal history questionnaire (refer Appendix O) which gathered primarily demographic information, but also investigated whether the player had suffered a concussive injury since the start of the season. On completion of the questionnaire, the tests comprising the second assessment were administered.

Of those completing the pre-season I assessment, 12 Group I participants did not partake in the second assessment as they failed to attend the training session, and attempts to assess them at a later point were thwarted. Of the 27 participants from Group I completing both pre-season assessments, 5 assessments featured incomplete results, leaving a total of 17 participants from this group who did not establish satisfactory baseline scores. As illustrated in Figure 4, this was not the case with Group II participants.

On completion of the baseline assessments, all participants, coaches, and members of team management were provided with a check sheet on brain injury (refer Appendix P) which detailed the symptoms that they needed to be aware of for the purposes of this study. Participants were asked to inform the team physiotherapist, manager, or coach if they experienced any symptoms of MTBI or lost consciousness at any stage during the rugby season. If reluctant to report to these individuals, players were encouraged to contact the researcher directly (a contact phone number was supplied to each participant). A seminar on MTBI sequelae and severity, recommendations for return to play, and risks associated with TBI was held, on the basis of their large number, for individuals monitoring Group I participants. This information was also summarised and included in a handout (see Appendix Q) and distributed to those attending the seminar and to individuals monitoring Group II participants. None of the individuals who attended this seminar were involved later in the AMQ (addressed in Chapter 7).

Mid-Season Assessment

This assessment followed the same procedure as the Preseason II assessment and featured the third alternate form of each measure, as no MTBI had been reported up until this point. Although 27 Group I participants completed the third assessment, only 23 had satisfactorily completed all assessments to this point (as seen in Figure 4). All Group II participants (n = 22) completed the mid-season assessment.

Post-Season Assessment

Serious consideration was given to abandoning the post-season administration, based on the disbandment of the majority of Group I members a number of weeks prior to the post-season assessment, as a result of failure to make the semi-final or final match for their grade. However, Group II participants made the club competition finals, which ensured that 21 of the original 22 members of this group could be re-tested prior to their last game. The post-season administration comprised the measures detailed in Figure 4 and was again conducted in the club changing rooms.

Brief Assessment

Participants sustaining a suspected brain injury were to be evaluated by the team's attending medical personnel, with diagnosis made on the basis of this evaluation and on the definition of MTBI provided. After a diagnosis had been made participants were to receive a brief assessment (using the Digit Symbol, SDMT, and Silly Sentences) within 24 – 48 hours post-injury, with re-administration of these measures 2 - 3 weeks later.

The version of the measures selected for use in this instance was to follow the sequential order of the administrations. For example, if a brief assessment was required prior to the mid-season assessment, version/form 3 of each of the measures would have been used, followed by version/form 4 at the 2 - 3 week follow-up, and version/form 1 at the post-season assessment. In addition to the assessment measures a report form was to be completed by the participant detailing the circumstances surrounding the MTBI (refer Appendix R).

Contact with the physiotherapist of Group II and the coaches of Group I participants was made by the researcher on a weekly basis each Sunday, to ensure all cases of MTBI were identified and assessed within the 48 hour time frame. If the participant made contact with the researcher, the reasons for choosing not to report to their coach/team physiotherapist were to be investigated. If their reluctance to report hinged on a fear of being stood-down, participants were to be encouraged to inform their coach and seek medical attention before returning to play. If the researcher had serious concerns about the MTBI suffered, in the interests of safety the player was to be informed that the coach would be contacted if they failed to report their injury.

9.5 DATA ANALYSIS

As with the two previous investigations (Hinton-Bayre et al., 1996; 1999), raw scores obtained on each measure (not standard scores) were used in the analysis. Raw scores for the Digit Symbol and SDMT constituted the number of symbols or digits correctly transcribed, while raw scores for the Sentence Completion subtest comprised the number of sentences correctly identified as being 'sensible' or 'silly'. As the manual for the Sentence Completion subtest recommends that an error rate greater than 10% should be treated with caution, the current study elected to exclude cases meeting this criterion from the analysis. To investigate statements regarding the parallel equivalence of the alternate forms for the SDMT, Digit Symbol, and Sentence Completion test and whether practice effects were evident in the sample (from the first to the second test exposure), paired samples (repeated measures) *t*-tests were conducted.

Prior to the analysis of performance across the course of the season, the average baseline score (Preseason I score + Preseason II score/2) and the highest preseason score on each of the three information processing speed tests was identified. To examine the performance of participants not suffering a MTBI, the cases in which a MTBI was reported were first excluded. A one-way repeated measures ANOVA was then conducted to assess whether changes in non-MTBI group scores were evident across baseline, mid-season, and post-season assessment. As the number of individuals suffering a MTBI was small, group analyses were not appropriate, with analysis possible only at an individual case level.

CHAPTER TEN

Results – Part II

This chapter presents the results of analyses conducted with data obtained through the administration of psychometric measures, to address the hypotheses detailed in Chapter 9. As mentioned in the previous chapter, the failure of players to report sustaining MTBI's meant recovery of function after concussion could not be monitored. However, despite this substantial setback (beyond the control of the present research), information gleaned from the RPQ allowed those having incurred a MTBI during the season to be identified. As a consequence, the identification of these individuals has allowed for additional post-hoc evaluations to be carried out, where alternatively (had it not been for the RPQ) such analyses would not have been possible.

10.1 PRACTICE EFFECT

10.1.1 Alternate Form Equivalence

Relationships between the alternate forms administered during the baseline assessments (Preseason I and Preseason II) were examined with strong relationships identified for forms 1 and 2 of the SDMT ($r = .79$, $p < .0005$), the DSST ($r = .82$, $p < .0005$) and the Speed of Comprehension Test ($r = .78$, $p < .0005$). As the decision was made not to present forms in a counterbalanced manner within each session (as discussed earlier), inferences regarding the equivalence of each of the alternate forms are unable to be made with any conviction.

10.1.2 Effect of Practice

To evaluate whether any effect of practice was evident in test scores across the first two assessment sessions, a paired samples t-test was conducted. No significant difference was identified between scores on the SDMT obtained at Pre-season I (M=52.64, SD=10.86) and Pre-season II (M=51.23, SD=12.13), $t(21)=.87$, $p=39$, $\eta^2=.04$. The η^2 statistics demonstrates a small to moderate effect size. The same non-significant trend was, however, not evident in relation to the Digit Symbol and Speed of Comprehension Test, as illustrated in Table 25.

Table 25.

Effect of repeated assessment on psychometric test performance

Psychometric Test	*Preseason*	*M*	*SD*	*Significance*
Symbol Digit Modalities Test	I	52.64	10.86	
	II	51.23	12.13	p=.392
Digit Symbol Coding Test	I	77.64	15.71	
	II	71.32	16.01	p<.001
Speed of Comprehension Test	I	68.53	17.90	
	II	54.37	16.08	p<.001

The paired-samples t-test conducted with the Digit Symbol revealed a significant decrease in scores obtained by Form 1 (M=77.64, SD=15.71) and Form 2 (M=71.32, SD=16.01), with performance decreasing by an average of 6.3 symbols, $t(22)=3.15$, $p=.005$, $\eta^2=.32$. After excluding three cases with unreliable Speed of Comprehension Test scores, paired-samples t-test for the preseason administrations of this measure revealed a statistically significant decrease in scores obtained by Form 1 (M=68.53, SD=17.90) and Form 2 (M=54.37, SD=16.08). Players performance on this test decreased by an average of 14.2 sentences, $t(19)=5.43$, $p<.0005$, $\eta^2=.62$.

Spot-the-Word test scores obtained at preseason I (M=42.65, SD=4.96) and post-season (M=42.5, SD=5.41) assessments were not found to be significantly different [$t(19)=.149$, $p=.89$, $\eta^2=.001$].

10.2 MONITORING RECOVERY OF FUNCTION

During the course of the season under investigation in this research phase, there were no reports of MTBI made by the participants. However, during the routine administration of the 1999 RPQ four of the 22 participants indicated having sustained a MTBI in accordance with the research definition. As a consequence of these participants' failure to report, the rate of recovery from MTBI could not be monitored. Group analyses have therefore only been conducted with participants who did not sustain a MTBI while analyses across individual cases have been carried out with each of the four participants reporting a MTBI.

A one-way repeated measures ANOVA was conducted to compare scores on the SDMT, the Digit Symbol, and the Speed of Comprehension Test across the baseline, midseason, and post-season administrations for the non-MTBI group. The means and standard deviations are presented in Table 26. Based on previous studies the average baseline (preseason) scores were used as comparison data. However, as the paired samples t-test had revealed that scores dropped at the Preseason II assessment rather than improving (i.e., showing a practice effect as noted by Hinton-Bayre, Geffen, & McFarland, 1997), the players best or maximum preseason score was also used to determine any changes against subsequent scores.

When the SDMT average baseline score (M=54.1, SD=9.5) was used to examine changes across all administrations, a significant difference was identified, Wilks'

Lambda=.61, $F(2, 13)=4.23$, $p<.05$, multivariate partial $\eta^2=.39$. However, as seen in Table 26, there was no significant effect identified for the SDMT administrations when the maximum preseason score was used [$M=57.7$, $SD=9.33$, Wilks' Lambda=.90, $F(2, 13)=.70$, $p=.51$, multivariate partial $\eta^2=.10$].

Table 26.

Comparison of non-MTBI group baseline (average and maximum) scores to midseason and post-season scores on psychometric measures.

Test	*Session*	*Baseline* *M (SD)*	*Midseason* *M (SD)*	*Postseason* *M (SD)*	*F*
Symbol Digit Modalities Test	BAVE	54.1 (9.5)	56.7 (9.5)	58.9 (11.3)	4.23*
	BMAX	57.7 (9.3)			.70
Digit Symbol Substitution Test	BAVE	78.1 (13.1)	80.3 (11.1)	92.4 (10.7)	36.25**
	BMAX	82.3 (12.9)			28.05**
Speed of Comprehension Test	BAVE	63.1 (17.6)	69.5 (12.9)	68.9 (15.1)	5.71*
	BMAX	71.8 (19.0)			0.57

Note. BAVE = Averaged Baseline; BMAX = Maximum Baseline
*$p<0.05$, **$p<0.005$

Highly significant differences were identified in relation to the Digit Symbol irrespective of whether the average baseline [$M=78.1$, $SD=13.1$; Wilks Lambda=.17, $F(2, 13)=31.9$, $p<.0005$, multivariate partial $\eta^2=.83$] or maximum preseason score [$M=82.3$, $SD=12.9$; Wilks Lambda=.19, $F(2, 13)=28.0$, $p<.0005$, multivariate partial $\eta^2=.81$] were used. As with the SDMT, significant differences across the test scores of the Speed of Comprehension Test emerged when the average baseline score ($M=63.1$, $SD=17.6$) was employed [Wilks' Lambda=.49, $F(2, 11)=5.71$, $p<.05$, multivariate partial $\eta^2=.51$], with no significant differences identified when the maximum preseason score ($M=71.8$, $SD=19.0$) was used, Wilks' Lambda=.91, $F(2,11)=.57$, $p=.58$, partial $\eta^2=.09$.

10.3 POST-HOC EVALUATIONS OF MTBI CASES

The individual results for those reporting a MTBI are presented in Figures 5, 6, and 7, against the non-MTBI group scores. As the use of average baseline score demonstrated significant improvement for each of the three measures, the highest (maximum) baseline score was used to examine performance in each case. As Figure 5 shows, there is no evidence of any significant improvements in scores on the SDMT for those forming the non-MTBI group.

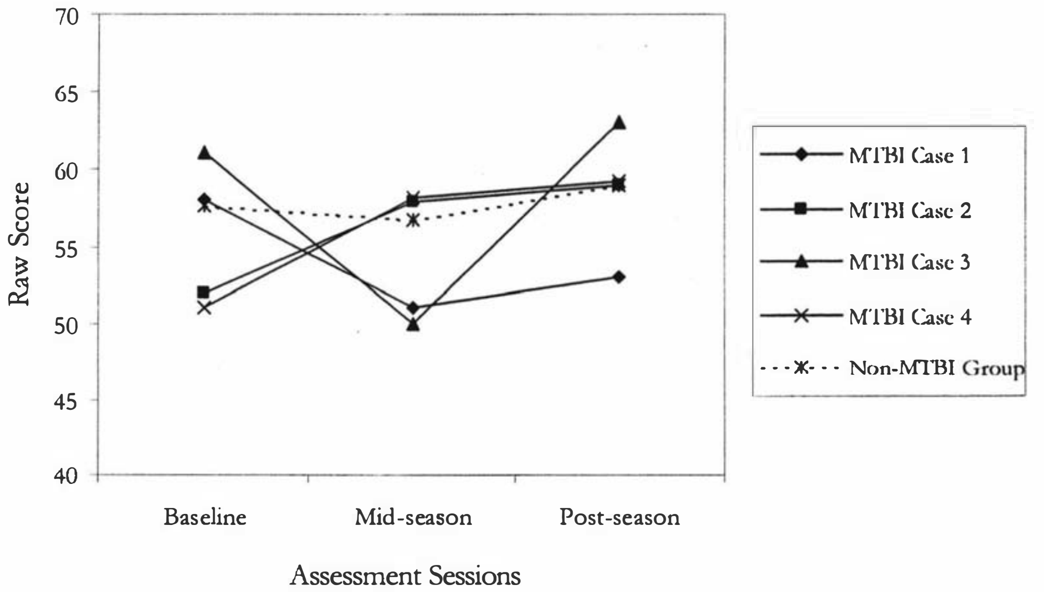

Figure 5. *SDMT Scores at Baseline, Mid-season and Post-season Assessments.*

With respect to individual case scores, there is evidence of improvements in performance from the baseline to mid-season assessment for both Case 2 and Case 4. However, the two remaining cases both show reduced performance at the midseason assessment from that of baseline. For Case 1, SDMT scores post-season improve but not to baseline levels of performance, while after dropping 11 units from baseline to mid-season, post-season scores for Case 3 return to preseason levels.

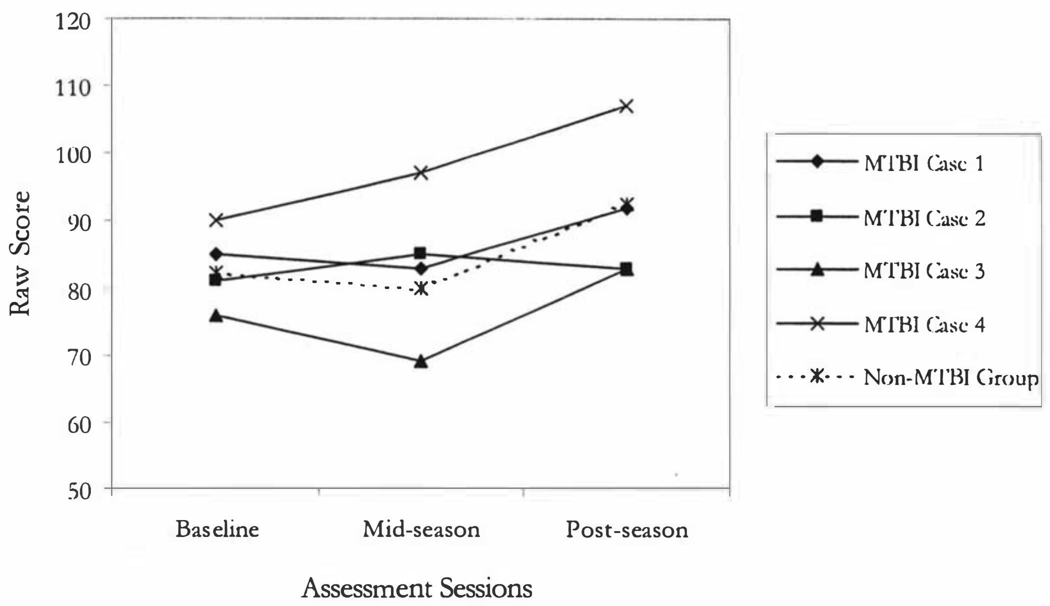

Figure 6. *Digit Symbol Scores at Baseline, Mid-season and Post-season Assessments.*

With respect to performance on the Digit Symbol, Figure 6 illustrates a steady improvement in scores (a significant change) across each of the assessment sessions, which is in part mirrored by Cases 1 and 4, after a small drop (2 symbols) recorded at the mid-season assessment. A larger drop in performance (7 units) is evident at the mid-season assessment for Case 3, with performance post-season exceeding the maximum baseline score. There was very little change in the performance of Case 2, apart from a slight improvement in test score at the midseason assessment. This performance is seen to contrast starkly with the performance of the non-MTBI group and other MTBI cases as it fails to demonstrate an improvement in test score by the post-season assessment.

The performance on the Speed of Comprehension Test is presented in Figure 7. As mentioned earlier, scores from three participants comprising the non-MTBI group were excluded. While a stable performance across assessment sessions is evident for the non-MTBI group (reflecting the non-significant finding), Case 3, and Case 4, more variable test scores are demonstrated for the two remaining cases (Case 1 and Case 2). While Case 2 shows a drop in performance from mid-season to post-season assessment of 9 sentences, more dramatically Case 1 showed a marked drop in score (17 sentences) from baseline, with evidence of some recovery in score (11 sentences) by the post-season assessment.

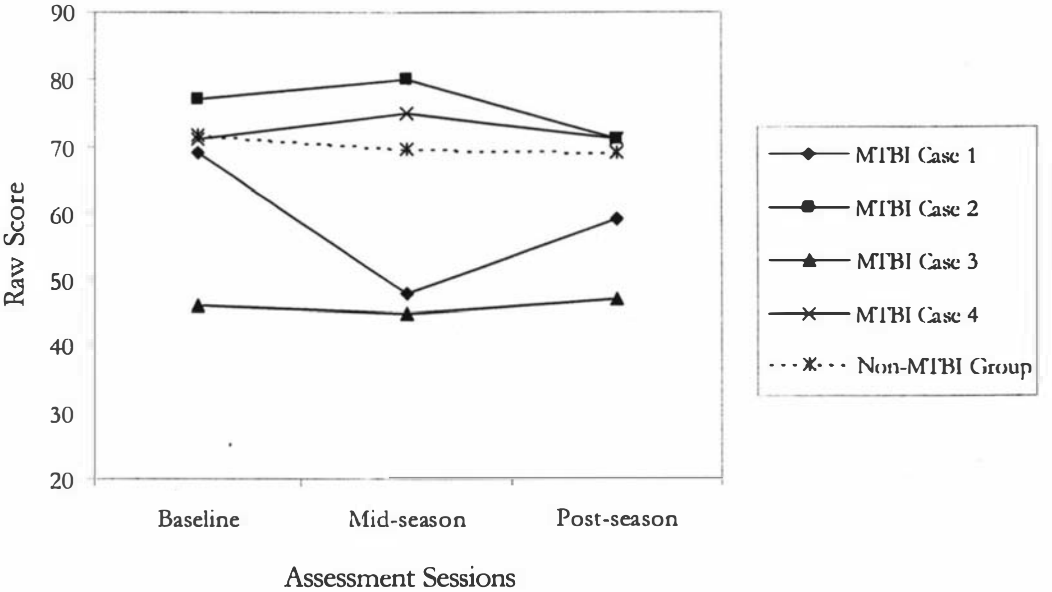

Figure 7. *Speed of Comprehension Test Scores at Baseline, Mid-season and Post-season Assessments.*

CHAPTER ELEVEN

Discussion

The first section of this chapter presents a summary of the findings associated with Phase I of the research, with Section 11.2 reviewing the outcome of the second research phase. Methodological issues encountered by, and limitations of, the current investigation are addressed in Section 11.3, with the final section of this chapter providing an overall summary of the research and recommendations for future investigations.

11.1 PHASE I: QUESTIONNAIRE FINDINGS

For ease of reading, the summarised findings associated with Phase I of the current study are presented, as in previous chapters, under subheadings relevant to the main objectives. The main aims of this particular phase were to identify the: (1) rate of MTBI and its relationship to other injury; (2) severity of MTBI; (3) risk factors (player- and game-related variables) associated with MTBI; (4) frequency of use of protective gear (mouthguards and headgear) and attitudes surrounding their use; (5) level of recognition, assessment and management in relation to MTBI; and (6) adherence to regulations and recommendations within the realm of club grade rugby.

11.1.1 Rate of Brain Injury and Relationship to Other Injury

The rate of MTBI as a proportion of total injuries obtained in the current investigation (14.4%) exceeds that of international rates of concussion for school grade players (1.1% - 12%) and elite/professional players (2.1% - 5.3%)[5]. This figure also exceeds MTBI rates obtained in earlier international investigations involving club grade players (2% - 10%) and rates established from the few national studies conducted to date, incorporating a combination of school and club players (4.5% - 9.1%)[6]. When compared to the other New Zealand studies, the rate of MTBI reported in the present investigation may be higher for a number of reasons. Firstly, previous national studies have been conducted in regions where provincial rugby is strong (e.g., Canterbury and Otago), with teams competing in both the first division (national) and Super 12 (international) competitions. In contrast, the Manawatu provincial side competes only in the third division of the national competition, and on this basis may reflect lower levels of skill, fitness, and/or ability.

Secondly, these studies have predominantly involved a mixture of school and club grade players. As school grade players in this country appear to have a low rate of MTBI (Durie & Munroe, 2000), this is likely to impact on the MTBI rate obtained in these investigations. Thirdly, earlier New Zealand studies have often incorporated women rugby players. As with school grade players, the frequency of injury in women's rugby is significantly lower than in men's (Gerrard et al., 1994), hence affecting the rate of concussion presented in these particular studies. Lastly, unlike the current investigation, analyses conducted by Bird et al. (1998) incorporated only competitive club grades, excluding lower social grade rugby (i.e., Senior II, III, and IV grade teams).

The rate of repeat MTBI in the current study (29.6%) was practically identical to the

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[5] These rate also represent MTBI as a proportion of total injuries

[6] Some caution in making such comparisons across studies is warranted - an issue discussed in 11.3 of this chapter

repeat MTBI rate (30.0%) reported by Bird et al. (1998). As anticipated, players suffering three or more MTBI prior to a season were more susceptible to MTBI within the season than players either having a history of 1 – 2 injuries or no MTBI history at all. Players with a history of concussion were not only more susceptible to MTBI, but were also almost twice as likely to receive a non-MTBI related injury than those not having sustained a concussion.

These results may lend weight to the argument that more injury is suffered after MTBI as a consequence of reduced information processing speed and reaction times, characteristic of concussion. As previous investigations have reported, individuals having sustained one MTBI are four-to-six times more likely to incur another such injury in the future (Kelly & Rosenberg, 1997; Marion, 1999). However, it may also be argued that those players with high rates of MTBI are more overly reckless and hence, injury prone. Aside from these conclusions, some caution interpreting the finding in relation to the non-MTBI related injury is warranted, as the data violated the homogeneity of variance assumption and featured group sizes which could be considered by some (Stevens, 1996) as dissimilar (the non-MTBI group was almost twice as large as the MTBI group). It is therefore important to note that the strength of association between these variables is only moderate.

11.1.2 Severity of Brain Injury

Previous investigations (Sparks, 1985; Dalley et al., 1992) using LOC as an indicator of MTBI have reported rates ranging from 0.4% - 2% of total injuries. The current investigation revealed that MTBI involving a LOC accounted for 3% of total injuries, exceeding that of earlier findings and lending support to the hypothesis that the rate of MTBI involving a LOC would be higher in club grade rugby than rates reported by investigations involving elite/professional or school grade rugby teams. Further, when analysis incorporates those MTBI diagnosed by a medical professional, *moderate* concussion accounts for 3.6% of total injuries. In explaining these results, it is important to consider that in contrast to club grade players, elite players are more likely to use protective gear regularly (i.e., headgear, mouthguards, padding around shoulders), have better conditioned bodies (i.e., strong neck and shoulder muscles), and display a higher level of skill. These factors may ultimately enable high velocity impacts to be better absorbed or inflict less damage. For those in the school grade, such high velocity impacts may be less evident on the basis of physiology, with players at this age not having the same physical stature (i.e., height and weight) with which to generate the same force on impact as their older counterparts. It is also more likely that competition at this level is more strictly controlled, reducing the reckless use of heavy impacts in play.

In their investigation of high-school gridiron players, Gerberich et al. (1983) reported that 2.4% of head trauma received a diagnosis of concussion. However, an additional 16.6% reported a LOC or loss of awareness that escaped diagnosis. In the current investigation, 7.4% of MTBI were diagnosed as concussion, with an additional 13.3% of players reporting a LOC that went undiagnosed. However, unlike the Gerberich et al. (1983) study, the number of MTBI in the present investigation featuring a loss of awareness has not been incorporated into this latter figure. Therefore, in addition to a higher rate of diagnosed MTBI, the present investigation is also likely to have produced a far higher rate of undiagnosed concussion.

One explanation for the fact that a third of *moderate* severity concussions escaped medical attention is that the duration of unconsciousness was brief and therefore was not noted by those monitoring the game. However, the more probable explanation is, that despite being aware of experiencing a LOC, the player himself chose not to seek medical attention. While not all MTBI resulting in a LOC received a diagnosis of concussion, these cases did receive more diagnoses by medical professionals than injuries of a lesser severity.

11.1.3 Player- and Game-Related Variables Associated with Brain Injury

Age and Grade of Player

A higher rate of MTBI in the 16 – 20 year age group found in the present research replicates the findings of earlier studies investigating general injury (Roux et al., 1987; Dalley et al., 1992). This finding may reflect the highly physical play, the continual modeling and realignment of body tissue, and "a misplaced sense of confidence" (Estell et al., 1995; p. 96) in the level of skill characteristic of players in this age group. However, only partial support for the original hypothesis was provided, as differences in the rate of MTBI for those aged 21 – 25 years in comparison to the other age groups were not identified as significant. This outcome may be explained by players in this slightly older age group exhibiting better-developed skills, more controlled play and having more physically mature bodies.

The finding that those under 21 years of age are at greater risk of MTBI is, in part, supported by the trend that Lower Grade players (incorporating Under 21's and Under 19's) were more likely to sustain MTBI than those in the highest ranked teams (i.e., Senior I grade). Unfortunately, this trend was not supported statistically. While this may be attributed to the analysis having insufficient power due to small sample size, it is more likely an outcome of the grouping used in the analysis, i.e., the inclusion of a number of much older players in the Lower Grade category may have effectively negated any significant difference. On the basis of these findings, it would appear that players under 21 years of age are at greater risk of incurring MTBI, irrespective of the grade they compete in.

Player Position

The current research suggests that the risk of incurring a MTBI is significantly greater for forwards than backs. This finding is supported by the outcomes of studies investigating general rugby injury (e.g., Roy, 1974; Sparks, 1985; Dalley et al., 1992; Seward et al., 1993; Wekesa et al., 1996), and is attributed primarily to the forwards role in maneuvers which require increased physical involvement and extra heavy-impact collisions.

In the present study, flankers (a forward position) were the position most likely to incur MTBI, a finding supported by Dalley et al. (1992) who identified flankers to be at greatest risk of injury in general. In the current investigation, a high degree of risk was also associated with three back row positions - first five-eight, second five-eight, and fullback. The position of fullback has previously been reported as being at highest risk of general injury (Davidson, 1987), while Dalley et al. (1992) identified this position as one of two having a high incidence of head injury. The positions least likely to incur MTBI in the current investigation, were the centre (back) and number 8 (forward) positions.

The variability in risk attributed to individual positions by different studies may be accounted for by different styles of play evidenced in different countries. In New Zealand, the emphasis has traditionally been on a more robust forward play, which may account for the higher risk of MTBI both to forwards, and specifically to flankers. Physiology may also account for the reason that flankers, as opposed to front-line forward positions (i.e., hookers and props), may be at greater risk. Front-line forwards tend to be of a heavier build with thicker, shorter necks which may more readily absorb impacts to the head. Flankers, in contrast, tend to be of a slighter build and much taller, hence, their necks may be longer and less able to provide support for impacts to the head. As Dalley et al. (1982) describe, flankers are "generally fast, big men tackling with significant impact" (p. 11). Their greater speed would likely enable them to be involved in more passages of play than that of their shorter, less agile counterparts, which would also increase the frequency of their exposure to risk.

Phase of the Game

Primarily incurred during competition, slightly more cases of MTBI were reported to occur during the second half of the match (41.7%) as opposed to the first half (37.4%).

This finding lends some small support both to the hypothesis that more MTBI would be incurred in the second half of the match, and to the outcomes of earlier investigations reporting rates of second half injury ranging from 55% - 61.7% (Lingard et al., 1976; Dalley et al., 1992; Wekesa et al., 1996). Reasons for this finding may be attributed to fatigue, which players would be more prone to in the second half of a match. However, this finding should be interpreted with some degree of caution since a number of respondents (20.9%) omitted to record the match half in which their injury was sustained.

Phase of Play

In the current study, MTBI was most typically incurred through a player's contact with the body of another player. Not unexpectedly, the tackle was associated with more MTBI (48.8%) than any other phase of play. This finding indicates that MTBI is more likely to be sustained in rugby as a consequence of indirect acceleration/deceleration forces. It has been argued that adult players, in comparison to school grade players, are likely to be more competent tacklers and should therefore be less prone to injury during this maneuver (Clark et al., 1990). However, in the present study, the rate of MTBI as a consequence of tackling is almost identical to the rate of concussion (48%) identified in an investigation of schoolboy rugby as a result of this same phase of play (Roux et al., 1987). It could therefore be argued that the skill level of tackling exhibited by club grade (adult) players within this region is akin to that of school-grade players.

As tackles are responsible for a large number of MTBI it would be logical to assume that back-line players would be highly susceptible to MTBI as their role dictates frequent involvement in tackles. However, support for this assumption was not demonstrated in the present study, as forwards incurred more MTBI than backs. To explain this outcome one must consider the relatively diverse role of the forward player, with 35% of MTBI reported being incurred in rucks/mauls and scrums (phases of play rarely involving back-line players) and 28% of MTBI in tackles accounted for by those in forward positions.

Therefore, in contrast to back-line players, the increased risk to forward players appears to be as a consequence of their almost exclusive involvement in forward play maneuvers and some additional involvement in tackles.

Of the MTBI incurred in tackles, 72% were sustained by back-line players – an outcome which supports both the current hypothesis and earlier findings (Dalley et al., 1982; Bird et al., 1997). As tackles are typically high velocity maneuvers, it was expected that more severe injury would emerge from this phase of play, and as backs were more frequently involved in tackles, they were assumed to be at greater risk of more severe injury (i.e., *moderate* concussion). However, this expectation was not supported by the present study. While reasons for this result are largely unclear, one explanation may relate to environmental factors – more specifically the condition of the ground. Previous research has indicated that when ground conditions are hard, MTBI is more frequent and more severe (Dalley et al., 1982), attributed to the ground being less able to absorb an impact of the head as compared to when it is softer. Accordingly, in drier seasons, not only may the severity of MTBI in general have been higher, but as backs sustained more MTBI through contact with the ground than forwards, they consequently may also have incurred more severe brain injury.

The rate of foul play identified in the current study (12.8%) was found to be lower than the investigations of Bird et al. (1992) involving club grade players (17.4%) and Roux et al. (1987) incorporating schoolboys (32%). However, the rate in the present investigation was higher than that of Dalley et al. (1992), who attributed no head or facial injuries to illegal play. The variability in rates of foul play may be a consequence of the sample group (i.e., club grade vs. school grade), the country in which the research took place (i.e., South Africa vs. New Zealand), or, more likely, the means in which foul play was determined in each investigation. For example, the present investigation considered MTBI arising from being punched or kicked (except if involved in a ruck/maul) as indicative of foul play. Bird et al. (1998) appeared to assess foul play from the perspective of the player (i.e., whether they believed it was foul play or not), while the remaining investigations have failed to describe how foul play was determined.

11.1.4 Use of Protective Gear

As anticipated, those participating in the current study indicated a high rate mouthguard use during competition (87%), with just over a third of players indicating regular use of mouthguards during training. The use of mouthguards in competition exceeds that of previous investigations where rates ranged from 66.4% - 85% (Dalley et al., 1992; Gerrard et al., 1994). While the rate of use reported in the present study appears impressive, it is important to note that this investigation has taken place after the introduction of mandatory laws enforcing mouthguard use during competition, whereas earlier rates were established prior to the formation of such regulations. Theoretically then, the current rate of mouthguard use should reflect a compulsory adoption of mouthguards, that is, 100%.

The reason for the lack of full compliance around mouthguard use may in part be explained by attitudes. In the present study, the vast majority of players (84.8%) believed mouthguards aided in preventing dental injuries, compared to 100% in previous investigations (Stokes & Chapman, 1991; Chapman & Nasser, 1993). It is worth noting that these earlier investigations have been conducted with elite New Zealand rugby players, who are likely to have been well educated as to the benefits of mouthguard use. Fewer players (67.4%) in the current investigation were convinced that mouthguards help prevent concussion, compared to 86.8% of coaches, members of team management and referees. Despite some apparent uncertainty on behalf of players as to the benefits offered by mouthguards, their rate of use eclipses the uncertainty reported. This finding is encouraging in that it demonstrates a reversal of a trend identified in an earlier study in which all players believed mouthguards provided local protection, although approximately one in five players did not wear one (Chapman & Nasser, 1993). The relationship between attitudes and use of mouthguards identified in the current investigation also appears to demonstrate that it is the players who are not aware of the benefits associated with mouthguard use, that are the ones who do not wear them.

As anticipated, club grade players favoured the less expensive mouthguards in contrast to elite/professional rugby players who tend to use expensive custom-made mouthguards. While players appear to be aware of some of the benefits of mouthguard use, and exhibit a high rate of adoption, there seems to be an underlying belief that all mouthguards are 'created equal' – therefore, little value is placed on obtaining the more expensive product. This raises some concern as to the protection afforded to club grade players against MTBI, as custom-made guards, as opposed to their cheaper counterparts, provide maximum safety and protection to a player (Chapman, 1985; Kerr, 1986; Chalmers, 1998).

The regular use of headgear was predictably much lower (28%) than the use of mouthguards. While no difference in headgear use was demonstrated between grades, forwards reported wearing them more than back-line players. This finding probably reflects the view that headgear protects against facial lacerations and the formation of "cauliflower ears" – injuries for which forward players are most susceptible as a consequence of their role in scrums, rucks and mauls.

Contrary to expectations, the majority of players (65.2%) indicated that headgear could prevent concussion. As no sport-specific helmets have been identified as beneficial in sports such as rugby (McCrory et al., 1992), this finding does present as somewhat of a concern, as it may represent a misplaced belief in the effectiveness of headgear to prevent MTBI. In contrast, coaches, team management, and referees appeared more realistic about the benefits of headgear, with only 36.8% believing it could prevent concussion. The use of headgear was found to more frequently reflect a personal choice, providing only partial support to the research hypothesis.

In relation to both mouthguard and headgear use, more players indicated their *reluctance* rather than their *refusal* to play without each piece of protective gear – a finding supporting the assumptions of the current study. This contrasts with previous findings, in which international players stating they would *refuse* to play without a mouthguard outnumbered players indicating their *reluctance* to do so (Stokes & Chapman, 1991; Chapman & Nasser, 1993). Therefore, it appears that club grade rugby players in the current study were more willing to play without protective gear than international players. Interestingly, players from the Lower Grade were significantly more reluctant to play without headgear than Senior I players. While reasons for this finding are unclear, it is thought this trend may reflect an increasing awareness of MTBI, with younger players (found predominantly in the Lower Grade) being more educated about MTBI than their older counterparts.

11.1.5 Levels of Recognition, Assessment and Management

Was Attention Received, When, and Why Not?

As an earlier New Zealand investigation had reported that 95% of concussions incurred by club grade players received medical treatment (Bird et al., 1998), it was anticipated that a similar rate would be evidenced in the current investigation. However, this proved not to be the case, with only 42.9% of MTBI attended to in some capacity – a proportion significantly lower than that identified in the earlier study. According to the findings of the current research, the failure of players to receive attention could be attributed primarily to the injury being considered 'minor' and therefore not deemed worthy of attention. Although this appears to point to a failure of players to appreciate the potential seriousness of MTBI, it is also considered likely to reflect a player's desire to continue their participation in the game, prompting them to downplay the severity of the injury and its associated symptoms.

In considering the findings, *moderate* concussions were identified as being more likely to receive attention than *very mild* to *mild* concussions – a trend anticipated on the basis that those monitoring the game would more easily identify a concussion of *moderate* severity, through either a LOC or an obvious constellation of symptoms. However, concern still remains in relation to the number of MTBI with potentially serious outcomes that appeared to go unrecognised and, therefore, failed to be appropriately managed.

Although more than half of the MTBI recorded escaped attention, of those receiving assistance, the majority (64.4%) obtained it immediately (i.e., during the match). While this finding had been anticipated, it is concerning to note that those having sought medical attention at a later point (i.e., after the match) are likely to have continued their participation in the game whilst injured. Unexpectedly, the current investigation unexpectedly showed that Senior I players, as opposed to Lower Grade players, were more likely to receive attention after the match than during it. This finding could be interpreted to reflect one of two situations: (1) MTBI were not recognised during the match by those monitoring the game; or (2) players did not report MTBI-related symptoms until the completion of the game. While the research demonstrates that both explanations are feasible, the latter situation is considered more likely, with the assumption that persisting symptoms prompt players to seek attention after the match (indicative of a *mild* or *moderate* severity concussion). While this assumption was not investigated in the present study, it does appear that Senior I players are more likely to continue playing after sustaining a MTBI than players in Lower Grades.

Level of Recognition

It had been anticipated that those monitoring Lower Grade teams would be less likely to identify MTBI symptomology than those monitoring Senior I players. However, the opposite appeared to be true, as a greater proportion of MTBI sustained by Lower Grade players received attention in comparison to Senior I players. This outcome may reflect less adequate monitoring of Senior I grade players; however, as with the reason these players are more likely to receive attention after the game, it more probably reflects Senior I players' reluctance to report. As the research has demonstrated, a player competing at this level is less likely to inform others of an injury perhaps because they perceive the injury to be minor. It continues to be a possibility that a player's failure to report is associated with personal cost (i.e., missing the remainder of the game or subsequent games, not wanting to appear soft, etc), despite the fact that the research has failed to endorse these reasons.

As predicted, those involved in club grade rugby were aware that concussion can be sustained with or without a LOC, which reflects that new knowledge regarding the criteria for a diagnosis of concussion has been widely disseminated. In terms of symptom recognition, those monitoring club grade players more frequently identified symptoms such as confusion/disorientation and dizziness/loss of balance as indicative of concussion. Contrary to expectation, the features of headache and memory loss (i.e., amnesia) were less well recognised. This finding does, however, lend support to the research of Maddocks et al. (1995) in which the most common clinical appearances in concussed players were reported to be dazed facial expression and unsteady gait. That the symptoms of confusion/disorientation and dizziness/loss of balance are more easily observed by those on the sideline, is the most likely explanation for these results. Symptoms such as amnesia and headache are less obvious to those monitoring the game, with the identification of such symptoms instead being reliant on the player's willingness to report them.

Who Attended the Injured Player?

Contrary to expectations, both RPQ and AMQ respondents reported that members of team management (including coaches) attended the majority of MTBI incurred, irrespective of grade (i.e., Senior I or Lower Grade). However, as anticipated, Senior I players were more likely than Lower Grade players to receive attention from qualified medical professionals. This may reflect the higher ranking and status of Senior I players, which correspondingly relates to greater concern for their welfare and their need to receive the best possible treatment and care.

The trend for Senior I players to more frequently receive attention from qualified medical professionals did not receive corroboration from AMQ respondents, who instead reported that doctors attended few MTBI. This inconsistency can be readily explained by the fact that doctors generally provide medical assistance at a point after the match (as opposed to during it), hence being unobserved by AMQ respondents.

Not only were *moderate* concussions more likely to receive attention, qualified medical personnel primarily attended to them, while *very mild* to *mild* severity concussions mainly received attention from coaches/team management. While this outcome was anticipated, it is reassuring to know that the assessment and management of *moderate* severity MTBI is likely to have been appropriate. However, as a LOC should not be considered analogous to injury severity in clinical terms, what is less well known is whether the remaining injuries are also appropriately managed. On the basis of these current findings it would appear that a LOC continues to be the standard for which qualified medical attention is deemed warranted.

Level of Competence of Assessor

AMQ respondents having obtained medical or first aid qualifications were found to be: more often in attendance at Senior I level; younger; and; more likely to use the GCS, than those without qualifications. While it would appear that those having received first-aid training are more prolific at Senior I level, it is these players who continue to escape assessment, or if an assessment is carried out, it often takes place after the game. This may indicate that while those with first-aid qualifications may be more evident in Senior I grade, these qualifications may not have translated to skills and knowledge specific to the assessment and management of MTBI. Of some concern is the somewhat limited knowledge regarding the appropriate management of an unconscious player. Only one AMQ respondent indicated knowledge of four of the five steps involved with attending an unconscious player (addressed in Chapter 7), with the majority aware of only two or three steps.

Reporting and Recording

Most respondents believed that the onus of responsibility for monitoring a concussed player should rest on the coach and team management, yet in spite of this, only one third of players indicated that their coach was aware of their MTBI history. This reveals some discrepancy between the sense that coaches should be responsible for monitoring a player having suffered a MTBI, and the reality of the situation.

11.1.6 Adherence to Regulations and Recommendations

Stand-down Observed?

The finding that only 11% of the 128 respondents reporting a MTBI were subject to the 3-week mandatory stand-down period is a very concerning outcome of the current research. This rate is far lower than that of Bird et al. (1998) who reported that 86% of MTBI cases in their investigation were subject to this three-week period of abstinence. This result is even more disturbing when consideration is given to the fact that at least 20% of MTBI involved a LOC, for which a 3-week suspension from play should occur automatically. While it is accepted that many symptoms of MTBI resolve quickly and are relatively innocuous, there is the potential for players with more severe concussion to continue to play before symptoms have resolved. In such situations, the risk of repeat MTBI is high, demonstrated in the current study by the fact that 74% of players reporting two or more MTBI's had never abstained from play, in contrast to the 5.1% of players who indicated the stand-down period was always observed.

In assessing whether the management of MTBI at the club grade level was appropriate, some of the findings generated in response to the relevant hypotheses were unexpected. The majority of those monitoring club grade players (AMQ respondents) reported that they would not return a player to the game if they were symptomatic, whether this was characterised by a player having lost consciousness or experiencing only a headache. This is a reassuring discovery, as it complies with Sports Medicine New Zealand's recommendations advocating a guiding policy of not returning an athlete to play while they are symptomatic. However, a small proportion of respondents still indicated that they would return the player to the game immediately, reflecting a lack of understanding of the potential seriousness of MTBI.

In terms of the period of abstinence that AMQ respondents recommended for a player reporting only a headache, the majority reported that a return to play would be permitted only after the player received medical clearance. Some respondents advocated a 2 – 3 week minimum stand-down period which, on the basis of the presenting symptom, is considered overly-cautious, particularly as most players in these circumstances could be returned to play after medical clearance or one asymptomatic week. For a player experiencing a LOC, the majority of AMQ respondents advocated a 2 – 3 week stand-down period or medical clearance before returning a player to the game. In the absence of a mandatory stand-down period, this could be considered by some standards to be acceptable management for a brief LOC (Maroon, 1999; Cantu, 1986). However, only 44% of respondents suggested the recommended 3-week stand-down period was appropriate, in accordance with the NZRFU directive. When knowledge regarding this directive was further assessed, only 34.2% indicated that a 3-week stand-down should occur in relation to a LOC. There appeared to be less awareness of what is appropriate for a player suffering two concussions involving a LOC during the season, with only 24.1% advocating an abstinence from play for a season – the stand-down period advised by Cantu

(1986). That individuals monitoring players are not more aware of national guidelines for abstinence is a concern, particularly as these are the individuals who have control over a player's ability to return to the field of play. These results indicate that greater education regarding such recommendations is warranted.

Abstinence from the Sport

As anticipated, a small number of players (5.3%) appeared to have ignored the advice of medical professionals to abstain from playing rugby indefinitely. While some players may have misinterpreted this question (i.e., recording having been told not to play rugby indefinitely, yet having only been advised to abstain from play for a season), it is likely that others had chosen to continue their participation in the sport, despite the potential for more catastrophic outcomes. This again may be reflective of a dearth of education surrounding MTBI directed at the level of the players, and signals a lack of appreciation for its potential implications. It may also reflect a naïve 'it won't happen to me' attitude. Such attitudes are likely to be maintained by the fact that catastrophic outcomes stemming from multiple MTBI are rarely publicised unless they have contributed to a death.

11.2 PHASE II – NEUROPSYCHOLOGICAL ASSESSMENT

It is important to highlight that as a consequence of the serious problems associated with non-response during this phase of the research, the results have been interpreted with caution. Hence, the discussion pertaining to these findings is largely speculative.

Examination of the effect of practice associated with each of the assessment measures produced mixed findings. While SDMT scores across the two pre-season assessments did not alter significantly, replicating earlier findings (Hinton-Bayre et al., 1996), scores on both the Digit Symbol and Speed of Comprehension tests decreased significantly by an average of 6.3 symbols and 14.2 sentences, respectively. Although no increase in scores were evident across the baseline assessments, with decreases in scores instead noted for two of the three measures, it cannot be stated with any degree of certainty that there was no effect of practice. The decrement in test scores could be attributed to the difficulties encountered with the less-than-ideal circumstances under which the tests were administered. The group assessment format meant that adherence by participants to the test instructions could not be as strictly monitored as it would have been in an individual assessment. Hence, some participants may have taken longer than allowed to complete the first administration, with better adherence to time with the second, which would account for the decrease in scores. Scores on the Spot-the-Word test did not alter significantly as a consequence of repeated administration, replicating the findings of the 1996 Hinton-Bayre study. The ability of this measure to produce stable scores across time, irrespective of MTBI, is attributed to the measures' reliance on semantic knowledge.

The present study revealed no significant difference in performance across time for both the SDMT and Speed of Comprehension Test when the highest pre-season score was used as a baseline, while a significant difference in performance for all three measures was noted when the average preseason scores were used. On the basis of these findings, it is advocated that the highest pre-season score (an indicator of best performance) should be adopted as the baseline figure against which subsequent assessment scores should be compared – a recommendation previously endorsed by Hinton-Bayre et al. in their 1999 investigation. That the Digit Symbol produced changes across time irrespective of the baseline figure used (i.e., highest or average pre-season score) is most likely explained by the less-than-ideal conditions in which testing occurred (addressed in Section 11.3). An alternative, although less plausible explanation on the basis of previous research findings, is the possibility that the alternate forms used were not equivalent – an issue not investigated by the present study.

The rate of recovery after MTBI could not be assessed due to the failure of four participants to report their injuries during the course of the season. However, some tentative observations may be made regarding the test performance of each of the four individuals sustaining a MTBI. While the timing of each MTBI is unknown, it could be estimated on the basis of test performance across each assessment session. For example, Case 1 may have sustained his injury prior to the mid-season assessment, as reduced performance (below maximum baseline figures) is evident at the mid-season assessment for SDMT and Sentence Completion. While improvements are noted post-season, they do not return to baseline levels. Case 3 showed quite dramatic drops in SDMT and Digit Symbol scores at mid-season assessment, and on this basis it could be assumed, like Case 1, that a MTBI was suffered prior to the mid-season assessment. What is more interesting with this case is the very low performance on the Speed of Comprehension Test evident across all three assessment sessions. This may reflect the test's sensitivity to MTBI, as this participant report's a history of 3 – 5 MTBI's in addition to suffering 3 MTBI's during the course of the season. Speed of Comprehension Test scores may therefore be indicative of persisting neuropsychological deficits from injuries suffered prior to assessment, as the participant's low performance on this task does not appear to stem from reading-related difficulties (seven years tertiary education).

Scores obtained by Cases 2 and 4 could allow for conjecture as to the severity of injury as the test scores do not appear to show any decrement in performance across time. Rather, an improvement is shown from baseline with most scores. These may therefore be indicative of *very mild* concussive injuries, in which no neuropsychological deficits were suffered.

Again, it is important to highlight that the observations made in relation to these latter findings are merely tentative assumptions as to the timing and severity of injury. As a consequence, not too much emphasis can be placed on the information drawn from these few individual cases.

11.3 METHODOLOGICAL ISSUES AND LIMITATIONS

Research conducted in the area of sports-related brain injury has methodological difficulties akin to aspects of other areas of brain injury research. However, some problems are also unique to this area. Methodological issues and limitations prominent in the current study pertain to retrospective design, terminology use and severity classifications, the collection of data, and data analysis.

Retrospective Research

One of the most fundamental methodological problems plaguing sport-related brain injury research is that it is often retrospective in nature. As such, the accuracy of the data produced may be questioned on the basis that rates of injury may be either over-reported, as a consequence of respondents embellishing instances of injury, or under-reported, as less severe injuries are often ignored and are easily forgotten. In terms of the current study, presentation of an under-reported rate of MTBI rather than an inflated one is considered the most probable in relation to the RPQ data. This assumption is supported in part by the subtlety of symptomology characteristic of MTBI, but also by players' reluctance to report (addressed later in this section). Use of a retrospective design has also restricted valid comparisons of the data obtained with other investigations employing alternative designs. As Thurman et al. (1998) highlight, this issue is one inherent to sport-related research given the lack of consistent definition and diversity of data collection methods employed - an issue unlikely to be rectified until universal definitions and research designs are consistently adopted. In spite of these issues, support for the relative accuracy of the data collected by this investigation is demonstrated through comparison with another 'like' study (i.e., Gerrard et al., 1994). The latter investigation revealed that 5% of injuries 'coming to medical attention' were concussions – a rate not dissimilar to that identified in the present study (6.2%).

The retrospective nature of the RPQ may also have produced inaccurate information pertinent to the circumstances surrounding MTBI. While players were given the option of indicating their uncertainty about the phase of play, manner of receipt, and factors associated with their injury being attended to, there is the possibility that there were inaccuracies in reporting. This may in part be a consequence of players having to recall injuries sustained during the previous 6 – 8 months, but also may be attributed to the symptomatic features of MTBI, as amnesia, confusion and disorientation are likely to influence players' recollection of the events surrounding their injury.

Terminology Use and Classifications of Severity

The inconsistent and interchangeable use of terms and definitions associated with concussion/MTBI is rife within brain injury research (an issue more extensively addressed in Chapter 2). To encourage players to consider all injuries suffered to the region of the head, the term *head injury* was used throughout the research, although an accepted definition of concussion accompanied the term to ensure MTBI criteria was met. The drawback of this was evident when making comparisons with the previous research literature, as many investigations have neglected to employ a specific concussion definition and instead have used abstinence from play or receipt of medical attention as indicators of 'injury'.

Had the current investigation instead used 'receipt of medical attention' as the criterion for injury, a number of cases of MTBI would have been excluded, as demonstrated by the present findings. While it could be argued that the receipt of medical attention may have excluded those innocuous MTBI's posing no serious risk to the player, were this argument correct, all injuries involving a LOC (a *moderate* concussion) would have received attention. However, the current investigation produced evidence to the contrary, with more than a third of *moderate* severity concussions failing to receive attention. In terms of obtaining a true incidence rate, this observation lends support to the use of a specific definition for concussion as opposed to the 'injury' definitions employed in earlier investigations.

The classification of injury severity also posed some difficulties for the present study. While a LOC or diagnosis of concussion could be readily classified as a *moderate* concussion, the absence of information regarding PTA duration means that injuries of a *moderate* severity occurring without a LOC or diagnosis may have been overlooked. Injuries of *very mild* severity have also been more easily distinguished from those MTBI classified as being *very mild – mild* or *mild*, with the distinction between the two latter categories being somewhat ambiguous. In addition, symptoms were not recorded for each case of MTBI reported by a player, rather they were recorded collectively. Consequently, some injuries may have been categorised as either more or less severe than they actually were. While there is a need for caution in interpreting the findings, the classification system employed in this investigation has been of value, enabling *moderate* and *very mild* to *mild* concussions to be distinguished.

By not adopting a standard definition of 'injury' (as employed in previous studies) to establish the frequency of non-MTBI related injury, the research has more likely captured very mild and recurring injuries in addition to those injuries involving an abstinence from play or receipt of medical attention. This assumption is supported by differences in the rate of defined 'injury' (n=222) and undefined 'injury' (n=607) as established by the 2000 RPQ, and that the total number of injuries reported in the present investigation (n=1,448) is more than double that identified by Bird et al. (n=602) despite similar sample numbers. Failure to use a recognised definition of 'injury' has meant that comparison with other investigations is somewhat limited. However, as data have been obtained in relation to *very mild* MTBI, for the purposes of presenting the rate of MTBI, it is considered appropriate that a definition of 'injury' encapsulating general injuries of equivalent severity be adopted.

Issues of Data Collection

It may be argued that threats to the reliability of Phase I of this investigation pertain to inconsistencies in the construction of the RPQ. However, while consecutive versions were slightly different, the alterations involved only the addition of extra questions or such minor (cosmetic) alterations in wording as to make no difference in the quality of data collected on each administration. As such, these changes were not considered to have compromised the quality of the data collected.

Problems inherent in the AMQ relate to the inclusion of two potentially loaded questions. The first asked whether the respondent believed a LOC was required for a diagnosis of concussion and the second related to the presentation of the orientation questions (see Appendix D) which featured only two sets of answers and the option to choose both or neither. As a consequence of the way these questions were posed, respondents may have unwittingly been directed to the 'correct' answer (i.e., 'yes' to the first question and 'both' for the second).

Issues relating to the assessment and management of MTBI may have been better examined by way of an interview, as the information sought was not always elicited by the AMQ. While an interview may have been less appropriate in terms of time, this format would have encouraged respondents to express their opinions in more depth. It also would have enabled the researcher to obtain more accurate information regarding assessment procedures by ensuring that respondents were not guided by potentially loaded questions or that they did not access resources to aid their answers.

External factors beyond the researcher's control impacted on the data collection process. Inconsistencies emerged in the way data was collected for Phase I of the research, which was unexpectedly influenced by the time of the season. For example, the first RPQ was administered during pre-season training (summer), so questionnaires could be administered on the training fields in the presence of the researcher. However, subsequent RPQ administrations took place at the end of the season (winter), where poor lighting and wet weather conditions meant questionnaires could only be completed in the presence of the researcher if clubrooms or changing rooms were available. Alternative methods of distribution had to be devised. In an effort to offset the impact of the time of season and the difficulties encountered in obtaining participants, the third RPQ was mailed to potential respondents rather than administered in person. As a result the latter sample may not have been entirely representative of the earlier participant groups. Therefore, some degree of conservatism is required when interpreting the results. With respect to Phase II, conditions under which assessments were conducted were far from ideal. Testing generally took place in team changing rooms and in large groups in which talking, glancing at the performance of neighbours, and adherence to test instructions (i.e., starting and stopping when required) was often difficult to monitor.

Missing data errors, where a participant "refuses to participate, cannot be located, or fails to answer all the questions" (Hyllegard, Mood, & Morrow, 1996; p. 207), was a problem in both phases of the current investigation. With respect to Phase I, respondents were often not in the researcher's presence and as a consequence questions were not always answered. There was also a very low rate of return of questionnaires distributed via post. While a generally accepted return rate for research employing this method is around 75% (Goodwin, 1995), for the distribution of the third RPQ the rate of return was less than 25%.

Phase II of the current investigation also encountered problems in relation to missing data. The rate of drop-out from the study was high, attributed to players relocating to different clubs, changing grades, or failing to turn up to practice. The latter was more evident after the mid-season assessment when players' motivation to attend practices appeared to diminish as a consequence of poor weather conditions or a failure to make club grade finals. Players' (and coaches) reluctance to continue participating in the second phase of the research also became more evident prior to the mid-season assessment.

While the research received the full support and commitment from the MRFU and the NZRFU, one of the biggest initial obstacles to the study was the attitudes held by some of those involved in club grade rugby. The attitudes of management and coaches played an important role in obtaining participants for both phases of the research, with those teams electing to participate appearing to have taken a proactive stance with respect to injury prevention. This commitment to injury prevention may have implications for the data collected, with the rate of MTBI obtained in the current study perhaps not being reflective of clubs where injury prevention is not a priority.

While club management and coaches may be committed to injury prevention, this stance did not always appear to be supported by the players, exemplified primarily by a reluctance to report. This situation is clearly evident in Phase II of the research, where despite being given clear instructions about reporting any symptoms associated with MTBI, participants failed to do so. Players are often only prepared to report MTBI symptomology when there can be no threat of repercussion - in this particular instance, where no stand-down period could be enforced. Such a phenomenon exemplifies the impact of the rugby culture on players willingness to report – a culture where players are typically applauded for their 'staunchness' or strength in the face of injury.

Electing to rely on participants reporting MTBI to those involved in monitoring the players may have contributed to player's reluctance to report. While a more effective method may have involved the researcher making contact with each participant after a match, this may have been construed as badgering, and as such the potential for damage to rapport was high. In retrospect, this method would have been unlikely to have altered the participants' willingness to report.

Analysis of Data

With respect to analyses associated with Phase I, inconsistencies inherent in the RPQ format meant certain research questions could not be answered. These inconsistencies relate to the use of some questions which engendered responses specific to each case of MTBI incurred by the respondent, while others required an answer based on the player's collective experiences. This decision had been made in the interests of brevity and simplicity. For example, the symptoms experienced in relation to MTBI were recorded collectively, as was the point at which attention was received ('How many were attended during the game?'), and whether the stand-down period was observed ('Was the stand-down period observed for all *head injuries* sustained during the season?'). As a consequence, in situations where more than one MTBI was reported, the experience of each case of MTBI in relation to these particular variables could not be distinguished.

Of some concern is that a few analyses in Phase I involved unequal group sizes, increasing the risk of Type I error (i.e., rejecting the null hypothesis when in fact it should be accepted). While *t*-tests conducted under these circumstances used the appropriate statistic (i.e., equal variances not assumed), there is the possibility that some results may be subject to this error. Small effect sizes may have contributed to the non-significant findings produced by some analyses in the first phase of the research. This situation may have been avoided had a larger sample size been obtained, enabling sufficient power to detect whether a relationship actually existed between the variables under investigation.

With respect to Phase II of the research, the analyses resulting in non-significant findings may also be attributed to insufficient power. Small numbers of participants sustaining a MTBI meant that group analyses could not be conducted. Non-MTBI and MTBI participants could also not matched (for age, years of education, premorbid intelligence) as a consequence of this small sample size. Additionally, the choice not to counterbalance the alternate forms of each measure at each administration, as in previous investigations, has weakened the ability of the research to comment on the equivalence of these forms.

11.4 GENERAL CONCLUSIONS

The findings of this investigation may be presented in a number of ways to allow for comparisons with previous research. If based on the definition adopted by the current study, MTBI accounted for 14.4% of total injury. If defined as 'injury' in the way this term is ascribed in much sport-related research (i.e., anything receiving medical attention), MTBI accounts for 6.2% of total injury, and if incorporating only those resulting in a LOC, the rate of MTBI is 3%. However, while the rate of MTBI exhibited within this club rugby sample is noticeably higher when compared to school and elite/professional teams, on the basis of earlier discussion, some caution in generalising from these findings is warranted.

Clear risk factors have been isolated by the current investigation, with younger players (16 – 20 years of age) and forwards, particularly flankers, being at greatest risk of MTBI. The tackle accounts for the majority of MTBI, ultimately as a consequence of the high velocity impact generated when contact is made with the body of an oncoming player. Back-line players are most at risk of incurring MTBI in this manner. In the present study, foul play accounted for a relatively small proportion of MTBI, which may reflect the successful enforcement of penalties for such infringements by referees. With respect to indicators of MTBI, dizziness and headache were the most frequently reported symptoms in the current investigation. However, for those monitoring the sport, dizziness and confusion were the two symptoms most commonly recognised. While this may highlight the subjective experience of players not realising that they are confused, it also reflects what those monitoring the players commonly observe. This disparity between what is being experienced and what is being observed may prove troublesome in terms of accurate diagnosis.

An important and concerning outcome of the research is the identification of the low rate of attendance afforded to MTBI, with less than half the MTBI reported in the current investigation receiving some form of medical attention. While it could be argued that this reflects the benign nature of the concussions reported, the results of the present study indicate that there is a proportion of MTBI escaping attention that have the potential for more serious outcomes. The limited attention afforded players at this level may also account for the high rate of repeat MTBI evidenced in this research, effectively enabling players to continue their participation in the sport whilst their performance is impaired, subsequently resulting in re-injury.

While those monitoring Senior I players appear better qualified to deal with MTBI in contrast to the Lower Grades, it is disconcerting to find that Senior I players receive less attention when such an injury occurs. This may be attributed to the subtlety of MTBI symptomology, although more probably reflects a reluctance to report on behalf of the player. Less likely, although possible, is the reluctance of coaches/team management to remove the player from the game, particularly as the level of competitiveness is much higher at Senior I grade. The reluctance to report may also account for attention being received at a later point in more Senior I cases of MTBI than Lower Grade cases. Such a scenario also highlights the potential severity of the injury suffered, with symptoms forcing a player to seek attention at the conclusion of the match more likely indicative of a *moderate* severity injury than a *very mild* one.

To date, the NZRFU have introduced two interventions, in the form of mandatory regulations, in an attempt to reduce the risk of MTBI to players. The first intervention deals with the management of MTBI, as evidenced by the enforcement of a 3-week mandatory exclusion period after a concussion (featuring a LOC). The low rate of adherence to this stand-down period identified in the present study is particularly concerning and likely reflects a combination of three scenarios: (1) the enforcement of regulations by those monitoring club grade players is somewhat lax on the basis that those monitoring appear to be unaware of national body directives and recommendations; (2) players are reluctant to report in order to avoid a stand-down period; and (3) injury prevention in relation to MTBI is not given sufficient priority.

The second intervention relates to the mandatory use of mouthguards, in which a player failing to produce a mouthguard prior to the commencement of a match is prohibited from playing. On the basis of this regulation, it was expected that 100% of players in the current study would use mouthguards; however, this was not the case. Contrary to the attitudes of elite/professional players, the degree of skepticism regarding the utility of mouthguards to prevent concussion and players willingness to play without mouthguards evidence in this research, may account for the lack of total compliance. Greater vigilance and harsher enforcement of this mandatory regulation on behalf of referees and coaches should see a corresponding increase in the frequency of mouthguard use during competition. Concern has also emerged in relation to the quality of the mouthguards used at this level of rugby, as this may be a contributing factor to this investigation's high rate of MTBI.

Future initiatives recommended to reduce the rate of MTBI evidenced at the club level relate primarily to education. The most cost-effective means of disseminating the information arising from this investigation is considered to be via injury prevention seminars and ACC generated pamphlets. These methods should target issues specifically surrounding MTBI, such as the identified risk factors, potential adverse outcomes, proven protective factors (i.e., use of mouthguards, strengthening of neck muscles), and the clarification of contentious issues (e.g., the efficacy of headgear, quality of mouthguards, abstinence from play). The problem of players' reluctance to report should also be broached in order to help dispel fears associated with the reporting of MTBI. Such initiatives should be directed both at players and at those whose role requires them to monitor club rugby players.

On the basis of the research findings, it is also advised that attendance at first-aid training should become compulsory for those monitoring club rugby players, with a focus on accurate assessment of MTBI and appropriate management of those with more severe outcomes (i.e., loss of consciousness). Further, those who regularly conduct assessments at this level (i.e., team physiotherapists and medical personnel) should employ a standardised sideline assessment procedure, such as the SAC or SCC, to ensure consistent practice when tending a concussed player. While such a recommendation is acknowledged as being somewhat more ambitious, it is considered a potentially achievable initiative if both regional- and national-body support could be harnessed.

With the current investigation failed both to monitor recovery from MTBI and to clarify the appropriateness of the neuropsychological measures for the specific population, further research at the club level is considered important. The incorporation of such measures into standard assessment practice has the potential to provide a cost-effective means of ensuring more accurate assessment and safer practice in terms of injury management. Essentially these brief measures would enable persisting deficits to be monitored and indicate when more extensive neuropsychological assessment should be carried out prior to a player's return to the sport. As funding and resources for players at this level of competition is not considered sufficient to allow for testing of all players prior to the season, research to establish baseline data is strongly advised. Similar investigations have already been conducted with ARF players (Maddocks, Saling, & Dicker, 1995), which as a consequence of the normative data established, allow testing to take place only after a MTBI has been incurred.

A number of methodological difficulties impacted on the present investigation, of which those relating to the collection of data proved the most problematic. For example, the failure of Phase II to accomplish its main objective (i.e., to monitor the rate of recovery from MTBI) was hindered primarily by the reluctance of players to report. This is an issue of major concern, and should not only be targeted in future injury prevention initiatives, but should also receive careful consideration prior to conducting research in the area. As recent research is largely prospective in nature and reliant on those coming to medical attention, the impact of an athlete's reluctance to report cannot be fully appreciated. Failure to report (and hence receive medical attention) poses a very serious problem in that it obscures the true rate of injury. While the retrospective design employed in the current study has been able to identify this as an issue, future use of such a design within this particular setting would not be advised. A better estimate of injury incidence may be achieved when the athlete feels confident that reporting will not engender any perceived adverse consequences (e.g. a stand-down period).

While larger scale prospective studies have been conducted with mixed school and club grade samples, research incorporating such a design to focus specifically on MTBI in the club grade is recommended. However, aside from considering the reluctance to report issue, the potential difficulties associated with conducting a prospective study with a club grade population are imperative to acknowledge. The relatively unstructured nature of club rugby contrasts in particular to that of elite/professional rugby, introducing new threats to the accuracy and completeness of the data collected. Many of these more unique issues (failure to attend practices, freedom to play for different grades, versatility regarding player position) have been evident in the present investigation, compromising the reliability and validity of the findings. More rigorous monitoring of players during the course of the season would also be advised, rather than a heavy reliance on those involved with monitoring the players. In order to address these issues, it is anticipated that any future investigation would need to be undertaken on a far larger scale, much like that of Bird et al's. (1995). Therefore, prerequisites would need to include increased financial support and access to resources, in addition to engendering greater support from all those involved, of which the greatest challenge is to obtain support from the players.

Additional directions for future research include the incorporation of women rugby samples in order to contrast the injury profiles and risk factors associated with gender. Also worth investigating is whether injury rates differ within those clubs that are more proactive in relation to injury prevention (as indicated by general attitude, carrying out injury prevention seminars, adopting appropriate injury management strategies, keeping an injury log, etc.) than those who are not.

Conducting research in this area is associated with considerable methodological challenges. Despite this, the present study has, unlike others, provided information specific to the rate and circumstances surrounding MTBI, establishing new insights and areas of concern and in some cases helping to clarify previously equivocal results. As a consequence, it has highlighted difficulties that need to be considered for future research and has provided a stepping stone from which further investigations can be based. More importantly, the findings, in many respects, stress the need for improved education and awareness in this population regarding MTBI, and bring to light the need for greater vigilance on behalf of the players and those monitoring the game.

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APPENDICES

APPENDIX A

Journal Article

APPENDIX B – D

Phase I: Questionnaires

RUGBY PLAYERS QUESTIONNAIRE (RPQ)

The following questions apply solely to *club grade rugby* and mainly relate to the *1998 season* unless stated otherwise. *Your answers are strictly confidential and will have no bearing on your future availability to play.*

1. **Surname:** ____________________

2. **First Name:** ____________________

3. **Your Age:** ________

4. **Are you:** Male ☐ Female ☐

5. **What rugby club do you currently play for?**

____

6. **Please state approximately how many years you have played club-grade:**

____

7. **What grade did you mainly play during the 1998 season? *(Tick one box only)***

Senior A ☐ Senior B ☐
Senior 3rds ☐ Women's ☐
Under 21's ☐ Under 19's ☐
Please specify other ____________________

8. **What position did you mainly play during the 1998 season? *(Tick one box only)***

Prop ☐ Hooker ☐ Lock ☐
Flanker ☐ Number 8 ☐ Halfback ☐
1st Five ☐ Wing ☐ 2nd Five ☐
Center ☐ Fullback ☐

9. **Did you wear headgear during the 1998 season?**

Always ☐ Sometimes ☐ Never ☐

10. **Did you wear a mouthguard during training sessions in the 1998 season?**

Always ☐ Sometimes ☐ Never ☐

11. **Did you wear a mouthguard during competition games in the 1998 season?**

Always ☐ Sometimes ☐ Never ☐

*For the purpose of this survey a head injury is any **injury to the head resulting in at least dizziness, disturbed vision, confusion and/or a loss of consciousness (a blackout).** Please apply this definition to the following questions.*

12. **Please circle approximately how many head injuries you received playing club-grade rugby before the 1998 season.**

None 1-2 3-5 6-8 9-12 13-15 15+

13. **Please circle the number of head injuries you received during the 1998 season.**

None 1 2 3 4 or more

If you did not sustain a head injury during the 1998 season please go to Question 25 over the page.

The following questions are for those who have sustained a head injury according to the definition provided. These questions apply to the 1998 season only.

14. **Of the head injuries you received how many occurred during: *(Place the relevant number in the box)***

Training ☐ Competition ☐ Not Sure ☐

For Questions 15 – 19 list your first head injury of the season as Injury 1, your second as Injury 2 and so on. If you received more than five head injuries, report the last five of the season.

15. **If you lost consciousness when you received your head injury place a tick in the relevant box. *If you did not lose consciousness or are not sure leave the box blank.***

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐
Injury 4 ☐ Injury 5 ☐

16. **Place in the box the letter that corresponds to the phase of the game you received your head injury(s).**

A = 1st Half B = 2nd Half
C = Training D = Not sure

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐
Injury 4 ☐ Injury 5 ☐

17. Place in the box the letter that corresponds to the phase of play you were involved in when you received your head injury(s).

A = Scrum B = Lineout C = Tackle
D = Ruck/Maul E = Other F = Not sure

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

18. Place in the box the letter that corresponds to the way you received your head injury(s)

A = Contact with ground
B = Contact with body of another player(s)
C = Punched D = Kicked
E = Other F = Not sure

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

19. Place in the box the letter(s) that correspond with the person(s) who attended to your head injury(s).

A = Doctor B = Coach/Team Official
C = Referee D = St. Johns
E = Other F = No Attention Received

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

(If you received no attention for your head injury(s) please go to Question 21).

Question 20 relates to where your head injury(s) first received attention.

20. How many were first attended to on the field during the game/training? ☐

How many head injuries were first attended to on completion of the game/training:

(a). At the rugby grounds? ☐

(b). At a doctor's surgery or hospital? ☐

21. Tick as many of the symptoms listed below that you experienced after your head injury(s).

Dizziness ☐ Headache ☐ Blurred vision ☐

Irritability ☐ Nausea ☐ Poor memory ☐

Difficulty/inability to concentrate ☐ Tiredness

Other ______________________ (Please list)

22. Do you still experience some of these symptoms?

Yes ☐ No ☐

If you ticked 'Yes' here, place another tick next to the symptoms you still experience (listed in Question 21).

23. How many of the head injuries you received during the 1998 season were diagnosed as concussion by a medical professional?

(Please record the number in the box) ☐

24. Was the recommended three-week stand-down observed for the head injury(s) you sustained?

Always ☐ Sometimes ☐ Never ☐

25. If you have sustained previous head injuries in club-grade rugby is your current coach aware of them?
(If you have never received a head injury go to Question 27).

Yes ☐ No ☐ Don't Know ☐

26. Have you ever been advised not to play rugby by a medical practitioner or neurologist due to head injury?

Yes ☐ No ☐

27. During the 1998 rugby season approximately how many injuries did you receive in the following areas?
(Place the number in the relevant box).

Knee ☐ Ankle ☐ Shoulder ☐

Chest ☐ Back ☐ Thigh ☐

Leg ☐ Foot/Toe ☐ Wrist ☐

Hand/Finger ☐ Hip/pelvis/groin ☐

Thanks for your participation in this survey.
Your time and effort is greatly appreciated.

RUGBY PLAYERS QUESTIONNAIRE (RPQ)

The following questions apply solely to *club grade rugby* and mainly relate to the *1999 season* unless stated otherwise. *Your answers are strictly confidential and will have no bearing on your future availability to play.*

1. **Surname:** ______________________

2. **First Name:** ______________________

3. **Your Age:** ________

4. **Are you:** Male ☐ Female ☐

5. **What rugby club do you currently play for?**

____

6. **Approximately how many years you have played club-grade rugby (not school grade)?**

____

7. **What grade did you mainly play during the 1999 season?** ***(Tick one box only)***

Senior A ☐ Senior B ☐
Senior 3rds ☐ Women's ☐
Under 21's ☐ Under 19's ☐
Please specify other ______________________

8. **What position did you mainly play during the 1999 season?** ***(Tick one box only)***

Prop ☐ Hooker ☐ Lock ☐
Flanker ☐ Number 8 ☐ Halfback ☐
1st Five ☐ Wing ☐ 2nd Five ☐
Center ☐ Fullback ☐

9. **Did you wear headgear during the 1999 season?**

Always ☐ Sometimes ☐ Never ☐

10. **Did you wear a mouthguard during training sessions in the 1999 season?**

Always ☐ Sometimes ☐ Never ☐

11. **Did you wear a mouthguard during competition games in the 1999 season?**

Always ☐ Sometimes ☐ Never ☐

For the purpose of this survey a head injury is any injury to the head resulting in at least dizziness, disturbed vision, confusion and/or a loss of consciousness (a blackout). Please apply this definition to the following questions.

12. **Please circle approximately how many head injuries you received playing club-grade rugby before the 1999 season.**

None 1-2 3-5 6-8 9-12 13-15 15+

13. **Please circle the number of head injuries you received during the 1999 season.**

None 1 2 3 4 or more

If you did not sustain a head injury during the 1999 season please go to Question 25 over the page.

The following questions are for those who sustained a head injury according to the definition provided. These questions apply to the 1999 season only.

14. **Of the head injuries you received how many occurred during:**
(Place the relevant number in the box)

Training ☐ Competition ☐ Not Sure ☐

For Questions 15 – 19 list your* first head injury *of the season as* Injury 1, *your* second *as* Injury 2 *and so on. If you received more than five head injuries, report the last five of the season.

15. **If you lost consciousness when you received your head injury place a tick in the relevant box. *If you did not lose consciousness or are not sure leave the box blank.***

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐
Injury 4 ☐ Injury 5 ☐

16. **Place in the box the letter that corresponds to the phase of the game you received your head injury(s).**

A = 1st Half **B = 2nd Half**
C = Training **D = Not sure**

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐
Injury 4 ☐ Injury 5 ☐

17. Place in the box the letter that corresponds to the phase of play you were involved in when you received your head injury(s).

A = Scrum **B = Lineout** **C = Tackle**
D = Ruck/Maul **E = Other** **F = Not sure**

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

18. Place in the box the letter that corresponds to the way you received your head injury

A = Contact with ground
B = Contact with body of another player(s)
C = Punched **D = Kicked**
E = Other **F = Not sure**

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

19. Place in the box the letter that correspond with the person(s) who attended to your head injury

A = Doctor **B = Coach/Team Official**
C = Referee **D = St. Johns**
E = Other **F = No Attention Received**

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

(If you received no attention for your head injury(s) please go to Question 21).

Question 20 relates to where your head injury(s) first received attention.

20. How many were first attended to on the field during the game/training? ☐

How many head injuries were first attended to on completion of the game/training:

(a). At the rugby grounds? ☐

(b). At a doctor's surgery or hospital? ☐

21. Tick as many of the symptoms listed below that you experienced after your head injury(s).

Dizziness ☐ Headache ☐ Tiredness ☐

Irritability ☐ Nausea ☐ Poor memory ☐

Difficulty/inability to concentrate ☐ Blurred vision ☐

Other ______________________ (Please list)

22. Do you still experience some of these symptoms?

Yes ☐ No ☐

If you ticked 'Yes' here, place another tick next to the symptoms you still experience (listed in Question 21).

23. How many of the head injuries you received during the 1999 season were diagnosed as concussion by a *medical professional*?

(Please record the number in the box) ☐

24. Was the recommended three-week stand-down observed for the head injury(s) you sustained during the 1999 season?

Always ☐ Sometimes ☐ Never ☐

25. Was the recommended three-week stand-down observed for head injuries you sustained prior to the 1999 season?
(If you have never received a head injury playing rugby go to Question 28).

Always ☐ Sometimes ☐ Never ☐

26. Was your coach this season aware of all previous head injuries you have sustained?

Yes ☐ No ☐ Don't Know ☐

27. Have you ever been advised not to play rugby by a medical practitioner or neurologist due to head injury?

Yes ☐ No ☐

28. During the 1999 rugby season approximately how many injuries did you receive in the following areas?
(Place the number in the relevant box).

Knee ☐ Ankle ☐ Shoulder/Arm ☐

Chest ☐ Back ☐ Thigh ☐

Leg ☐ Foot/Toe ☐ Wrist ☐

Hand/Finger ☐ Hip/pelvis/groin ☐

Thanks for your participation in this survey. Your time and effort is greatly appreciated.

For any questions you may have relating to this survey please contact Sally Wills on 350 5799 Ext. 7907. Alternatively, leave a message and contact details at the Psychology Clinic at Massey University, phone 350 5196.

RUGBY PLAYERS QUESTIONNAIRE (RPQ)

The following questions apply solely to *club grade rugby* and mainly relate to the *2000 season* unless stated otherwise. It is important that you read each question carefully and answer honestly. *Your answers are strictly confidential.*

1. **Surname:** ______________________

2. **First Name:** ______________________

3. **Age:** __________

4. **Are you: Male ☐ Female ☐**

5. **What rugby club do you currently play for?**

____

6. **Approximately how many years have you played club-grade (not school grade) rugby?**

____

7. **What grade did you *mainly* play during the 2000 season? *(Tick only one box)***

Senior A ☐ Senior B ☐ Senior 3rds ☐

Under 21's ☐ Under 19's ☐ Senior 4ths ☐

Womens ☐ Other ______________

8. **What position did you *mainly* play during the 2000 season? *(Tick only one box)***

Prop ☐ Hooker ☐ Lock ☐

Flanker ☐ Number 8 ☐ Halfback ☐

1st Five ☐ Wing ☐ 2nd Five ☐

Center ☐ Fullback ☐

---

*For the purpose of this survey a head injury is any **injury to the head resulting in at least dizziness, blurred vision, headaches, confusion and/or a loss of consciousness (a blackout).***

Please apply this definition to the following:

9. **Please circle approximately how many head injuries you received playing club-grade rugby *before* the 2000 season?**

None 1-2 3-5 6-8 9-12 13-15 15+

10. **Please circle the number of head injuries you have received *during* the 2000 season.**

None 1 2 3 4 or more

If you answered 'None' *for Question 10 please skip to Question 25, otherwise continue at Question 11*

The following applies only to *the 2000 season.*

11. **Of the head injuries you received how many occurred during:** ***(Place the number in the relevant box)***

Training ☐ Competition ☐ Not Sure ☐

For Questions 12 – 15 & 17 list your first head injury of the season as Injury 1, your second as Injury 2 and so on. *(If you received more than five head injuries report the last five you sustained).*

12. **If you lost consciousness when you received your head injury place a tick in the relevant box. *If you did not lose consciousness or are not sure, leave the box blank.***

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

13. **Place in the box the letter that corresponds to the *period of the game* you received you head injury(s).**

A = 1st Half B = 2nd Half
C = Training D = Unsure

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

14. **Place in the box the letter that corresponds to the *phase of play* you were involved in when you received your head injury(s).**

A = Scrum B = Lineout C = Tackle
D = Ruck/Maul E = Other F = Unsure

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

15. **Place in the box the letter that corresponds to the *way* you received your head injury(s).**

A = Contact with ground
B = Contact with body of another player(s)
C = Punched D = Kicked
E = Other F = Unsure

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐

Injury 4 ☐ Injury 5 ☐

16. Of the head injuries you sustained how many received some form of attention?
If no head injuries received attention go to Question 19, otherwise continue. ☐

17. Place in the box the letter that corresponds with the *person(s) who first attended* to your head injury(s).

A = Doctor **B = Referee**
C = Coach/Trainer **D = St Johns**
E = Team Physiotherapist **F = Other**

Injury 1 ☐ Injury 2 ☐ Injury 3 ☐
Injury 4 ☐ Injury 5 ☐

18. *Question 18 relates to where you first received attention for your head injury(s).*
How many were attended *during* the game/training? ☐

How many were attended *on completion* of the game/training:

a. At the rugby grounds? ☐

b. At a doctor's surgery or hospital? ☐

19. Of the head injuries that *did not* receive attention, was this because you:
(Circle the appropriate letter)

A. Chose not to report the head injury as you considered it to be minor and symptoms disappeared within a couple of minutes.

B. Chose not to report the head injury, despite symptoms continuing throughout the game

C. Wanted to report the head injury but there was no-one available to attend to your injury

D. Other reason(s)? *(Please state)*

____

If you circled* 'B' *continue at Question 20, otherwise skip to Question 21

20. If you continued to experience symptoms, indicate your reasons for not reporting your head injury:
(You may circle more than 1 letter if required)

A. Didn't want to be removed from the game

B. Didn't want to risk missing future games

C. Didn't want to appear 'soft'

D. Didn't think injury was severe enough to report

E. Other *(Please State)*________________

21. Tick as many symptoms listed below that you experienced after your head injury (s).

Dizziness ☐ Blurred Vision ☐ Headache ☐
Tiredness ☐ Poor memory ☐ Nausea ☐
Difficulty/inability to concentrate ☐ Irritability ☐

22. How many of the head injuries you received during the 2000 season were diagnosed as *concussion* by a medical professional? ☐

23. Was your coach aware of *all* of the head injuries you report sustaining this season?

Yes ☐ No ☐ Don't Know ☐

24. Was the recommended three-week stand-down period observed for the head injuries you sustained during the 2000 season?

Always ☐ Sometimes ☐ Never ☐

25. Have you ever been advised not to play rugby ever again by a medical practitioner or neurologist as a result of head injury?

Yes ☐ No ☐

26. Did you wear headgear during the 2000 season?

Always ☐ Sometimes ☐ Never ☐

27. Did you wear a mouthguard during *training sessions* in the 2000 season?

Always ☐ Sometimes ☐ Never ☐

28. Did you wear a mouthguard during *competition games* in the 2000 season?

Always ☐ Sometimes ☐ Never ☐

29. During the 2000 rugby season *how many* injuries did you receive in the following areas?
(Place the number in the relevant box)

Neck ☐ Knee ☐ Ankle ☐
Chest ☐ Back ☐ Thigh ☐
Leg ☐ Foot/Toe ☐ Wrist ☐
Hand/Finger ☐ Shoulder/Arm ☐
Hip/Pelvis/Groin ☐

30. How many of the injuries identified in Question 29 either *received medical attention* and/or *required you to miss competition for at least one week?* ☐

Thanks for your participation with this survey.
Your time & effort is greatly appreciated.

APPENDIX C

HEADGEAR AND MOUTHGUARD USE QUESTIONNAIRE (HMQ)

1. Have you <u>ever</u> received a head injury while playing club-grade rugby?

   Yes ☐ No ☐ Not Sure ☐

2. Do you wear headgear during <u>training</u> sessions?

   Always ☐ Sometimes ☐ Never ☐

3. Do you wear headgear during <u>competition</u>?

   Always ☐ Sometimes ☐ Never ☐

4. Would you be <u>reluctant</u> to play without headgear?

   Yes ☐ No ☐ Maybe ☐

5. Would you <u>refuse</u> to play without headgear?

   Yes ☐ No ☐ Maybe ☐

6. If you wear headgear, what brand of headgear do you wear? *If you <u>never</u> wear headgear, go to Question 8*

   ____

7. Why did you choose to wear headgear while playing rugby? *(Tick as many as apply).*

   Personal Choice ☐ Advice of Medical Personnel (e.g. doctor) ☐
   Advice of Coach or Team Management ☐ Advice of Family Member or Friends ☐

8. Do you believe headgear can protect you against head injury?

   Yes ☐ No ☐ Sometimes ☐ Don't Know ☐

9. Do you wear a mouthguard during training sessions?

   Always ☐ Sometimes ☐ Never ☐

10. Do you wear a mouthguard during competition?

    Always ☐ Sometimes ☐ Never ☐

11. Would you be <u>reluctant</u> to play without a mouthguard?

    Yes ☐ No ☐ Maybe ☐

12. Would you <u>refuse</u> to play without a mouthguard?

    Yes ☐ No ☐ Maybe ☐

13. What type of mouthguard do you wear?

    Boil and bite ☐ Custom-made ☐ Other ☐ ____________________

14. Do you believe mouthguards help prevent dental injuries?

    Yes ☐ No ☐ Maybe ☐

15. Do you believe mouthguards help prevent concussion (head injury)?

    Yes ☐ No ☐ Maybe ☐

ASSESSING AND MANAGING HEAD INJURY QUESTIONNAIRE (AMQ)

This is an independent survey designed to gather information relating to current practices associated with the assessment and management of concussion in club-grade rugby. Your answers are strictly confidential and will have no bearing on your current position or level of involvement in club-grade rugby.

1. **Are you:** Male ☐ Female ☐

2. **Your age:** ________

3. **Tick the appropriate box below indicating:**

   a. Your *current role* in club grade rugby.

   b. Who *most frequently attends* to a head-injured/ concussed player during competition.

	a. My Current Role	b. Who Attends Injury
Coach	☐	☐
Team Trainer	☐	☐
Team Manager	☐	☐
Team Physiotherapist	☐	☐
Referee	☐	☐
St. Johns Personnel		☐
Doctor	________	________
Other (Specify)	________	________

4. **What grade(s) are you mainly involved with?**

Senior A ☐ Senior B ☐ Senior 3rds ☐

Senior 4ths ☐ Under 21's ☐ Under 19's ☐

Womens ☐ Other *(Specify)* ________

5. **Please state your highest recognised medical or first aid *qualification.***

____

If no medical/first aid *qualification* tick the box ☐

If no medical/first aid *training* tick the box ☐

6. **Do you believe mouthguards aid in preventing concussion?**

Yes ☐ Maybe ☐ No ☐

7. **Do you believe headgear aids in preventing concussion?**

Yes ☐ Maybe ☐ No ☐

Questions 8 & 9 relate to the recognition and diagnosis of concussion.

8. **Please list the signs and symptoms that you associate with concussion?**

____

____

____

9. **Do you believe a player must lose consciousness to be diagnosed with concussion?**

Yes ☐ Don't Know ☐ No ☐

Questions 10 – 14 relate to the initial assessment of a player who has received a head injury.

10. **The Glasgow Coma Scale (GCS) is a measure used to assess the level of consciousness after a head trauma.**

    a. Have you *heard* of this measure?

    Yes ☐ No ☐

    b. Have you ever *used* this measure?

    Yes ☐ No ☐

11. **If 'Yes' to 10 b, how frequently do you use the GCS to assess a suspected head injury of a club-grade rugby player?**
(If 'No' to 10 b continue at Question 12)

Always ☐ Frequently ☐
Hardly Ever ☐ Never ☐

12. **What other measures do you use to assess a player's conscious state?**

____

____

13. **What procedure would you follow if the player were knocked unconscious?**

____

____

____

14. What set of questions might you use to assess a player's level of confusion after a blow to the head?
Circle the letter (a-e) most applicable

a. What day of the week is it? What is today's date? What year is it? What is your date of birth?

b. Which ground are you at? Which team are you playing today? Which side scored the last try? What is the score? What team did you play last week?

c. Combination of both *a* and *b*

d. Neither *a* or *b*

e. Other *(Please state)*__________________

Questions 15 & 16 are based on the following case:
A rugby player was momentarily stunned after receiving a blow to the head during a game. The player 'saw stars' and had blurred vision for about 30 seconds. After 3 or 4 minutes the player reports feeling much better, except for a slight headache.

15. Would you allow this player to return to the game?

Yes ☐ Maybe ☐ No ☐

If 'No', please state why, and when you would allow this player to return to competition.

____

____

16. If this same player had also lost consciousness, would you allow them to return to the game?

Yes ☐ Maybe ☐ No ☐

If 'No', please state why, and when you would allow this player to return to competition.

____

____

17. If you selected 'Maybe' in Question 15 or 16, what factors would influence your decision to allow or disallow this player to return to play?

____

____

____

18. Under what circumstances would you advise a player to stand-down for:

a.Three weeks______________________

b.One season______________________

The following questions relate to the reporting and recording of head injuries that are sustained whilst playing club-grade rugby.

19. Do you believe team management should have knowledge of a player's previous history of head injury?

Yes ☐ Don't Know ☐ No ☐

20. Whose responsibility do you believe it should be to monitor head injuries sustained by club grade players?

____

21. Do you believe there should be a report form solely for detailing information specific to head injury? (i.e. evidence of loss of consciousness, time period player was unconscious etc).

Yes ☐ Don't Know ☐ No ☐

22. Do you suggest any improvements that could be made with regard to the reporting of head injuries.

____

____

Only those who complete the Serious Injury Report Form supplied by the MRFU should answer questions 23 & 24.

23. Please indicate your degree of satisfaction with the Serious Injury Report Form.

Unsatisfactory ☐ Satisfactory ☐

24. If you rated this form as 'Unsatisfactory', please provide the reason for this below.

____

____

Thanks for your participation in this survey. Your time and effort is greatly appreciated.

If you have any questions regarding this survey please contact Sally Wills at the Massey University Psychology Clinic on 350 5799 Ext.7356.

APPENDIX E – I

Phase I: Communications

APPENDIX E

Massey University
COLLEGE OF HUMANITIES & SOCIAL SCIENCES

School of Psychology
Private Bag 11 222,
Palmerston North,
New Zealand
Telephone: 64 6 356 9099
Facsimile: 64 6 350 5673

INFORMATION SHEET FOR CLUB GRADE RUGBY COACHES

Re: Rugby Players Questionnaire (RPQ)

Research is currently being conducted within the Manawatu region on the rate and severity of head injury occurring in club-grade rugby. This research is being conducted by Sally Wills in fulfillment of a doctorate at Massey University, under the supervision of Dr. Janet Leathem, Senior Lecturer and Clinic Director of the Massey Psychology Clinic.

As a coach of a club-grade team your permission is requested to approach players in your team in order to administer of brief questionnaire. The questionnaire will include questions relating to head injuries sustained, how these injuries were sustained, position and grade of player, and the number of head injuries attended to by medical personnel. The questionnaire will take approximately 5-10 minutes to administer.

An objective of this research is to identify the rate and severity of head injury occurring within club grade rugby as well as identifying factors related to the occurrence of head injury. Head injuries that are sustained may impact on players performance on the rugby field, possibly leading to slower reaction times and in turn increasing the likelihood for incurring more injuries, not only head-related.

Written support and full cooperation for this research has been given by both Evan Crawford, the manager of the NZRFU Rugby Services, and Allan Brown, CEO of the MRFU. Your cooperation with the administration of this survey would be greatly appreciated. The survey is voluntary although we would hope that many would choose to participate, as the findings may prove valuable to the future well being of players.

If you agree to allow your team to participate in this research, you will be contacted by phone to arrange a suitable time for the survey to be administered.

Thank you for your cooperation.

Yours sincerely

Sally Wills BA(Hons)
Ph.D. Researcher

Janet Leathem (Ph.D)
Supervisor

APPENDIX F

Massey University
COLLEGE OF HUMANITIES & SOCIAL SCIENCES

School of Psychology
Private Bag 11 222,
Palmerston North,
New Zealand
Telephone: 64 6 356 9099
Facsimile: 64 6 350 5673

INFORMATION SHEET FOR CLUB GRADE RUGBY PLAYERS

Re: Rugby Players Questionnaire (RPQ)

You are being invited to participate in a survey which will help assess the rate and severity of head injury sustained whilst playing club grade rugby. Sally Wills is conducting the survey in fulfillment of a doctorate at Massey University, under the supervision of Dr. Janet Leathem, Senior Lecturer and Clinic Director of the Massey Psychology Clinic.

An objective of this research is to identify the rate and severity of head injury occurring within club grade rugby as well as identifying factors related to the occurrence of head injury. The intent of this research is not to devalue or present the game of rugby in a negative way. Rather, it is hoped that the findings may prove valuable to the future well-being of players. It is also intended that the findings of this survey will contribute to the second phase of this research which plans to identify more effective means of assessing head injury sustained whilst playing club grade rugby.

If you agree to take part in this survey, you will be asked to complete a questionnaire (tick boxes) which will take about 5-10 minutes. By answering the questionnaire it is considered that you have agreed to participate in this research.

If you consent to take part in this research you have the right to:

- a full explanation of the nature of the study being undertaken, prior to your inclusion
- ask any further questions about the study that occur during participation
- refuse to answer any particular question(s) or to withdraw from the study at any time
- provide information on the understanding that it will remain completely confidential to the researchers.
- be offered a summary of the findings from this study upon its completion.

Written support and full cooperation for this research has been given by both Evan Crawford, the manager of NZRFU Rugby Services, and Allan Brown, CEO of the MRFU. Should you wish to clarify any further aspects of this study, please feel welcome to contact myself on (06) 350 5799, Ext. 7907, or Dr. Janet Leathem at the Psychology Clinic on (06) 350 4131. Thank you for your time and cooperation with this research.

Yours sincerely

Sally Wills BA (Hons.)
Ph.D. Researcher

Janet Leathem (Ph.D.)
Supervisor

APPENDIX G

Massey University
COLLEGE OF HUMANITIES & SOCIAL SCIENCES

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Private Bag 11 222,
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School of Psychology
Massey University
PALMERSTON NORTH

July, 2000

Dear

This letter is written with regard to research that has been underway for the past two years investigating the incidence of head injury sustained by club-grade players in the Manawatu region. A number of clubs have participated in past surveys investigating head injury sustained during the 1998 and 1999 seasons, and we are writing to request your permission to distribute questionnaires to your team in this the final phase of the study.

The questionnaire is similar in nature to those previously administered, comprised of questions relating to head injuries sustained during the current season, how these injuries were sustained, severity of head injury, position and grade of player and number of head injuries attended to by medical personnel. The questionnaire is brief, requiring players to tick boxes or place a letter or number in a box. The objective of this research is to identify the incidence and severity of head injury occurring within the club grades as well as examine the factors related to the occurrence of head injury.

Distribution of the questionnaire will be different to previous years. Over the next three weeks players competing in the Senior I, II, and Colt's grades will each receive the questionnaire and a freepost envelope at their residential address, which they will be asked to complete and return free of charge. As we are aware that this is of some inconvenience to players, we are offering a small incentive to the club for their time and effort. Each completed and returned questionnaire will result in a $3 contribution of sporting goods vouchers *awarded to the club*. Obviously if only 1 or 2 players in the club complete the questionnaire this won't amount to much, however if 50 questionnaires are returned this would amount to $150 worth of vouchers. These vouchers could be used to help raise money for the club (raffle) or assist in the purchase of essential sporting equipment or medical supplies – disposal is at the club's discretion.

We plan to administer the current survey during the last month of the season, with questionnaires being sent out from the 10th of July. We would greatly appreciate your cooperation by firstly, informing your team over the next week that these questionnaires are to

be distributed and secondly, encouraging players in your team to complete the forms honestly and return them as quickly as possible.
We wish to stress that the information gathered from these questionnaires will provide valuable information in the interests of improving player welfare, to both the MRFU and the NZRFU of which written support and full cooperation for this research has been given by both institutions.

If you would like to know more about the research in general or have any queries about the current survey, please contact me on (06) 350 5799, ext. 7356.

Yours sincerely

Sally Wills BA (Hons)
Ph.D. Researcher

Janet Leathem Ph.D
Supervisor

APPENDIX H

Massey University
COLLEGE OF HUMANITIES & SOCIAL SCIENCES

School of Psychology
Private Bag 11 222,
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New Zealand
Telephone: 64 6 356 9099
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School of Psychology
Massey University
PALMERSTON NORTH

August, 2000

Dear

As you may be aware, a survey is underway involving players in your club that is investigating factors related to the rate and severity of head injury sustained in rugby. Based on data previously gathered, current assessment and management strategies pertaining to head injury have been identified as an important, although currently neglected, area of investigation.

As a result a brief questionnaire has been developed **to identify the techniques and strategies currently utilised by those who may be involved with initial assessment and/or management of a head injured player.** Coaches and persons comprising a team's management (i.e., trainers, managers, and physiotherapists/medical personnel) are individuals who may find themselves in such a position. As you are one of these people, we are asking for your cooperation by **completing the enclosed questionnaire and returning it in the freepost envelope provided.**

It is important for that you are aware that there are no correct or incorrect answers and that you use **your knowledge and experience** to form the answers for each question. The purpose of the questionnaire is to identify current methods involved in dealing with a head-injured player as well as obtaining viewpoints about head injury in general.

As we are aware that completing this questionnaire is an inconvenience, you are offered the same incentive as the players in your club – **each questionnaire returned will be worth $3, awarded to the club in the form of sporting goods vouchers.**

Again, we have obtained the full support and encouragement of the MRFU for conducting this research, with the overall interest of both parties to improve player welfare. If you have any questions regarding any aspect of this study please contact us on 350 5196 at the Massey Psychology Clinic.

Yours sincerely

Sally Wills	Janet Leathem
Ph.D. Researcher	Supervisor

APPENDIX I

Massey University
COLLEGE OF HUMANITIES & SOCIAL SCIENCES

School of Psychology
Private Bag 11 222,
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School of Psychology
Massey University
PALMERSTON NORTH

August, 2000

Dear

Over the last two years players of club-grade rugby in the Manawatu region have been involved with a survey investigating factors relating to the rate and severity of head injury sustained in club-grade rugby. Based on the data gathered, current assessment and management strategies pertaining to head injury has been identified as an important, although currently neglected, area of investigation.

As a result a brief questionnaire has been developed **to identify the techniques and strategies utilised by those who may be involved with initial assessment and/or management of a head injured player.** As a referee involved with club-grade rugby you may find yourself in the position of having to deal with a head injured player, and for this reason we are asking for your cooperation by **completing the enclosed questionnaire and returning it in the freepost envelope provided.**

This is an independent survey designed to gather information relating to current practices involved in dealing with a head-injured player, as well as obtaining viewpoints about head injury in general. It is important that you that you use **your own knowledge and experience** to form the answers for each question, and are aware that there are no correct or incorrect answers. **Your answers are strictly confidential.**

This research is being conducted by Sally Wills in fulfillment of a doctoral degree at Massey University in the area of neuropsychology, under the supervision of Professor Janet Leathem of the Massey Psychology Clinic. We have obtained the full support and encouragement of the MRFU for conducting this research, and the Manawatu Rugby Referees Association is also aware of this survey. If you have any questions regarding any aspect of this questionnaire please contact us on 350 5196 at the Massey Psychology Clinic.

Yours sincerely

Sally Wills
Ph.D. Researcher

Janet Leathem
Supervisor

APPENDIX J - M

Phase II: Alternate Forms

Digit Symbol—Coding

Sample Items

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4

5	6	3	1	4	1	5	4	2	7	6	3	5	7	2	8	5	4	6	3

7	2	8	1	9	5	8	4	7	3	6	2	5	1	9	2	8	3	7	4

6	5	9	4	8	3	7	2	6	1	5	4	6	3	7	9	2	8	1	7

9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

2	7	3	6	5	1	9	8	4	5	7	3	1	4	8	7	9	1	4	5

7	1	8	2	9	3	6	7	2	8	5	2	3	1	4	8	4	2	7	6

Digit Symbol—Coding

Sample Items

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4

5	6	3	1	4	1	5	4	2	7	6	3	5	7	2	8	5	4	6	3

7	2	8	1	9	5	8	4	7	3	6	2	5	1	9	2	8	3	7	4

6	5	9	4	8	3	7	2	6	1	5	4	6	3	7	9	2	8	1	7

9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

2	7	3	6	5	1	9	8	4	5	7	3	1	4	8	7	9	1	4	5

7	1	8	2	9	3	6	7	2	8	5	2	3	1	4	8	4	2	7	6

Digit Symbol—Coding

Sample Items

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4

5	6	3	1	4	1	5	4	2	7	6	3	5	7	2	8	5	4	6	3

7	2	8	1	9	5	8	4	7	3	6	2	5	1	9	2	8	3	7	4

6	5	9	4	8	3	7	2	6	1	5	4	6	3	7	9	2	8	1	7

9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

2	7	3	6	5	1	9	8	4	5	7	3	1	4	8	7	9	1	4	5

7	1	8	2	9	3	6	7	2	8	5	2	3	1	4	8	4	2	7	6

Digit Symbol—Coding

Sample Items

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4
5	6	3	1	4	1	5	4	2	7	6	3	5	7	2	8	5	4	6	3
7	2	8	1	9	5	8	4	7	3	6	2	5	1	9	2	8	3	7	4
6	5	9	4	8	3	7	2	6	1	5	4	6	3	7	9	2	8	1	7
9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6
2	7	3	6	5	1	9	8	4	5	7	3	1	4	8	7	9	1	4	5
7	1	8	2	9	3	6	7	2	8	5	2	3	1	4	8	4	2	7	6

KEY 1

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⨪	Γ	⊣	(	>	Γ	(	⊣	>	+	∸	)	⊢	>	Γ

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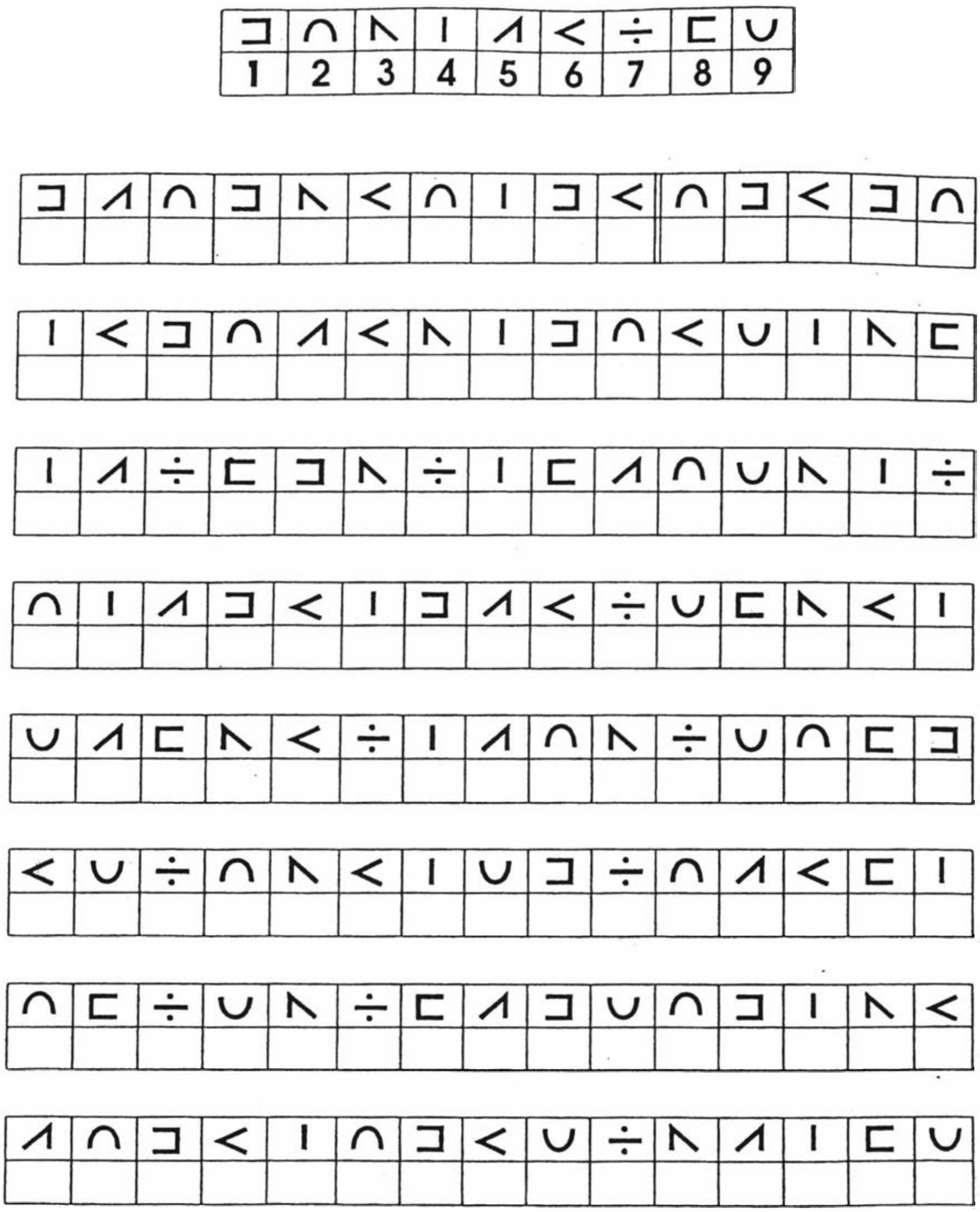
1 2 3 4 5 6 7 8 9

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⊥	⊂	∣·	⊔	∠	⊂	⦣	⊥	∣·	⊔	⊂	⊓	⊥	⦣	·∣

⊥	∠	=	·∣	∣·	⦣	=	⊥	·∣	∠	⊔	⊓	⦣	⊥	=

⊔	⊥	∠	∣·	⊂	⊥	∣·	∠	⊂	=	⊓	·∣	⦣	⊂	⊥

⊓	∠	·∣	⦣	⊂	=	⊥	∠	⊔	⦣	=	⊓	⊔	·∣	∣·

⊂	⊓	=	⊔	⦣	⊂	⊥	⊓	∣·	=	⊔	∠	⊂	·∣	⊥

⊔	·∣	=	⊓	⦣	=	·∣	∠	∣·	⊓	⊔	∣·	⊥	⦣	⊂

∠	⊔	∣·	⊂	⊥	⊔	∣·	⊂	⊓	=	⦣	∠	⊥	·∣	⊓

1 Admirals are people
2 Footstools are small
3 Beef steaks can be bought in shops
4 Dragonflies have wings
5 Grapes are people
6 Grass snakes move around searching for food
7 Prime Ministers have feathers
8 Bishops wear clothes
9 Bedroom slippers are made in factories
10 Beavers have strong teeth
11 Forks are manufactured goods
12 Architects can be bought in shops
13 Prime Ministers hold a political office
14 Vans grow in gardens
15 Pliers are found in tool chests
16 Tomato soup is a liquid
17 Admirals have fins
18 Wives often have husbands
19 Beef steaks are footwear
20 Grapes come from plants
21 Wives are made in factories
22 Beer lives in trees
23 Penguins are living creatures
24 Dragonflies are manufactured goods
25 Haddocks are fish
26 Beer is an alcoholic drink
27 Bishops are islands
28 Architects undergo a long training
29 Tomato soup moves around searching for food
30 Vans are vehicles
31 Haddocks have wheels
32 Footstools wear clothes
33 Pencils undergo a long training
34 Fish and chips move around searching for food
35 Climbing boots are made in factories
36 Gin is sold by butchers
37 Potatoes can be eaten
38 Can-openers are said to have loud voices
39 Fish and chips are fried
40 Mothers are parents
41 Crows are in charge of ships
42 U.S. Presidents have feathers
43 Grass snakes come from pigs
44 Corporals are people
45 U.S. Presidents hold a political office
46 Popes wear clothes
47 Drills are found in tool chests
48 Trucks grow in gardens
49 Popes are footwear
50 Corporals come from calves
51 Pliers are made in factories
52 Forks have feet
53 Carrots come from cattle
54 Wives can be bought in shops
55 Roses grow in gardens
56 Beavers are manufactured goods
57 Radishes can be bought in shops
58 Wool comes from sheep
59 Books are vegetables
60 Tomato soup is people
61 Haddocks are a liquid
62 Biscuits can be eaten
63 Snails are made from apples
64 Radishes are furniture
65 Books can be bought in shops
66 Grass snakes have shops
67 Penguins are birds
68 Vans wear clothes
69 Pliers have a profession
70 Wool has handles
71 Grass snakes are living creatures
72 Spoons are used for eating soup
73 Mothers are part of the family
74 Crows are a liquid
75 Pineapples are used for storage
76 Drills have a profession
77 Sharks are good swimmers
78 Trucks wear clothes
79 Biscuits come in long strands
80 Hammers are found in tool chests
81 Oranges are furniture
82 Pencils are made in factories
83 Squirrels are manufactured goods
84 Carrots can be eaten
85 Cobras serve on city councils
86 U.S. Presidents are made in factories
87 Can-openers have feet
88 Bees move around searching for food
89 Potatoes are cooked
90 Gin is alcoholic
91 Gin moves around searching for food
92 Can-openers are kitchen utensils
93 Popes are people
94 Roses deliver sermons
95 Beef steaks crawl on their bellies
96 Oranges can be eaten
97 Climbing boots live in monasteries
98 Ladles are kitchen utensils
99 Pineapples are fruit
100 Trucks carry loads

1 Dentists undergo a long training
2 Tigers have fins
3 Tables wear clothes
4 Oranges are people
5 Dentists can be bought in shops
6 Crows are living creatures
7 Sharks have wheels
8 Oranges come from plants
9 Trucks are vehicles
10 Bees are manufactured goods
11 Gin is an alcoholic drink
12 Tables are flat
13 Mothers are made in factories
14 Squirrels live in trees
15 Cobras move around searching for food
16 Can-openers are manufactured goods
17 Sharks are fish
18 Bees have wings
19 Butterflies are manufactured goods
20 Jeeps grow in gardens
21 Boa constrictors move around searching for food
22 Generals are people
23 Onions can be eaten
24 Psychiatrists can be bought in shops
25 Salmon have wheels
26 Skunks stink
27 Butterflies have wings
28 Salmon are fish
29 Roast beef moves around searching for food
30 Chests of drawers wear clothes
31 Jeeps are vehicles
32 Sherry is an alcoholic drink
33 Nightingales have four legs
34 Saucepans are good swimmers
35 Chests of drawers are used for storage
36 Melons are people
37 Veal cutlets can be bought in shops
38 Veal cutlets have a mane
39 Brothers-in-law are made in factories
40 Saucepans are manufactured goods
41 Generals have red breasts
42 Brothers-in-law are male
43 Screwdrivers are found in tool chests
44 Psychiatrists undergo a long training
45 Sherry is sold by a butcher
46 Skunks have fins
47 Nightingales are living creatures
48 Melons come from plants
49 Bananas are people
50 Lions have manes
51 Apples have wings
52 Squirrels are usually sold in pairs
53 Cobras are used for eating soup
54 Boa constrictors have fins
55 Onions have legs
56 Roast beef can be eaten
57 Screwdrivers carry disease
58 Bananas can be eaten
59 Lion is a military title
60 Apples are carpenters' tools
61 Mothers are sold by a butcher
62 Aunts are footwear
63 Bedroom slippers are footwear
64 Brandy is for cutting wood
65 Buses have wheels
66 Captain is an alcoholic drink
67 Champagne usually has palm trees
68 Climbing boots are said to have loud voices
69 Robins are for sitting on
70 Saws are carpenters' tools
71 Spoons are often used for eating soup
72 Buses are meat
73 Cobras come from plants
74 Sergeant is a dish
75 Tomato soups are usually sold in pairs
76 Drills are made in factories
77 Aunts wear clothes
78 Captains wear clothes
79 Drills have wings
80 Grapes can be bought in shops
81 Carving knives are often used in kitchens
82 Tractors are used by farmers
83 Chairs can be bought in shops
84 Tigers can go over rough ground
85 Spoons have sharp teeth
86 Cupboards are parents
87 Footstools are made in factories
88 Trout move around searching for food
89 Bedroom slippers grow underground
90 Chairs come from sheep
91 Brandy is a liquid
92 Cupboards are made from wood
93 Robins have legs
94 Trout may contain drawers
95 Climbing boots are usually sold in pairs
96 Sergeants wear clothes
97 Owls are used for storage
98 Carving knives have legs
99 Owls have wings
100 Footstools grow in gardens

1 Spaghetti comes in long strands
2 Rattle snakes move around searching for food
3 Pork chops can be bought in shops
4 Carving knives come from pigs
5 Beer is sold by butchers
6 Flowers grow in gardens
7 Carving knives are manufactured goods
8 Lions have strong teeth
9 Doctors undergo a long training
10 Aunts are always female
11 Spaghetti moves around searching for food
12 Chairs are for sitting on
13 Chairs wear clothes
14 Lions are footwear
15 Shoes are made in factories
16 Priests come from sheep
17 Flies have wings
18 Mayors have feathers
19 Peas hold a political office
20 Aunts are made in factories
21 Priests wear clothes
22 Bananas come from plants
23 Saws are found in tool chests
24 Rattle snakes are for cutting wood
25 Sergeants are people
26 Robins are living creatures
27 Trout usually have palm trees
28 Doctors can be bought in shops
29 Pork chops come in long strands
30 Sergeants are always female
31 Trout are fish
32 Mayors hold a political office
33 Buses are vehicles
34 Robins come from cattle
35 Captains are used for eating soup
36 Owls are living creatures
37 Physicists undergo a long training
38 Pork chops are part of the family
39 Cod are fish
40 Tractors are vehicles
41 Captains are people
42 Wasps are manufactured goods
43 Chisels can be eaten
44 Champagne is sold by a butcher
45 Desks may contain drawers
46 Monks wear clothes
47 Owls have blades
48 Lettuces have long ears
49 Grandmothers are usually elderly
50 Mutton chops are for sitting on
51 Bishops are people
52 Shoes come in long strands
53 Banana is a military title
54 Physicists are made from apples
55 Cod undergo a long training
56 Tractors usually have palm trees
57 Wasps are living creatures
58 Chisels have handles
59 Champagne can be bought in shops
60 Desks come from cows
61 Monks are used for eating soup
62 Lettuces grow in gardens
63 Brandy contains drawers
64 Mutton chops come from sheep
65 Apples are fruit
66 Bees are always female
67 Grandmothers grow underground
68 Chests of drawers are made in factories
69 Salmon have fins
70 Cider serves on city councils
71 Squirrels have sharp teeth
72 Tables are manufactured goods
73 Flies are a liquid
74 Peas can be eaten
75 Saws have a profession
76 Swans have wings
77 Rabbits can be eaten
78 Architects wear clothes
79 Chests of drawers have sharp teeth
80 Radishes come from plants
81 Salmon live in trees
82 Figs can be eaten
83 Penguins are found in kitchens
84 Corporal is a military title
85 Grapes live in monasteries
86 Pliers crawl on their bellies
87 Corporals come from cattle
88 Bishops usually have palm trees
89 Brandy is an alcoholic drink
90 Architects are kitchen utensils
91 Rabbits serve on city councils
92 Cobras crawl on their bellies
93 Peas come from plants
94 Figs move around searching for food
95 Wives are always female
96 Radishes can go over rough ground
97 Cider is a liquid
98 Tables have husbands
99 Apples are in charge of ships
100 Swans have prongs

1 Figs come from plants
2 Rabbits have long ears
3 Champagne is an alcoholic drink
4 Grandmothers are made in factories
5 Physicists can be bought in shops
6 Cod have wheels
7 Figs are people
8 Lettuce can be eaten
9 Wasps have wings
10 Spoons are manufactured goods
11 Mutton chops can be bought in shops
12 Chisels are found in tool chests
13 Monks have prongs
14 Nightingales are a liquid
15 Skunks have legs
16 Boa constrictors are living creatures
17 Spoons are for cutting wood
18 Shoes are manufactured goods
19 Generals come from plants
20 Saucepans have feet
21 Onions crush their prey
22 Jeeps can go over rough ground
23 Skunks are manufactured goods
24 Melons are furniture
25 Nightingales are birds
26 Screwdrivers have a profession
27 Onions can be bought in shops
28 Veal cutlets are meat
29 Brothers-in-law can be bought in shops
30 Butterflies hold political office
31 Sherry moves around searching for food
32 Melons can be eaten
33 Psychiatrists are kitchen utensils
34 Veal cutlets crawl on their bellies
35 Butterflies move around searching for food
36 Jeeps wear clothes
37 Screwdrivers are made in factories
38 Psychiatrists wear clothes
39 Sherry is a liquid
40 Saucepans are kitchen utensils
41 General is a military title
42 Mayors are made in factories
43 Vans deliver goods
44 Cider is made from apples
45 Forks are found in kitchens
46 Admirals come from plants
47 Prime Ministers are made in factories
48 Beef steaks crawl on their bellies
49 Beavers have legs
50 Beer moves around searching for food
51 Grandmothers are always female
52 Physicists are people
53 Cod have fins
54 Lettuce are vehicles
55 Wasps are often used for eating soup
56 Mutton chops crush their prey
57 Chisels are living creatures
58 Monks live in monasteries
59 Boa constrictors undergo a long training
60 Brothers-in-law wear clothes
61 Cider is a military title
62 Prime Ministers are living creatures
63 Beavers are kitchen utensils
64 Cupboards can be bought in shops
65 Doctors are living creatures
66 Shoes have red breasts
67 U.S. Presidents have legs
68 Flies are in charge of ships
69 Haddocks are fruit
70 Dentists are people
71 Priests are always female
72 Radishes undergo a long training
73 Beef steaks are officers
74 Pork chops are sold by butchers
75 Dragonflies move around searching for food
76 Spaghetti is cooked
77 Roast beef are good swimmers
78 Fish and chips are cooked
79 Admiral is a military title
80 Desks have strong teeth
81 Peas undergo a long training
82 Potatoes can be bought in shops
83 Rattle snakes crawl on their bellies
84 Fish and chips are fruit
85 Roast beef can be bought in shops
86 Haddocks have fins
87 Doctors are vehicles
88 Potatoes are a liquid
89 Penguins are good swimmers
90 Dragonflies hold a political office
91 Spaghetti is people
92 Swans are furniture
93 Bedroom slippers have husbands
94 Rattle snakes have feathers
95 Popes crush their prey
96 Desks often have legs
97 Priests are people
98 Swans have feathers
99 Cupboards can be eaten
100 Flies are small

The Spot-the-Word Test   Version A

livid	–	trasket	broxic	–	oasis
thrash	–	listid	pinnace	–	strummage
holomator	–	dross	mannerism	–	whitten
orifice	–	serple	daffodil	–	gombie
phalanx	–	distruvial	bellissary	–	cyan
chloroleptic	–	lapidary	vellicle	–	sampler
biothon	–	palfrey	necromancy	–	ghoumic
archipelago	–	zampium	narwhal	–	epilair
groudy	–	toga	venady	–	monad
moxid	–	tangible	plargen	–	savage
moralist	–	florrical	clegger	–	minim
quince	–	bostry	knibbet	–	mandrake
lignovate	–	epicene	canticle	–	grammule
gibbon	–	wonnage	threnody	–	epigrot
hipple	–	osprey	brastome	–	banshee
element	–	pargler	shako	–	strubbage
viridian	–	psynoptic	paraclete	–	elezone
glorvant	–	onyx	froopid	–	clod
plankton	–	whippen	rouse	–	choffid
akimbo	–	periasty	goblet	–	prelly
centaur	–	tritonial	flexipore	–	viscera
vinady	–	bargain	agipect	–	almond
prinodal	–	mango	tarantula	–	hostent
reticule	–	fluxent	trelding	–	rafters
frembulous	–	ontology	legify	–	archaic
loxeme	–	legerdemain	obsidian	–	plassious
hoyden	–	clinotide	restance	–	zombie
aboriginal	–	hostasis	pimple	–	brizzler
clavanome	–	bestiary	frellid	–	static
zando	–	albatross	hilfren	–	domain

The Spot-the-Word Test Version B

slank	–	chariot	coracle	–	prestasis
lentil	–	glotex	paramour	–	imbulasm
stamen	–	dombus	dallow	–	octaroon
loba	–	comet	fleggary	–	carnation
pylon	–	stroin	liminoid	–	agnostic
scrapten	–	flannel	naquescent	–	plinth
fender	–	ullus	thole	–	leptine
ragspur	–	joust	crattish	–	reform
milliary	–	mantis	wraith	–	stribble
sterile	–	palth	metulate	–	pristine
proctive	–	monotheism	pauper	–	progotic
glivular	–	stallion	aurant	–	baleen
intervantation	–	rictus	palindrome	–	lentathic
byzantine	–	chloriant	hedgehog	–	mordler
monologue	–	rufine	prassy	–	ferret
elegy	–	festant	torbate	–	drumlin
malign	–	vago	texture	–	disenrupted
exonize	–	gelding	isomorphic	–	thassiary
bulliner	–	trireme	fremoid	–	vitriol
visage	–	hyperlistic	farrago	–	gesticity
froin	–	oratory	minidyne	–	hermeneutic
meridian	–	phillidism	pusality	–	chaos
grottle	–	strumpet	devastate	–	prallage
equine	–	psynomy	peremptory	–	paralepsy
baggalette	–	riposte	chalper	–	camera
valance	–	plesmoid	roster	–	falluate
introvert	–	vinadism	scaline	–	accolade
penumbra	–	rubiant	methagenate	–	pleonasm
breen	–	malinger	drobble	–	infiltrate
gammon	–	unterried	mystical	–	harreen

APPENDIX N – R

Phase II: Communications and Questionnaires

APPENDIX N

Massey University
COLLEGE OF HUMANITIES & SOCIAL SCIENCES

School of Psychology
Private Bag 11 222,
Palmerston North,
New Zealand
Telephone: 64 6 356 9099
Facsimile: 64 6 350 5673

INFORMATION SHEET FOR CLUB GRADE RUGBY PLAYERS

Re: Head Injury Assessment

You are being invited to participate in an ongoing study of which this phase intends to assess the rate of recovery after sustaining a head injury whilst playing rugby. Sally Wills, who is currently completing her doctorate at Massey University, is conducting this study and is being supervised by Dr. Janet Leathem, Clinic Director of the Massey Psychology Clinic. The aim of the research is to assess the effect of both singular and repeat concussions on cognitive functioning and to monitor the rate of recovery to pre-injury levels of functioning.

Support for this research has been obtained from the Manager of Rugby Services for the NZRFU and from the Manawatu Rugby Football Union. It is not the intention of this research to devalue or present the game of rugby in a negative way; rather, it aims to improve player welfare for those participating within club grade rugby by raising awareness regarding the incidence and severity of head injury and its assessment and management.

If you agree to take part in this study, you will firstly be asked to complete a consent form, recording your willingness to participate. You will then be asked to complete a series of neuropsychological measures that will assess certain areas of functioning that may be impaired after a head injury is sustained, such as attention, memory and information processing speed. This assessment will be conducted twice prior to the start of the rugby season, once during the season and again at the end of the season. The administration of these measures will occur in a group situation and take approximately 10 – 15 minutes.

If you agree to participate in this research, you will also be asked to notify the researcher immediately following any concussion that you may sustain during the season, or give consent for the team doctor/physiotherapist or coach to notify the researcher. Once the researcher has been notified, you must be willing to be administered a series of brief tests (taking approximately 10 minutes) within 48 hours of sustaining the concussion, and then again two weeks later.

In consenting to take part in the research, you have the right to:

- A full explanation of the nature of the study being undertaken, prior to your inclusion
- Ask any further questions about the study that arise during participation
- Refuse to answer any particular question(s) or to withdraw from the study at any time
- Provide information on the understanding that it will remain completely confidential to the researchers
- Be offered a summary of the findings from this study upon its completion

Should you wish to clarify any further aspects of this study, please feel welcome to contact myself on (06) 350 5799, Ext. 7907, or Dr. Janet Leathem on (06) 350 5799, Ext. 2083. Thank you for your time and cooperation with this research.

Yours sincerely

Sally Wills	Dr. Janet Leathem
Ph.D Researcher	Clinic Director

CONSENT FORM

Re: Head Injury Assessment

I have read the information sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I understand that by agreeing to participate in this research, I will be asked to notify the researcher immediately following any head injury/concussion that I may sustain during the season, or give consent for the team doctor/physiotherapist or my coach to notify the researcher. Once the researcher has been notified, I understand that I will be contacted in order for an assessment to be arranged.

I agree to provide information to the researchers on the understanding that my identity will be known to them only.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed: ....

Name: ....

Date: ....

PERSONAL HISTORY QUESTIONNAIRE FOR CLUB RUGBY PLAYERS

1. **Surname:** ______________________ **First Name:** ______________________

2. **Date of Birth:** / /19

3. **Ethnic Origin:** Pakeha ☐ Maori ☐ Pacific Islander ☐ Asian ☐

   Other (Please Specify) ______________________

4. **Years of Education:** ______________________

5. **Current Occupation:** ______________________

6. **Rugby Club Member of:** ______________________

7. **Rugby Grade:** Senior A ☐ Senior B ☐ Senior 3rds ☐ Colts ☐

8. **Other sports played:** ______________________

   ____

9. **Time spent playing sport (including rugby):** ______________ (hours per week)

10. **Have you sustained a head injury during pre-season training/competition this year?**

    Yes ☐ No ☐ Not Sure ☐

11. **If you answered 'Yes' to Question 10, did you lose consciousness?**

    Yes ☐ No ☐ Not Sure ☐

APPENDIX P

CHECK SHEET FOR HEAD INJURY ASSESSMENT

What to look for:

Any injury to the head resulting in at least:

- **dizziness,**
- **disturbed vision (i.e., blurred vision, double vision),**
- **confusion, *and/or***
- **a loss of consciousness (i.e., a blackout)**

You may experience these symptoms due to a knock to the head or a hard blow to the body, which may affect the head (i.e., a whiplash effect). Other symptoms you may experience *immediately* after a head injury include:

- nausea
- headache
- ringing in the ears
- poor memory (can't remember the score, set moves etc.)

Symptoms you may experience *after* the initial symptoms include:

- headache
- tiredness
- irritability
- difficulty or an inability to concentrate (i.e., at work, study, etc.)
- poor memory (forgetting to do things you were asked to do, etc.)

What to do:
Inform your coach, team manager, doctor or physiotherapist, if you receive an injury to the head that results in the symptoms that are listed in bold print at the top of the page.

When to inform:
We need to be informed within 24 hours of the injury, so that a brief assessment can be conducted. You will be required to provide as much detail as possible about injury you sustained.

Important:
By reporting that you have sustained a head injury will not affect your availability to play, *unless stated otherwise by your coach or doctor*. Information gathered from any of the assessments will not be used to make a decision regarding your availability to play.

For further information, you can contact me on (06) 350 5799 Ext. 7356.
Thank you for your cooperation – good luck for the season!

Sally Wills (Ph.D. Researcher)

SEMINAR PRESENTATION:

ASSESSMENT AND MANAGEMENT OF CONCUSSION

What to look for:

Any injury to the head resulting in at least:

- **dizziness,**
- **disturbed vision (i.e., blurred vision, double vision),**
- **confusion, *and/or***
- **a loss of consciousness (i.e., a blackout)**

These symptoms may be experienced due to a knock to the head or a hard blow to the body, which may affect the head (i.e., a whiplash effect). Other symptoms that may be experienced *immediately* after a head injury include:

- nausea
- headache
- lack of awareness of surroundings
- ringing in the ears

As an observer, signs that a head injury has occurred include:

- slow recovery from a tackle/hit etc
- the player appearing 'groggy' and unsteady on their feet
- aggression
- refusal to leave the field
- the player seeming confused, not sure of the game plan, etc.

Additional symptoms that may be experienced *after* (days to weeks) initial symptoms include:

- persistent headache
- tiredness
- irritability
- sleep disturbance
- difficulty or an inability to concentrate (i.e., at work, study, etc.)
- poor memory (forgetting to do things you were asked to do, etc.)
- intolerance of bright lights and loud noises.

SIDELINE ASSESSMENT OF CONCUSSION

Before Resuming Play:

Player should be asked the following:

- the name of the other team
- what ground the game is being played at
- what side scored the last goal
- how long the game has been going
- what team was played last week
- whether we won last week

These questions relate to recent memory and assess the player's orientation. If the player has difficulty answering these, do not allow them to return to the game. Questions such as what is the day, the month, the year are not always reliable, as this aspect of memory is relatively intact.

Other brief tests that can be given include

- digits forward and backward (series of numbers to be repeated forwards and backwards)
- three-item recall (three words and three objects given prior to brief assessment then asked to be recalled after assessment completed)

Do not return to play if:

- The player lost consciousness – a player having lost consciousness should not resume play until cleared by medical professional.
- The player continues to suffer symptoms (i.e., headache, dizziness, confusion, blurred vision, etc.).

SEVERITY OF CONCUSSION

Grade 1 (Mild):	Transient confusion, no loss of consciousness, symptoms resolve in < 15 minutes.
Grade 2 (Moderate):	Transient confusion, no loss of consciousness, symptoms resolve in < 15 minutes.
Grade 3 (Severe):	Loss of consciousness.

RETURN TO PLAY BASED ON SEVERITY

Grade 1:	Remove from play. If symptoms resolve within 15 minutes may return to play after 30 minutes.
Grade 2:	Remove from play. Requires neurological evaluation. May return to play if asymptomatic for one week.
Grade 3:	Remove from play on fracture board with head mobilised if unconscious. Send to hospital for neurological evaluation. May return to play after one month if asymptomatic for at least one week.

GENERAL RECOMMENDATIONS

1. It is mandatory that a player should stand-down for three weeks after receiving a concussion
2. After a second concussion in one season they should not play again that season
3. After a total of three concussions they should leave contact sports

POTENTIAL RISKS AFTER A CONCUSSION

Post-concussion Syndrome: Symptoms such as headache, fatigue, irritability, impaired memory and concentration last for a period of 6 months. Increased risk of developing second impact syndrome

Second Impact Syndrome: Involves diffuse cerebral swelling. Relatively rare, but typically fatal. Occurs if an athlete who has sustained an initial head injury, sustains a second head injury before symptoms associated with the first have cleared.

HEAD INJURY REPORT FORM

Surname: ______________________ **First Name:** ______________________

Rugby Club: ______________________________________

Grade: ______________________________________

Field Injured At: ______________________________________

Date of Injury: ______________________________________

DESCRIPTION OF HEAD INJURY

1. What symptoms did you experience immediately after sustaining the head injury?

Dizziness ☐ Headache ☐ Blurred Vision ☐ Nausea ☐

Ringing in Ears ☐ Tiredness ☐ Difficulty concentrating ☐ Irritability ☐

2. What symptoms are you currently experiencing?

Dizziness ☐ Headache ☐ Blurred Vision ☐ Nausea ☐

Ringing in Ears ☐ Tiredness ☐ Difficulty concentrating ☐ Irritability ☐

3. Did you lose consciousness?

Yes ☐ No ☐ Not Sure ☐

4. Describe briefly where on the head (includes the face) or the body you were hit.
(E.g. right hand side, above the right ear)

____

____

DESCRIPTION OF HOW INJURY OCCURRED

1. Did the injury occur during:

Competition ☐ Training ☐

2. If the injury occurred during competition, in which phase of play did it occur?

1st half ☐ 2nd half ■ Not sure ☐

3. Did you anticipate the hit/contact/impact?

Yes ☐ No ☐

ON-FIELD TREATMENT

1. Who attended to the head injury you received?

Doctor ☐ St Johns ☐ Team Official ☐ Referee ☐ No-one ☐

2. Were you removed from the field when you received attention?

Yes ☐ No ☐ Not sure ☐

3. After receiving the head injury, did you continue to play?

Yes ☐ No ☐ Not sure ☐

4. Can you please describe in short detail what medical attention you received (if any)?

____

____

PLAYING CONDITIONS

1. What were the weather conditions like during the game?

Fine ☐ Overcast ☐ Cloudy ☐ Drizzle ☐ Heavy rain ☐ Windy ☐

Other (please state) ________________________________