EPIDEMIOLOGY AND CONSEQUENCES OF HEAD INJURY: A COMPARISON OF FOCAL/SHARP HEAD INJURIES AND GENERALIZED/BLUNT HEAD INJURIES

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ABSTRACT

The purpose of the present study was to compare neurobehavioural outcomes and performance on neuropsychological measures of two groups of subjects with head injuries - those with focal/sharp head injuries and those with generalized/blunt head injuries. The study was conducted in two parts. Part one involved examining epidemiology and neurobehavioural outcomes of 235 subjects with head injuries. As expected, young males with low educational levels were most likely to sustain head injury. Maori subjects were overly represented in comparison to general population statistics. Subjects sustaining head injuries from focal/sharp head injuries, such as assaults, exhibited more irritability than subjects with generalized/blunt head injuries. No conclusive information was obtained concerning post-traumatic epilepsy or post-traumatic stress disorder.

Part two of this study involved a comparison of the performance of subjects on a wide range of neuropsychological measures. It was predicted that subjects with focal/sharp head injuries would exhibit more specific cognitive difficulties than subjects with generalized/blunt head injuries. Some support was provided for this hypothesis, but more often the data contradicted it. Subjects with focal/sharp head injuries were less likely to experience difficulties in areas sensitive to frontal lobe damage. Overall, in most cases, the subjects in this study performed at lower levels on the neuropsychological measures than the norms and control subjects in other studies.

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INTRODUCTION

In the past two decades, the neuropsychology of head injury has received considerable attention. Research has tended to focus on the neurobehavioural consequences (Lezak, 1995; Morse & Montgomery, 1992; Prigatano, 1992), on epidemiology (Kolb & Whishaw, 1990; Parker, 1990), and the dimensions and classifications of injury - on minor and severe, and open and closed, particularly closed (Kolb & Whishaw, 1990). Most research focuses on individuals who have received frontal and temporal lobe damage sustained at high velocity due to rapid deceleration in motor vehicle accidents (MVA's), which are the major cause of traumatic brain injury. While there is considerable literature on damage sustained in such circumstances, there is little on head injury due to other accidents, such as falls and direct blows to the head which are still classified as closed head injury, but are sustained at lower velocity. These may include a number of acceleration as well as deceleration injuries and are likely to be more focal as well. Furthermore, comparison of the neurobehavioural consequences of sharp and blunt head injury is not widely documented. Sharp injuries are those likely to be more associated with non MVA's.

This research aims to examine the frequency with which different types of head injury occur, and to compare the neurobehavioural outcomes in a group with high velocity, deceleration injuries of the kind sustained in MVA's, with a group with injuries sustained at lower velocity. Clinical observation suggests that the neurobehavioural consequences of sharp head injury are, in some respects, worse than those associated with blunt head injury. In particular, such individuals seem to exhibit more irritability and have a higher likelihood of developing post-traumatic epilepsy than those with a blunt head injury. At the same time, clinical observation suggests that sharp head injury is associated with less change on formal neuropsychological assessment, than those sustaining blunt head injury.

The first chapter in this study presents an overview of the literature on head injury - epidemiology, measures of severity, classifications, outcomes, and factors affecting recovery, with particular emphasis on some areas such as post-traumatic epilepsy and post-traumatic stress disorder, that are not so frequently reported.

Chapter two presents a list of hypotheses that have been formulated from clinical observations. Methodology is presented in Chapter three, and the results of the various analyses are provided in Chapter four. The discussion of the results is presented in Chapter five, along with recommendations for future research.

CHAPTER ONE

HEAD INJURY

INTRODUCTION

Head injury involves damage to the brain resulting from a blow to the head, the head striking a stationary object, or the head being violently shaken (Wright, 1993). "A traumatic head injury is defined as the product of a definite physical blow or wound to the head that is significant enough to produce (a) an alteration in consciousness, no matter how brief, and/or (b) associated neurological or neurobehavioural dysfunction" (Begali, 1992, p.12).

Over the last two decades, with modern medical and technical advances, an increasing number of people are surviving from severe head injuries. As a result, it has become obvious that the effects of the damaged brain are not just physical (Begali, 1992; Lezak, 1995), and that behaviour disorders are amongst the most challenging problems faced by individuals with head injuries (Jacobs, 1990).

This chapter takes a detailed look at head injury, beginning with the epidemiology of head injury, followed by measures of severity such as Post-traumatic Amnesia (PTA) and the Glasgow Coma Scale. Various classification systems such as minor/moderate/severe, open/closed, blunt/sharp, and acceleration/deceleration injuries are covered. This is followed by the outcomes of head injury - post-concussion syndrome, neurobehavioural sequelae of head injury, frontal lobe syndrome, post-traumatic epilepsy, and post-traumatic stress disorder. The chapter concludes with an overview of factors affecting recovery.

EPIDEMIOLOGY

In the United States it has been estimated that over 8 million head injuries are sustained each year (Parker, 1990). Approximately 400,000 people are admitted to hospital each year for head injuries (Kolb & Whishaw, 1990; Parker, 1990), and the mortality rate from head injury is about 25 people per 100,000 (Parker, 1990). In New Zealand approximately 9,000 people are admitted to hospital with head injuries each year (Carr, 1993). This equates to a rate of approximately 170 people per week. These figures do not include the many minor head injuries that go unreported. As there have been no formal epidemiological studies completed on head injury in New Zealand, the incidence has been generalised from overseas studies. The incidence rate has been estimated at 250-370 people per 100,000 (Carr, 1993). The Accident Rehabilitation and Compensation Insurance Corporation (ACC) provides a total figure of 7,461 head injuries (excluding facial injuries) for the year ending June 1995. This figure is for entitlement claims only, so the minor head injuries involving a visit to the doctor only, may not be included (Accident Rehabilitation and Compensation Insurance Corporation, 1995).

The Central Regional Health Authority have provided figures of hospitalisation in the Manawatu and Central Region from 1989 to 1994. The incidence rate for head injuries in these areas is 25/10,000 (Central Regional Health Authority, 1996), equating to 250/100,000 which is similar to the estimation provided by Carr (1993).

Head injury is most common in the 15-24 age group. Males receive more head injuries than females, with a ratio of more than 2 males to 1 female (Begali, 1992). Motor vehicle accidents (MVA's) are the most common cause of head injuries, with falls being the second most common cause. Together MVA's and falls account for about 60% to 75% of head injuries (Begali, 1992; Department of Health and Human Services, 1989 [cited in Wright, 1993]; Lezak, 1995). Assaults, sports injuries, work accidents, and recreational injuries account for a further 25% to 40% of reported head injuries (Department of Health and Human Services,1989 [cited in Wright, 1993]; Lezak, 1995) and possibly account for more unreported head injury.

Head injury is more common in the lower socioeconomic class, in people who are unemployed, and in people with lower educational levels (Begali, 1992). Head injury from assaults and household accidents are more common in people with lower socioeconomic status (Begali, 1992). Head injury due to falls are more common in children (Currie, 1993; Goldstein & Levin, 1987) and in the elderly (Goldstein, Levin, Presley, Searcy, Colohen et al.,1994). Children are also more likely to have mild head injuries rather than severe head injuries (Jennett, 1989). The cause of head injury in children is often different from that of adults. Children are more likely to be involved in accidents occurring at a lower velocity than adults (Van Hout, 1992). Therefore, a large number of minor and unreported focal head injuries are sustained at low velocity, due to falls and blows, during recreation/home activities.

To address epidemiology further, data obtained from subjects in the present study will be collaborated and compared with published data. The cause of head injuries, the ratio of males to females, ethnicity, age and the level of education of people receiving head injuries, will be discussed. Children however, will not be studied.

MEASURES OF SEVERITY

Post-traumatic Amnesia (PTA)

PTA, first used as a measure of severity of head injury by Russell in the 1930's, refers to "the loss of memory from the time of the original injury to the time when continual day-to-day memory has been re-established" (Evans, 1994, p.142). Duration of PTA includes anterograde amnesia and the coma period, and lasts about four times the duration of coma (Lezak, 1995). PTA can be measured at any time after the injury and is a useful guide for later cognitive outcome, such as memory (Long & Schmitter, 1992). PTA provides six categories of severity (as shown in Table 1.1). As previously mentioned, the three categories of minor, moderate, and severe are also commonly used. There is good evidence to suggest that the duration of PTA correlates with later memory disturbance (Kolb & Whishaw, 1990). PTA duration also correlates with Glasgow Coma Scale ratings (Lezak, 1995).

However, there are difficulties in using PTA as a severity measure. PTA is said to end when the patient exhibits continuous ongoing memory, but deciding just when continuous memory returns can be difficult, especially when patients are confused or aphasic. Further, if the individual has been discharged before PTA has ended, the examiner often has to estimate the duration of PTA from the individual and family reports (Lezak, 1995).

Table 1.1: Post-traumatic Amnesia

PTA Duration	Severity
<5 minutes	Very mild
5-60 minutes	Mild
1-24 hours	Moderate
1-7 days	Severe
1-4 weeks	Very severe
More than 4 weeks	Extremely Severe

(Lezak, 1995).

Glasgow Coma Scale (GCS)

"This scale attempts to predict outcome by numerically rating levels of responsiveness on the basis of eye opening and best verbal and motor responses on a 15-point scale" (Jones, 1992, p. 250). The GCS was developed by Teasdale and Jennett in 1974 as a measure of neurological functioning following head injury. The scale was designed to assess the depth and duration of coma. Coma was defined as being unable to open the eyes, obey commands, or speak (Sataloff, 1993).

There are three components making up the GCS, as set out in Table 1.2. Eye opening (E) is scored on a 4-point scale, ranging from 'opens eyes spontaneously' (score 4) to 'no eye opening' (score 1). Motor response (M) is scored on a 6-point scale, ranging from 'obeys commands' (score 6) to 'no movement' (score 1). Verbal response (V) is scored on a 5-point scale, ranging from 'appropriate and oriented' (score 5) to 'no sounds' (score 1). The scores are added together to give the overall GSC score (Sataloff, 1993).

Table 1.2: Glasgow Coma Scale

Score	**Severity**
8 or less	Severe injury
9-12	Moderate injury
13-15	Minor injury

(Kolb & Whishaw, 1990).

There are also difficulties associated with the GCS. Generally, ratings taken within the first few hours or the first day after the injury, are used as the baseline for severity, but in some cases deterioration does not occur for a few days, and as a result the individual is misclassified. Other factors that can affect the GCS score are alcohol intoxication, medication/sedation, injuries affecting speech, or the ability to open the eyes (Lezak, 1995).

The Glasgow Outcome Scale, developed for use in conjunction with the GCS, has five levels as shown in Table 1.3. Although the scale gives a straightforward, and an easily understood view of the general status of the head injured individual, it does not reveal any behavioural or personality disturbances of the individual (Bond, 1983).

Table 1.3: Glasgow Outcome Scale

Good recovery	Resumption of normal life-style
Moderate disability	Disabled but independent
Severe disability	Conscious but dependent
Persistent vegetative state	Unresponsive and speechless
Death	

(Sataloff, 1993).

CLASSIFICATIONS

The many classifications of head injury are typically described separately, almost as if they are independent entities. It is important to note however, that these classifications overlap with each other, e.g. a minor head injury can be a deceleration blunt injury.

Minor/Moderate/Severe Head Injury

Some classifications sub-divide minor head injuries into very mild and mild, and severe head injuries into severe, very severe, and extremely severe (e.g. Morse & Montgomery, 1992; Lezak, 1995). In this section, the classifications, minor, moderate, and severe, will be used, as this method of classification is most commonly used.

Minor Head Injury

Minor head injury (MHI) involves an injury to the head resulting in brain contusion without fracture to the skull or major hemorrhage (Duckett & Duckett, 1993). Following a MHI there is a brief loss of consciousness of up to 20 minutes in length, anterograde and retrograde amnesia, and confusion (Duckett & Duckett,1993). The period of PTA for a MHI is less than 1 hour (Bigler, 1984; Gronwall, 1991). On the GCS, a person with a MHI will score between 13 and 15 on arrival at hospital (Kay, Newman, Cavallo, Ezrachi & Resnick, 1992).

The majority of head injuries are minor, and account for 70% to 90% of all head injuries (Kay, Newman, Cavallo, Ezrachi & Resnick, 1992; Kraus & Nourjah, 1989). A large portion of these MHI's result from injuries caused by assaults, sports injuries, falls or hitting the head on some solid substance e.g. a wall (Gronwall, 1991). With regard to pathology, the areas of the brain most likely to be damaged in MHI are the anterior portions of the frontal and temporal lobes. Microscopic lesions are also evident. However, there is increasing evidence that the pathology involved in MHI may be a more gradual process (Mandel, Sataloff & Schapiro, 1993).

Neurobehavioural symptoms of MHI include headaches, poor memory, impaired concentration, sleep difficulties, vertigo, irritability, sensitivity to light and noise, and fatigue. These symptoms have been termed the post-concussion syndrome (PCS) (Gronwall, 1991), which will be discussed later in this chapter.

Moderate Head Injury

An individual who has experienced a GCS score of 9-12 (Parker, 1990), and/or a PTA duration of 1-24 hours, is classified as having a moderate head injury. The most common complaints reported by people with moderate head injuries include headaches, memory problems, and difficulty with daily living (Lezak, 1995). Individuals with moderate head injuries sustain more damage than individuals with minor head injuries, and require more intensive medical care (Morse & Montgomery, 1992).

Severe Head Injury

"Although fewer than 10% of head trauma victims are severely injured, they present a major and growing social problem because their rehabilitation needs are so great and so costly, because so few return to fully independent living, and because their disabilities create severe financial and emotional burdens for their families" (Lezak, 1995, p.186).

A head injury is classified as severe when the PTA is greater than 24 hours, and a GCS of 8 or less (Parker, 1990). A severe head injury (SHI) results from injuries to the skull (linear fracture, depressed fracture, and basilar fracture) and lesions of the brain (cerebral concussion, cerebral contusion, and cerebral laceration) (Miller, 1992). The most common cause of SHI are MVA's (Currie,1993).

The neuropsychological effects of SHI fall into two major categories: cognitive/executive and emotional. Cognitive impairments following a SHI include deficits in attention, memory (particularly acquisition and retrieval of information), and the ability to use knowledge (usually associated with frontal lobe injury). The nature of the deficit depends on the location, extent, and nature of the lesion (Lezak, 1995). Executive dysfunction is often the most disabling effect of a SHI. This includes lack of awareness of one's self and surroundings, effecting self-determination, self-direction, and regulation. Abilities to plan, recognise, and choose alternatives may be impaired (Lezak, 1995).

Emotional and behavioural changes resulting from SHI's vary significantly. The most common changes include increased irritability, impatience and short temperedness; increased withdrawal; lack of motivation; reduced ability to tolerate pressure; reduced or lack of self-confidence; tactlessness, impulsiveness, and socially inappropriate behaviour (Coughlan, 1988). Anger and depression can increase over time due to damage to orbital areas of the brain (Prigatano, 1992).

Open/Closed Head Injury

Open Head Injury

An open head injury refers to an injury where the skull has been penetrated. This can occur from gunshot or missile wounds, or when fragments of bone have penetrated the brain (Kolb & Whishaw, 1990). Tissue damage tends to be concentrated along the path of the object. In some cases, the penetrating object may cause damage to the brain because of shock waves and pressure. The extent and severity of this damage depends upon the object - its speed, wobble, and malleability (Lezak, 1995). In open head injuries there is an added risk of intracranial infection. Management of these injuries usually involves minimising that risk. However, infection may be delayed for months or years (Jennett & Teasdale, 1981).

Open head injuries usually produce distinctive and predictable symptoms, as the lesion is focal (Lezak, 1995). Often people with open head injuries do not lose consciousness, and when they do, they tend to have a rapid return to consciousness. Explanation of the extent of the forms and nature of open head injuries has contributed significantly to the understanding of brain function (Kolb & Whishaw, 1990).

Open head injuries caused by nonmissile accidents are classified into compound depressed fractures of the skull vault and fractures of the skull base. A fracture is determined to be 'depressed' if the inner table fragments are depressed by at least the thickness of the skull. A compound depressed fracture is when there is an associated scalp laceration. About half the cases of depressed fractures are caused by road accidents. Other open head injuries include puncture wounds caused by injuries with sharp instruments e.g. scissors; scalp wounds; and missile injuries from missile or gunshot wounds (Jennett & Teasdale, 1981).

Closed Head Injury

A closed head injury (CHI) is caused from a blow to the head, where the skull remains intact and the brain is not exposed (Lezak, 1995). Damage at the site of the injury is known as the coup injury, and any damage resulting from the brain being forced to the opposite side, is termed a countercoup. Microscopic lesions often occur as a result of the brain movement. This brain movement can also damage the major fibre tracts that connect areas of the brain, in particular, the corpus callosum and the anterior commissure. The corpus callosum connects the left and right hemispheres of the brain. If this connection is disrupted, what is known as the disconnection syndrome, occurs. Hemorrhages can occur from bleeding, producing pressure. If this bleeding forms into a mass, a hematoma will occur. Swelling of the brain results from edema, which refers to a collection of fluid in and around the damaged area (Kolb & Whishaw, 1990).

The pathology of CHI can be divided into two stages - primary injury which occurs at the time of impact, and secondary injury which may follow at any time after the injury. Primary injury consists of macroscopic lesions and microscopic lesions. Macroscopic lesions include the coup and countercoup contusions (bruising), and lacerations (tearing) from depressed skull fracture. Microscopic lesions include the shearing of nerve fibres (Kolb & Whishaw, 1990). Secondary injury after a CHI includes intracranial hemorrhage, edema, ischemic brain damage, intracranial pressure and brain shift. These secondary effects may be as destructive as the immediate effects, sometimes more destructive. Hemorrhages are the most common secondary injuries (Lezak, 1995).

CHI's can result from motor vehicle accidents, sports accidents, falls, explosions, and falling objects (Parker, 1990). In motor vehicle accidents, the frontal and temporal lobes are often damaged. This is because, when a vehicle comes to a sudden stop (rapid deceleration), the brain is slammed to the front of the skull (Lezak, 1995).

Blunt/Sharp Head Injury

Blunt Head Injury

Blunt head injury is due to acceleration/deceleration forces that effect the brain as a whole, often as the result of MVA's (Jennett & Teasdale, 1981). It is one of the most common types of head injuries and it overlaps with closed head injury. As soon as the skull is fractured, it becomes an open injury. At the time of the injury, skull fractures can cause contusions on the surface of the brain and countercoup contusions on the opposite side. Diffuse axonal injury may also occur, as well as intracranial hemorrhages and cerebral edema. Cerebral edema often occurs 12-24 hours after the initial injury. This can be a direct result of the primary damage, or it can occur as a result of any hypoxic or ischemic damage. Late effects of blunt head injury are the cumulative effects of the other injuries. Late effects can be loss of neurons and axons, atrophy and enlarged ventricles (Weller, 1994).

Cognitive sequelae after a blunt head injury include disturbances in learning and memory, rate of information processing, and adaptive or executive functions. Aphasia, apraxia, and agnosia are not characteristic after a blunt head injury (Tate, Fenelon, Manning & Hunter, 1991). The outcomes from a blunt head injury overlap with the outcomes already covered in the section on mild/moderate/severe injury.

Sharp Head Injury

Information on sharp head injury is limited. Hooper (1969) describes these injuries as focal. The area of the brain damaged is usually confined to the specific area that has been injured. With increasing force of the blow, there is more damage to other areas of the brain, but the damage at the site of the blow and consequences related to the area damaged, are most severe (Hooper, 1969).

Sharp head injuries occur from blows to the head i.e. from assault, being hit by a golf ball, or hitting the head on a cupboard door. Sharp head injuries overlap with open head injuries. Open injuries are often focal, but sharp injuries are not necessarily open.

One particular study which may have important implications for the present study was conducted by Dunlop, Udvarhelyi, Stedem, O'Connor, Isaacs et al. (1991). Their subjects, matched for initial severity, were separated into a deterioration group (deterioration in emotional or cognitive functioning 6 months or more following trauma), and an improvement group (improvement in functioning 6 months or more following trauma). Case records were reviewed and information was gathered on demographic characteristics, past medical and personal information, the location, type and nature of the injury, Glasgow Coma Score, the length of coma and amnesia, neurological symptoms, CT scan findings, psychiatric symptoms, and types of treatment. Dunlop et al. (1991) "found that the deterioration group was more likely to have been involved in assaults and less likely to have been involved in motor vehicle accidents than the improvement group" (p.154).

However, it was also found that the deterioration group was more likely than the improvement group to have a previous history of alcohol abuse. In addition to this, the deterioration group was more likely to have had a skull fracture with left parietal lobe damage. The most common symptoms to deteriorate were agitation/hostility, apathy, emotional lability, withdrawal, and depression (Dunlop et al., 1991). The cause of deterioration was not determined in this study.

Deceleration/Acceleration Head Injury

Deceleration Head Injury

Deceleration injuries occur when the moving head comes to a sudden stop. This often occurs in motor vehicle accidents. The brain tends to continue forward when the skull has stopped moving (Parker, 1990).

Acceleration Head Injury

Acceleration injuries occur when the (relatively) stationary brain is suddenly moved within the skull (Parker, 1990). The head is struck and suddenly moves, causing the brain to move in the opposite direction of the skull movement (Hooper, 1969), such as from a falling object, or being struck by a car.

Velocity

Motor vehicle accidents are often high velocity accidents. The impact is high because of the sudden deceleration typical of this type of accident. Falls are low velocity accidents as the impact is usually less severe. High velocity accidents, such as MVA's, are more likely to result in a serious head injury than low velocity accidents (Gronwall, 1991). In a comparison of high velocity and low velocity accidents, Currie (1993) found that individuals suffering from a high velocity injury experienced a higher incidence of multiple injuries associated with a high incidence of extracranial complications, than those suffering from low velocity injuries.

In conclusion, this section has described a number of different classification systems used for head injuries, and emphasized the overlap that occurs among these systems. This current study will provide data on the frequency and proportions within each classification system - minor/moderate/severe, deceleration/acceleration/compression, and low/high velocity.

OUTCOMES

Discussion of the outcomes of head injury typically include such neurobehavioural sequelae as social and cognitive, frontal lobe syndrome, and post-concussion syndrome. However, other outcomes are discussed and developed here because they are more likely to be associated with focal, non-MVA head injury. These include post-concussion syndrome (PCS), post-traumatic epilepsy, and post-traumatic stress disorder (PTSD). The outcomes will be presented in order according to the approximate frequency with which they are reported by head injured individuals and their families. As with classifications, these outcomes overlap with each other. For example, post-concussion syndrome and post-traumatic stress disorder both have some symptoms in common e.g. irritability, fatigue, and concentration difficulties. Frontal lobe syndrome overlaps with them both.

Post-concussion Syndrome (PCS)

"Severe symptoms may be produced by relatively minor injuries, although very few of these patients have objective focal neurological deficits" (Parker, 1990, p.281). Symptoms experienced immediately after regaining consciousness often include headaches, dizziness, vomiting, nausea, drowsiness and blurred vision. Symptoms often reported a few weeks later include headaches, dizziness, irritability, anxiety, depression, poor memory, poor concentration, insomnia, fatigue, poor hearing and poor vision (Rutherford, 1989). However, the most commonly reported symptoms include headaches, dizziness, poor concentration and memory, fatigue and irritability (Bohnen, Twijnstra & Jolles, 1992; Currie, 1993; Gronwall, 1991; Jennett & Teasdale, 1981). Nearly 70% of individuals admitted to hospital after minor head injury experience headaches, and approximately 70% also experience dizziness (Currie, 1993). In a study of approximately 4000 patients, over 95% appear to have had a post-traumatic headache after cerebral concussion (Sadwin, Rothrock, Mandel, Sadwin & O'Leary, 1993). Bohnen, Jolles and Twijnstra (1992) found that their subjects with PCS performed slower on attention tasks and were less efficient in information processing, than head injured subjects without PCS and controls.

PCS has also been termed post-traumatic headache, post-brain trauma cephalgia, and post-accident headache (Sadwin et al., 1993). Post-concussion symptoms involve an organic basis that results from head injury, as well as the individual's emotional response to the trauma (Long & Williams, 1988). The symptoms resulting from a minor head injury may produce major medical and social disruptions to the head injured individual and his/her family (Leathem, Heath & Woolley, 1996; Sadwin et al., 1993), and can affect the individual's ability to return to previous levels of functioning (Jennett & Teasdale, 1981).

Neurobehavioural Sequelae of Head Injury

Neurobehavioural sequelae of head injury with be discussed in terms of both behavioural-cognitive behaviour and behavioural/personality/social behaviour.

Cognitive

Behavioural-cognitive outcomes are very important consequences of head injury. The most common problems will briefly be discussed.

Attentional difficulties are very common among head injured individuals. These difficulties can be divided into arousal, sustained attention and concentration, selective attention, and alternating attention. Individuals with moderate or severe head injuries generally exhibit all or most of the above difficulties (Morse & Montgomery,1992).

Memory is a persistent complaint of many individuals with head injuries. PTA is commonly experienced immediately after the injury. Generally, the more severe the injury, the more severe the memory impairment. Recovery from memory impairment is slower than other cognitive functions, with many people still complaining of memory difficulties after two years (Brooks, 1983). Types of memory affected include: anterograde and retrograde memory, declarative and procedural memory, and auditory verbal and visual spatial memory. Anterograde and declarative memory difficulties are most common. The processes involved in learning are also affected with head injury (Morse & Montgomery, 1992).

Executive functions include the many processes involved in completing goals and problem solving. The frontal lobes play an important role in executive functioning. This is why many individuals who have head injuries from motor vehicle accidents have problems with this type of organization and planning (Morse & Montgomery, 1992).

Finally, language is often disrupted with moderate to severe injuries. Aphasia is the term used for language problems. These include: word-finding, understanding complex material, pragmatics, spelling, writing and articulation, and mathematics (Morse & Montgomery, 1992).

A number of neuropsychological tests measure the cognitive outcomes of head injury. Such tests include the Wechsler Adult Intelligence Scales (Revised), the Wechsler Memory Scale (Revised), the Rey Auditory Verbal Learning Test, Rey-Osterreith Complex Figure, and the Paced Auditory Serial Addition Test.

Behavioural

"The behavioural manifestations of head injury are perhaps the most difficult to understand, measure, predict, and treat of all of the disorders that accompany traumatic brain injury" (Rosenthal, 1983, p.197). The most common behavioural and personality changes include increased irritability and increased withdrawal; lack of motivation; reduced ability to tolerate pressure; reduced or lack of self-confidence; becoming tactless, impulsive, impatient, short tempered and socially inappropriate (Coughlan, 1988). Anger and depression can increase over time with moderately to severely head injured individuals (Prigatano, 1992). Other behavioural problems can include increased frustration, greater dependence on others, insensitivity to others, and an overall more demanding attitude (Prigatano, 1986). Irritability, social withdrawal, socially inappropriate behaviour and anxiety will be discussed in more detail, as these are often the most common and most disrupting symptoms resulting from head injury.

Prigatano (1992) suggests that "Irritability, which can briefly be defined as a tendency to be easily annoyed or upset, is commonly reported after TBI" (p.363). Many individuals with a head injury are highly active, impatient and restless. They often become irritated when attempting a task that used to be easy, but is now difficult. Frustration may occur and the individual can become angry and upset at the people around him/her (Howard & Bleiberg, 1983). An individual who becomes irritated may display a variety of behaviours such as hyperactivity, aggressive behaviour (verbal or physical), disinhibition, or reduced control (Charness, 1986).

Social withdrawal sometimes occurs after the individual has repeatedly failed in coping with the environment. Generally this means less social contact with others. This can also cause depression, which includes feelings of worthlessness, helplessness, guilt, lack of interest in work and family, and decreased libido (Prigatano, 1986). Lack of motivation can be seen in many forms. Some of these include decreased drive, decreased initiative, reduced interactions, reduced rate of activity, flat affect and passivity (Charness, 1986).

Socially inappropriate behaviour can be observed in some head injured individuals. These individuals may be talkative, given to making jokes (often inappropriately), flippant, and only want their own opinions to be heard. There may be inappropriate sexual behaviour and sexual remarks (Coughlan, 1988). Judgement and tactfulness in social situations are generally qualities that individuals exercise according to their personality and the type of situation. However, "when a person, who is normally well behaved socially, sensitive to the needs of others, and in control of those inner feelings of dislike and frustration that everyone experiences from time to time, becomes tactless, talkative, and hurtful, there is no doubt about the change" (Jennett & Teasdale, 1981, p.295). The individual lacks the ability to inhibit impulses and cannot regulate any of his/her behaviours (Howard & Bleiberg, 1983). Impaired self control can include disinhibition, impulsiveness, reduced self-monitoring, and an inconsistency between planned and actual behaviour (Charness, 1986). Examples of impulsiveness include impulsive eating, sexual impulsiveness, impulsive spending of money, and substance abuse (Lezak, 1988). The individual often cannot understand abstract meanings, i.e. 'can't take a hint' or understand sarcasm.

Anxiety can occur when head injured individuals are unable to deal with their cognitive confusion. They may feel threatened, and feel anxiety about their life. Some may feel a need to relieve anxiety and tension, and may do so by being impulsive and behaving inappropriately. These behaviours can add to the individual's confusion and feelings of hopelessness (Prigatano, 1986).

Frontal Lobe Syndrome

The so-called frontal lobe syndrome overlaps with other outcomes. The frontal and temporal lobes are often damaged bilaterally in head injuries, particularly MVA's. Altered emotional behaviour is commonly reported after frontal lobe damage. The most common changes include decreased drive (apathy), decreased self-monitoring, and lack of control (disinhibition) (Stuss & Benson, 1986). The most classic example of the frontal lobe syndrome is that of Phineas Gage, written by Harlow in 1968. Gage was a dynamite worker who sustained a severe open/sharp frontal lobe injury when an explosion blasted an iron tamping bar through the front of his head. Gage survived the accident and his physical recovery was near complete. However, his emotional behaviour and personality significantly changed. He was described as being fitful, irrelevant, indulging in gross swearing, having little opinion of his friends, impatient, stubborn, and unpredictable (Stuss & Benson, 1986; Kolb & Whishaw, 1990). Different regions of the frontal lobes produce different symptoms when damaged. Damage to the orbitofrontal cortex produces the positive symptoms (pseudopsychotic) mentioned below. When the dorsolateral prefrontal area is damaged, negative symptoms (pseudodepressed) are displayed. Damage to the medial frontal area produces symptoms such as a lack of spontaneous movement, gesture and verbal output (Parker, 1990).

Two types of personality are typical of frontal lobe damage. These are pseudodepression and pseudopsychopathy (Kolb & Whishaw, 1990; Parker, 1990). Pseudodepressed people (damage more likely left-sided) exhibit negative symptoms such as apathy, indifference, loss of initiative, reduced sexual interest, little overt emotion, reduced talking and an inability to plan ahead. Pseudopsychotic people (damage more likely right-sided) exhibit positive symptoms such as immature and inappropriate behaviour, restlessness, lack of tact, coarse language, promiscuous sexual behaviour, hyperactivity, and they often make poor jokes, tell pointless stories, and find them very funny even if others do not (Kolb & Whishaw, 1990; Parker, 1990).

The following tables summarize the consequences of head injury, by listing the symptoms reported by different researchers. The lists are arranged in this way to show the most commonly reported symptoms, and to illustrate differing opinions. Tables 1.4 and 1.5 list the emotional and personality changes resulting from head injury and frontal lobe damage respectively. Table 1.4 suggests that the most commonly reported symptoms are irritability, anger/aggressiveness, impulsiveness, inappropriate social behaviour, emotional lability, anxiety, depression, psychotic behaviour, and childishness. Table 1.5 shows that the most commonly stated symptoms of frontal lobe damage are loss of initiative/drive/goal-directed behaviour and inappropriate social behaviour. There is a lot of overlap between these two tables. However, a number of symptoms associated with frontal lobe damage (Table 1.5) have been reported, that are not present in Table 1.4. These include: poor judgement; dull or flat affect; diminished anxiety; facetiousness; mild euphoria; decreased self-monitoring; rigidity; and over reactivity.

Table 1.4: Emotional and Personality Changes reported by researchers as resulting from Head Injury

	Prigatano, 1992.	Rosenthal, 1983.	Morse & Montgomery, 1983.	Coughlan, 1988.
Irritability	#	#	#	#
Anger/aggressiveness	#	#	#	#
Loss of initiative/drive/ goal-directed behaviour	#	#	#	#
Impulsiveness	#	#	#	#
Inappropriate Social Behaviour	#		#	#
Emotional Lability	#	#	#	
Anxiety	#	#	#	
Depression	#	#	#	
Psychotic Behaviour	#	#	#	
Childishness	#	#	#	
Apathy		#	#	
Helplessness	#	#		
Impatience	#			#
Denial		#	#	
Selfishness		#	#	
Lack of insight of limitations	#		#	
Sensitivity to pressure/ distress/noise	#			#
Sexual Disturbances		#	#	
Violence	#			
Reduced self-confidence				#
Withdrawal				#
Untidiness		#		
Restlessness	#			
Suspiciousness	#			
Drug/Alcohol Abuse		#		
Aspontaneity	#			
Sluggishness/tires easily	#			
Loss of interest in environment	#			

Table 1.5: Emotional and Personality Changes reported by researchers as resulting from Frontal Lobe Damage

	Rosenthal, 1983.	Walsh, 1994.	Stuss & Benson, 1986.	Lezak, 1995.
Loss of initiative/drive/ goal-directed behaviour	#	#	#	#
Inappropriate Social Behaviour	#		#	#
Impulsiveness		#		#
Apathy	#		#	
Decreased self-monitoring			#	#
Childishness	#			
Anger/aggressiveness	#			
Sexual Disturbances	#			
Poor Judgement	#			
Dull or Flat affect	#			
Diminished Anxiety		#		
Sluggishness/tires easily	#			
Facetiousness		#		
Mild euphoria		#		
Rigidity			#	
Over reactivity			#	

Post-traumatic Epilepsy

Epilepsy is defined by recurrent, unprovoked seizures, i.e. a single seizure does not mean epilepsy (Jacobson & Sperling, 1993). Epilepsy can develop days, months or years after the head injury, although the greatest risk for post-traumatic epilepsy is in the first year, when the onset can be very disrupting to the person who has made considerable recovery (Jennett, 1983). Although the risk for developing post-traumatic epilepsy is between 5% and 10% regardless of the severity of the head injury (Jacobson & Sperling, 1993), it is more common after head injuries that are severe rather than moderate or minor (Jennett, 1983).

Post-traumatic epilepsy has been divided into two subgroups - early and late epilepsy. Early epilepsy usually occurs in the first week after the injury, frequently in children under 5 following a mild head injury, and seldom in adults except when the injury involves a depressed fracture, intracranial hematoma, or several hours of unconsciousness (Jennett, 1983). Late epilepsy is more common in the first year after head injury. Three main factors have been found that increase the likelihood that late epilepsy will develop. These include acute intracranial hematoma, early epilepsy, and depressed fracture of the skull vault (Jennett, 1983). Of the individuals who have a depressed fracture penetrating the dura, about one third will have epilepsy. This proportion increases to about 80% if these individuals have a seizure within the week after the injury, or if they were unconscious for more than 24 hours (Martin, 1974).

Another aim of the present study was to report the frequency of post-traumatic epilepsy, and to clarify any relationships between post-traumatic epilepsy and particular types of injury.

Post-traumatic Stress Disorder (PTSD)

Post-traumatic stress is a normal reaction to sudden or abnormal events in people's lives. Whether or not a person experiences PTSD, or to what extent, is dependent upon a number of factors. These include the extent and nature of the trauma, previous experiences, background, personality, and the amount and quality of support received (Parkinson, 1993).

"Symptoms found in patients following motor vehicle accidents are not limited to post-concussion syndrome" (Rubinstein, 1993, p.112). Rubinstein (1993) found that the most frequent symptom reported from his patients was the recurring re-experiencing of the accident. These took the form of flashbacks, dreams, or physiologic reactivity when exposed to the conditions related to the accident. The anxiety associated with this is characteristic of PTSD. However, it was unclear from the study whether or not Rubinstein's (1993) patients had head injuries. Davidoff, Laibstain, Kessler & Mark (1988) suggest that if an individual with a minor head injury fails to recover from post-concussion syndrome, then that individual is suffering from post-traumatic stress disorder.

Behavioural symptoms commonly associated with PTSD from a head injury include: sleep-cycle disturbances, concentration difficulties, irritability, anger, and extreme alertness to danger. The most frequent of these symptoms is sleep-cycle disturbance, commonly caused by nightmares. People with PTSD also suffer from a lack of energy, fatigue, inertia, and loss of initiative. These symptoms may lead to a depressive syndrome (Rubinstein, 1993). The above symptoms also overlap with the neurobehavioural difficulties from head injury.

After a traumatic episode many people experience grief. Reactions are different from one person to another, but the process can be broadly categorised into four stages. Stage one is shock. Reactions of denial and crying are typical of this stage. Stage two is anger. This includes blame, anxiety and fear. Stage three is depression. Feelings of helplessness, loss of identity and isolation are commonly experienced. Stage four is acceptance and healing (Parkinson, 1993). Individuals who have had head injuries may go through the grieving process, particularly if they are aware of the consequences of the injury.

Indirect consequences of head injury reflect the individual's emotional reactions to awareness of the head injury and its consequences. A head injured individual may or may not be aware of their deficits, depending upon the type and extent of the head injury (Lezak, 1988). Therefore, it seems that individuals who are aware of their difficulties are more likely to experience post-traumatic stress and grief.

Head injured individuals become anxious when they realise they have changed, particularly their mental ability. Anxiety can also occur as a result of fears of not being in control of ones own life. Their self-confidence decreases which may result in feelings of inadequacy, confusion, and even fears of going crazy. Depression may occur as a response to loss. This loss may take the form of the loss of the use of a limb, the loss of some mental ability, or the loss of a job, independence or dignity (Lezak, 1988).

FACTORS AFFECTING RECOVERY AFTER HEAD INJURY

The process of recovery after a head injury is influenced by a number of factors. A previous head injury can significantly affect recovery. Having more than one head injury can produce a cumulative effect, causing recovery to be slower. If a person has had minor head injuries, the cumulative effects eventually lead the injuries to equal that of a major head injury (Parker, 1990). The effects of age on recovery has been long debated, and is generally suggested that younger people recover better than older people (Long & Schmitter, 1992).

Other pre-injury factors that can influence recovery include: education; occupation; socioeconomic status; and pre-existing diseases (Long & Schmitter, 1992). Psychiatric disorders such as depression and neurosis, and alcohol or other substance abuse often reduce the rate of recovery. Any previous stressors, or additional stressors resulting from the head injury may amplify the situation. These stressors may include: relationship problems; financial problems; or employment worries (Gronwall, 1991). Previous personality characteristics can affect the person's attitude toward the trauma, and how they adapt to the consequential effects (Parker, 1990).

Other factors than affect recovery include: the nature of the injury; the length of time since the injury; level of intelligence; profession, social and family support; motivation; and communication skills (Parker, 1990).

While it was outside the scope of the present study to examine how factors affect recovery, information would be provided on the age of the subjects, education, frequency of multiple injuries, nature of the injury, and the time between the injury and clinical attention.

SUMMARY

This chapter has provided a detailed overview of head injury. Areas discussed were epidemiology, measures of severity, classification, outcomes - post-concussion syndrome, neurobehavioural sequelae of head injury, frontal lobe syndrome, post-traumatic epilepsy, and post-traumatic stress disorder, and finally factors affecting recovery. Although classification systems and outcomes were described separately, there is clearly considerable overlap between them. This overlap between outcomes and between classifications is not often acknowledged, with head injuries generally lumped together without differentiation between the differing effects of different types of injuries i.e. sharp and blunt, and research is typically based on the minor/moderate/severe dimension, and less on open/closed. The classification sharp/blunt has rarely been documented, nor has the neurobehavioural consequences of sharp head injury. Yet the Dunlop et al. (1991) study clearly suggests that emotional and behavioural deterioration is more likely associated with sharp head injury.

The current study will examine epidemiology of the following areas:

- Cause of accident
- Gender and Ethnicity
- Age and Education
- Classification systems - mild/moderate/severe, acceleration/deceleration/compression, high velocity/low velocity
- Post-traumatic Epilepsy
- Neurobehavioural outcomes

CHAPTER TWO

FORMULATION/HYPOTHESES

The number of young people sustaining head injuries has been termed the 'silent epidemic'. That the victims are young has important long-term health and welfare implications. Why some individuals do well after head injury, while others have symptoms sometimes in excess of what might be expected from the severity of the injury, is a mystery and major concern.

Clinical observation, and more recently specific research (Dunlop et al., 1991), suggests that it is possible that those with 'sharper' head injuries occurring at lower velocity, represent a different group. These injuries, often sustained by an assault or a fall are not as commonly reported as closed/blunt head injuries and therefore, have not been documented as widely.

The purpose of the first part of this study was to compare the demographics of a group of subjects with generalized/blunt head injuries to a group with focal/sharp head injuries. These groups would then be compared in part two for difficulties in neuropsychological functioning. It was hypothesized that some of the neurobehavioural consequences of focal/sharp head injury would be worse than those associated with generalized/blunt head injury, particularly in terms of irritability and a higher likelihood of developing post-traumatic epilepsy. Further, it was thought that focal/sharp head injuries and generalized/blunt head injuries could result in different cognitive outcomes and levels of PTSD. Finally, it was expected that individuals with focal/sharp head injuries (not sustained from MVA's) would be less likely to suffer from the symptoms associated with frontal lobe syndrome, which are associated more with MVA's.

Part One

Epidemiology

Where possible, demographic information concerning head injury, would be compared to overseas data. It was expected than no differences would be found.

Sequelae

It was specifically hypothesized that there would be differences between individuals with focal/sharp head injuries and those with generalized/blunt head injuries, between individuals with injuries sustained at high velocity and those sustained at low velocity, and between groups with acceleration and deceleration injuries, along the following dimensions:

- Irritability
- Post-traumatic epilepsy
- Post-traumatic stress

Part Two

Neuropsychological sequelae in terms of general cognitive function and frontal lobe function, would be considered on the following dimensions:

- Cause of Head Injury	MVA & MBA / Falls, Collisions, Assaults, Other
- Velocity	Low Velocity / High Velocity
- Force	Acceleration / Deceleration
- Site of Injury	Nonfocal / Focal

As cause of head injury, velocity, force and site of injury overlap considerably with each other, it is likely that similar differences would be seen among these categories.

Taken as a group, it was predicted that the subjects from the present study would differ significantly from the normative data.

CHAPTER THREE

METHOD

OVERVIEW OF THE PRESENT STUDY

This study involved two parts, both using data which had been previously collected from clients with head injuries. Part one considered the demographic characteristics and the physical and behavioural outcomes of 235 people with head injuries. Part two of this study involved using statistical analyses (t-tests) to compare the performance of different groups of head injured subjects, on a wide range of neuropsychological measures.

Methodological issues will be presented, including ethical concerns, demographic information about the subjects, the procedures employed for both parts of this study, and the measures used.

ETHICAL ISSUES

Subjects in this study had previously signed a consent form allowing their information to be used for research purposes. Data for each subject was given an identification number to ensure privacy and confidentiality. Identity and identifying characters of the subjects were known only to the clinic director. Once information was entered onto data files, anonymity was ensured. Data files were only seen by the current investigator and her supervisor.

RESEARCH SETTING

Subjects had been previously seen at the Massey University Psychology Clinic located on the Massey University Campus in Palmerston North. A smaller group of subjects with head injuries had been previously interviewed and assessed at Manawatu Prison, a low security facility, located at Linton, approximately 10 km south of Palmerston North.

SUBJECTS

A total of 235 subjects were included in this study. Of these 203 were consecutive clients previously seen at the Massey University Psychology Clinic between 1989 to the present day. The remaining 32 subjects were males from the Manawatu Prison who had volunteered to be part of a control group in a previous study. Initial interviews, however, had revealed that these individuals had sustained head injuries in the past.

Subjects were screened to exclude those with confounding factors which could distort the results. These factors which included alcohol and substance abuse, strokes and psychiatric illness could have complicated the results, rendering it difficult to determine whether the head injury was solely responsible for the neuropsychological sequelae. Table 3.1 presents the demographic characteristics of the subjects involved in the first part of this study.

Table 3.1: Demographic Characteristics of Subjects (n=235)

Gender	(n)	(%)
Male	171	72.8
Female	64	27.2
Age		
11-20	41	17.4
21-30	93	39.6
31-40	58	24.7
41-50	28	11.9
51-60	9	3.8
61+	6	2.6
Ethnicity		
Pakeha	177	75.3
Maori	49	20.9
Other	7	3.0
Not Stated	2	0.8
Years of Secondary Education		
No High School Education	4	1.7
High School 1-2 yrs	69	29.4
High School 3-4 yrs	97	41.3
High School 5 yrs	21	8.9
Tertiary 1-2 yrs	20	8.5
Tertiary 3+ yrs	11	4.7
Not Stated	13	5.5

PROCEDURE

Information extracted from clients' files included demographic characteristics (gender, age, ethnicity and education), information about the injury, and behavioural and physical sequelae resulting from the injury, as well as neuropsychological test results.

Information about the injury included the cause, severity, force, velocity, site of injury and assessment interval. Cause of head injury included MVA, MBA, fall from a height, fall from a moving object, fall other (tripping over), assault with an object (hammer, bottle), assaults (fight, attack), collisions (sporting accidents, running into a tree, being hit by a roller door, knocking the head on a cupboard door) and other/more than one head injury. The final category 'other/more than one head injury' included the few head injuries that could not be classified under the other categories (e.g. chainsaw accident), and a considerable number of subjects who had sustained multiple head injuries.

Other information about the head injury included severity (PTA), the force of the injury (acceleration, deceleration, compression or multiple [since only one subject sustained injury due to multiple forces, this subject was excluded from the analysis]), the site of injury (nonfocal, occipital, parietal, temporal, frontal, fronto-temporal), velocity (low velocity - impact less than estimated 10 mph, or high velocity - impact more than estimated 10 mph), and assessment interval (months between the injury and being seen at the clinic).

Behavioural and physical sequelae resulting from the head injury were determined from the clients' case notes, and included irritability, mood (appropriate, depressed, euphoric, flat), psychotic behaviour, anxiety and flashbacks. Physical sequelae included epilepsy, headaches, dizziness, eye, ear, smell and taste problems.

All the above information, along with any neuropsychological results was entered into a data base. It is important to note here, that not all neuropsychological measures had been administered every client.

The first part of the present study involved a series of basic analyses conducted to determine frequencies and proportions of factors surrounding the cause of head injury and neurobehavioural sequelae. In the second part of the study, comparisons were made between the performance of various groups (as set out in table 3.2) on a range of neuropsychological assessment measures. Matching subjects for different variables resulted in groups with varying numbers of subjects.

Table 3.2: Groups and Variables Selected for Analysis

	Group 1	**N (Range)**	**Group 2**	**N (Range)**
Whole Sample	MVA & MBA	12-90	Falls, Collisions, Assaults, Other	11-87 *
Assessment Interval (less than 36 months)	"	9-30	"	13-39
Gender, Ethnicity, Education, Severity	"	17-31	"	9-17
Whole Sample	Low Velocity	11-59	High Velocity	12-57
Gender, Education	"	9-42	"	9-56
Whole Sample	Acceleration	8-23	Deceleration	28-118
Whole Sample	Nonfocal	9-10	Focal	44-58

* The upper values do not add to 235, as no test was completed by all of the subjects.

MEASURES

The following psychological and neuropsychological tests were used.

Wechsler Adult Intelligence Scale - Revised (WAIS-R):

This test is designed to measure general intellectual functioning of individuals aged 16-74 years. It consists of eleven subtests - six verbal tests and five performance tests (Spreen & Strauss, 1991; Wechsler, 1981), as described in Table 3.3 below.

Table 3.3: Subtests of the WAIS-R

Verbal Subtests	
Information	Comprises of 29 general knowledge questions.
Digit Span	Lists of three to nine digits are read aloud by the examiner, and then recited back from memory by the subject. In the second part, subjects are to recite two to eight digits in reverse order.
Vocabulary	The subject is asked to state what each word means.
Arithmetic	The subject is given math problems to solve without the use of pen and paper.
Comprehension	16 items assessing logical reasoning and understanding of proverbs.
Similarities	The subject is to say how two items are similar.
Performance Subtests	
Picture Completion	Identification of missing parts on 20 cards.
Picture Arrangement	Sets of cards are to be arranged so that they tell a story.
Block Design	Reconstruction of a series of designs by putting together blocks.
Object Assembly	Cut-out components of common objects.
Digit Symbol	The subject is presented with a key with nine symbols paired with nine digits. The subject is to fill in the symbols under the corresponding number. The time limit is 90 seconds

(Anastasi, 1982; Wechsler, 1981)

Rey Auditory Verbal Learning Test (RAVLT):

The purpose of this test is to assess learning and memory. A list of 15 nouns (List A) is read to the subject. The subject is then required to recall the list. After five trials are completed, a different list of 15 words (List B) is read as an interference. Subjects recall List B, and then List A again. After 20 minutes delay, subjects must recall List A. Finally, a story is read that includes all words in List A. Subjects are required to identify as many words from that list as they can (Spreen & Strauss, 1991; Rey, 1964).

Rey-Osterrieth Complex Figure Test (RCFT):

This test measures visuospatial constructional ability and visual memory. The subject is to copy the complex figure as accurately as possible. The subject is then asked to recall the figure from memory. After 30 minutes delay, the subject is to recall the figure again (Spreen & Strauss, 1991; Rey, 1941; Osterrieth, 1944).

Logical Memory (subtest of Wechsler Memory Scale-Revised):

This verbal memory measure involves reading a story to the subject and asking the subject to recall as much of it as possible. A second story is then read to the subject and again recalled by the subject from memory. After a 30 minute delay, the first, then the second story is recalled by the subject, and then Story B (Spreen & Strauss, 1991; Wechsler, 1987).

Finger Tapping (part of the Halstead-Reitan Neuropsychological Battery):

This test is designed to measure motor speed. Subjects are required to tap on the manual tapper as quickly as possible for 10 seconds for 5 trials, using the dominant index finger first, then non-dominant (Spreen & Strauss, 1991).

Trail Making Test (part of the Halstead-Reitan Neuropsychological Battery):

The purpose of this test is to assess visual attention, mental flexibility and motor function. The subject is required to join 25 numbers randomly scattered on a page, in the correct order, as quickly as possible, and without lifting the pencil from the paper (Spreen & Strauss, 1991).

Paced Auditory Serial Addition Test (PASAT):

This is a test to assess information processing. Sixty-one numbers (pre-recorded on a cassette tape) are read to the subject. The subject must add pairs of numbers so that each new number is added to the previous number. The subject gives the response aloud, which is recorded by the examiner. Four trials are given at differing speeds (Spreen & Strauss, 1991; Gronwall, 1977; Gronwall & Sampson, 1974; Gronwall & Wrightson, 1981).

Stroop Colour-Word Test (SCWT):

The SCWT measures information processing, concentration and divided attention. The three trials include reading the word (either "green", "red" or "blue") written in black on white background, reading the colour of XXXX's (in green, red or blue ink), and reading the colour of the ink of the word, "green", "red" or "blue" (written in different coloured ink than it reads). (Spreen & Strauss, 1991; Stroop, 1935).

The Milner/Austin Maze:

This test measures self-correcting behaviour, and the ability to follow instructions. Through trial and error, the subject is required to learn a path through a 10 by 10 grid of boltheads using a stylus. The number of errors is expected to decrease as the subject learns the path (Walsh,1985; Milner, 1965).

Twenty Questions:

This is a test of deduction, logical thinking and problem solving. The subject is presented with a page of 42 pictures, and asked first to name them. The examiner then thinks of one picture and asks the subject to find out what it is by asking questions, to which the examiner may answer only yes/no. The object is to identify the correct item having asked as few questions as possible. Questions can be divided into constraining (any question referring to two or more pictures, e.g. 'can it be eaten?'), non-constraining (question referring to a specific picture, e.g. 'is it the fish?'), and pseudo-constraining questions (question which refers only to a single picture, e.g. 'does it have fins?'). The subject's score is recorded according to the total and type of questions asked (Lezak, 1995; Laine & Butters, 1982).

CHAPTER FOUR

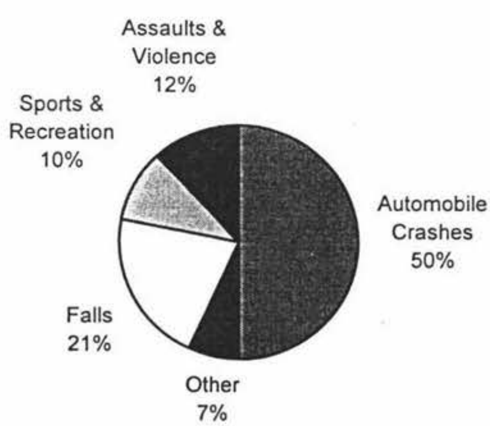
RESULTS

PART ONE: EPIDEMIOLOGY

Factors Affecting Head Injury

a) Causes of Head Injury

The various causes of head injury are depicted in Figure 4.1. The first graph (Figure 4.1a), provided by the Department of Health and Human Services (1989) (cited in Wright, 1993), is included as a comparison point for the results obtained in this study.



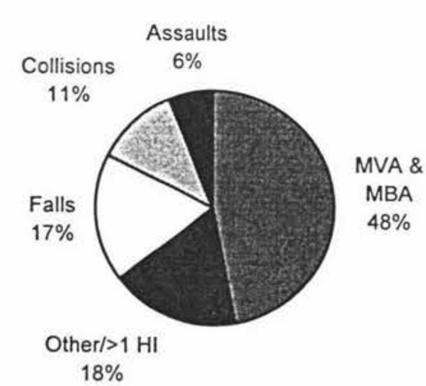


Figure 4.1 Causes of Head Injury

a) Department of Health and Human Services (1989) (cited in Wright, 1993)

b) The Present Study

The second graph (Figure 4.1b) shows the causes of head injury from the total sample of subjects (n=235) involved in the present study. According to this data, motor vehicle accidents (MVA's) and motor bike accidents (MBA's) were the leading cause of head injuries (46.81%) in the current study. Other/more than one head injury constituted 17.87% of all head injuries, followed closely by falls (17.45%), then collisions (11.49%), and finally assaults (6.38%).

Comparison of these two graphs reveals the proportion of assaults in the current study is only half the number of assaults and violence in the U.S. study, where the 'other' category is more than doubled. However, since it is unclear what exact criteria were used for allocation to respective groups in the U.S. study, the difference could be due to classification rather than representing a real cross-cultural difference.

b) Severity

The proportion of subjects sustaining mild, moderate and severe head injuries according to the cause of accident is presented in Figure 4.2. The data suggest that the majority of MVA's, MBA's and falls result in severe head injuries, and that the majority of assaults, collisions, and other/more than one head injury result in mild head injuries.

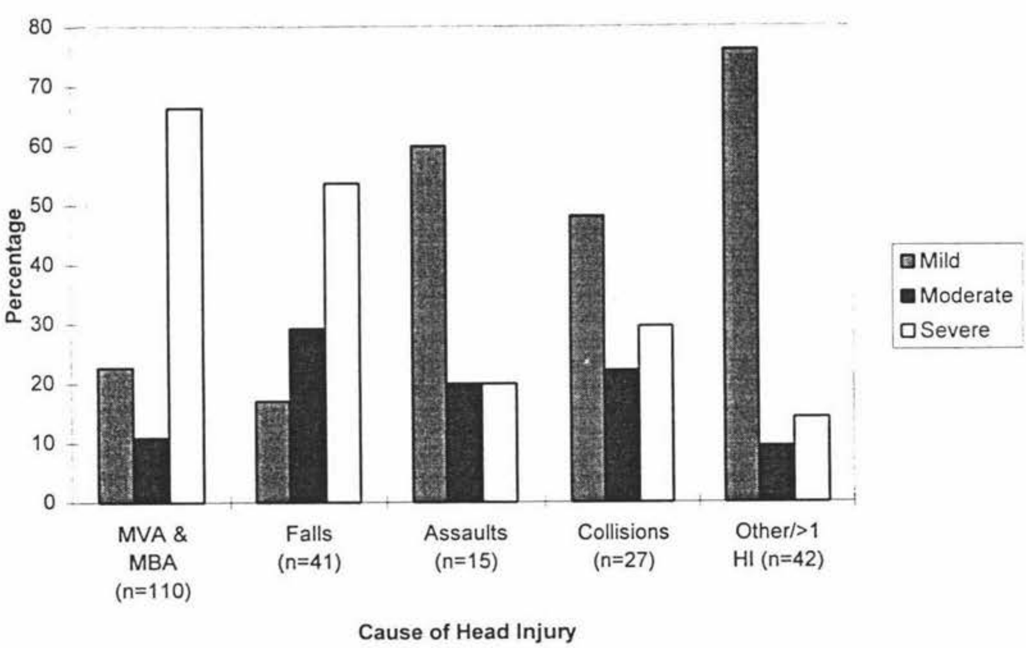


Figure 4.2

Proportion of Subjects sustaining Mild, Moderate and Severe Head Injuries according to the Cause of Head Injury

c) Velocity

Figure 4.3 shows the proportion of subjects sustaining head injuries at low and high velocity according to the cause of accident. MVA's and MBA's were predominantly sustained at high velocity, whereas falls, collisions and other/more than one head injury were mostly sustained at low velocity. However, assaults were solely low velocity injuries.

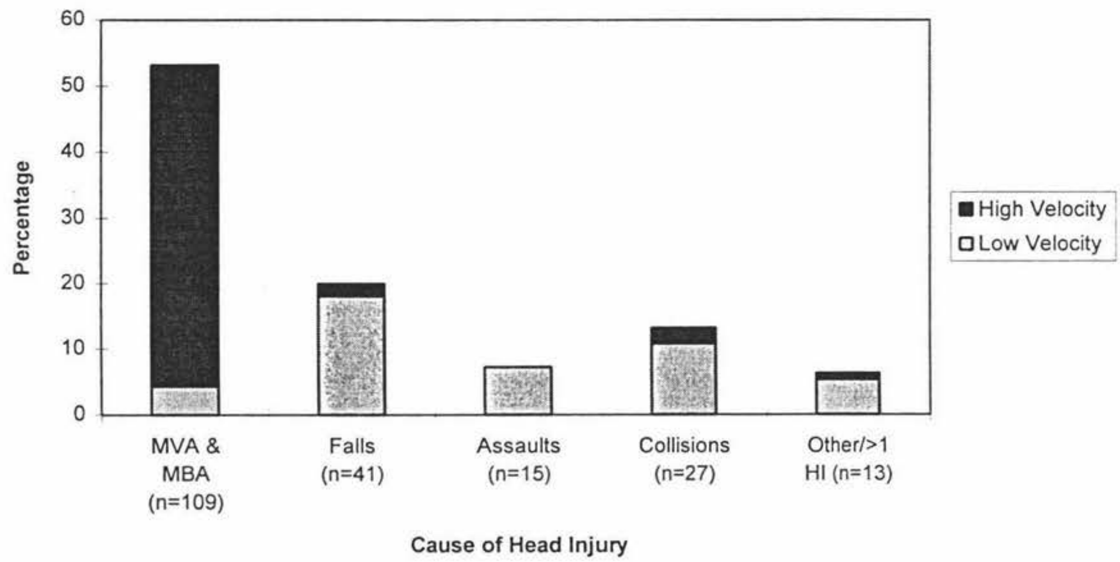


Figure 4.3

Proportion of Subjects sustaining High Velocity and Low Velocity Head Injuries according to the Cause of Head Injury

d) Gender

The proportion of female and male subjects according to the cause of accident, is shown in Figure 4.4. The ratio of males to females is 2.67:1, with the proportion of males in comparison to females, greater in each of the five cause of head injury categories. A different way of looking at gender is shown in Figures 4.5a and 4.5b, where proportions of the causes of head injury are presented independently for females and males. For example, Figure 4.4 shows that 47% of all head injuries are due to MVA's and MBA's, with a male to female ratio of nearly 2:1. However, of all head injuries sustained by males 43% were due to MVA's and MBA's (Figure 4.5b), compared to 60% for females (Figure 4.5a).

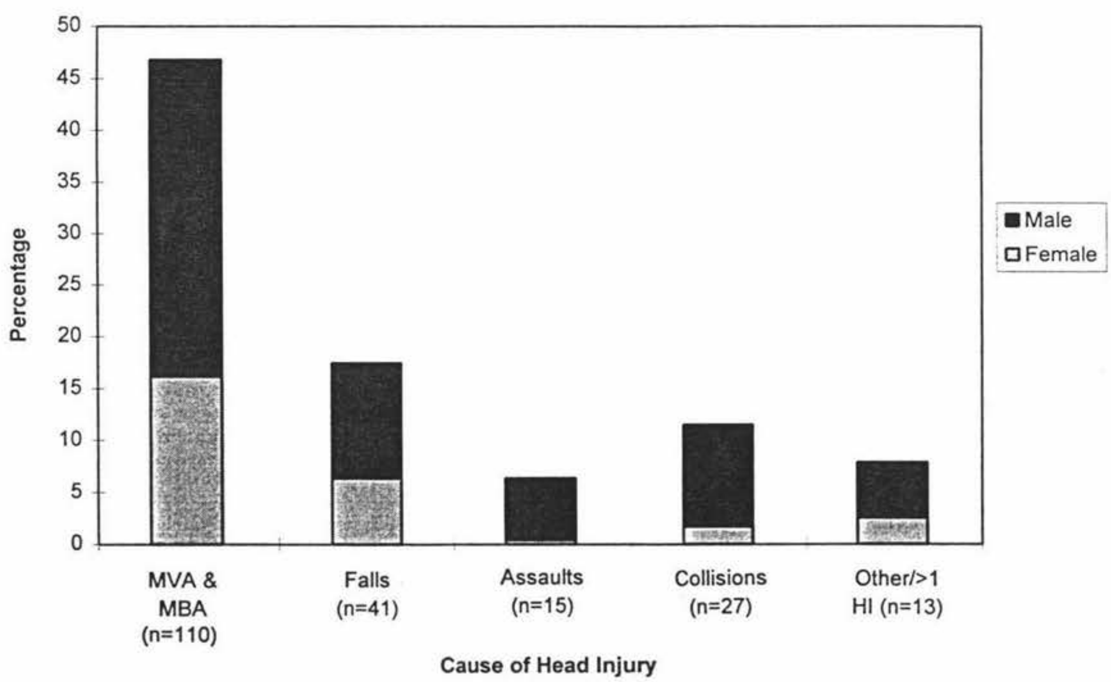


Figure 4.4

Proportion of Female and Male Subjects according to the Cause of Head Injury

i) Females

While females clearly sustained fewer head injuries than males, 60% of their head injuries were due to MVA's and MBA's, followed by falls at 23%, other/more than one head injury, and collisions. Assaults accounted for fewer head injuries in females than males.

ii) Males

MVA's and MBA's were also the leading cause of head injuries for male subjects, followed by other/more than one head injury, then falls, collisions and assaults.

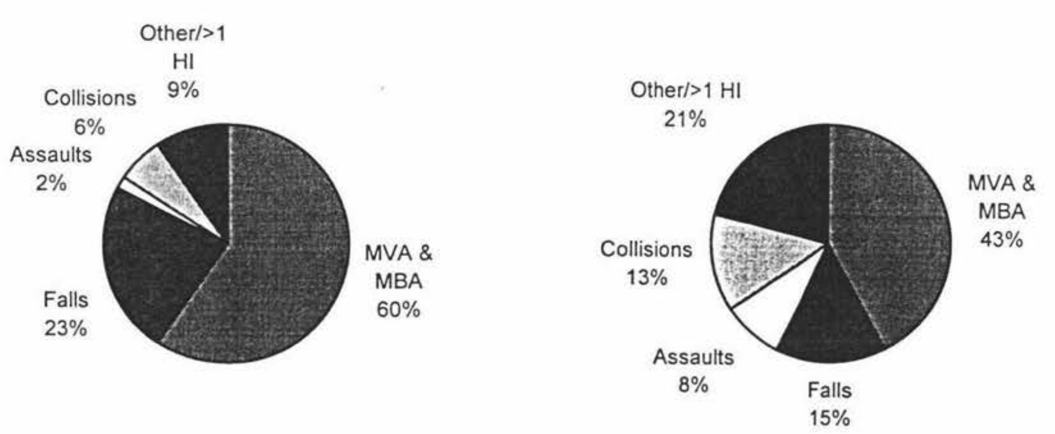


Figure 4.5

a) Proportion of Female Subjects sustaining Head Injuries according to the Cause of Head Injury

b) Proportion of Male Subjects sustaining Head Injuries according to the Cause of Head Injury

e) Ethnicity

The proportions of Pakeha, Maori and subjects of other ethnic origin, sustaining head injuries due to different causes, is shown in Figure 4.6. The proportion within each cause of accident category is dominated by Pakeha people. However, since thirteen per cent of the general population identify as New Zealand Maori (Department of Statistics New Zealand, 1994) and 21% of the subjects in the present study identified as being Maori, Maori are clearly overly represented in head injury statistics. Further, of those receiving head injuries from assaults, 40% of them were Maori, and of people in the category other/more than one head injury, 38.1% of them were Maori. Another view of ethnicity is presented in Figures 4.6a and 4.6b, where proportions of causes of head injury are shown separately for Pakeha and Maori. For example, Figure 4.6 shows that 47% of all head injuries were due to MVA's and MBA's, with a Pakeha to Maori ratio of more than 4:1. Figure 4.7a shows that of all head injuries sustained by Pakeha 49% were due to MVA's and MBA's, compared to 37% for Maori (Figure 4.7b).

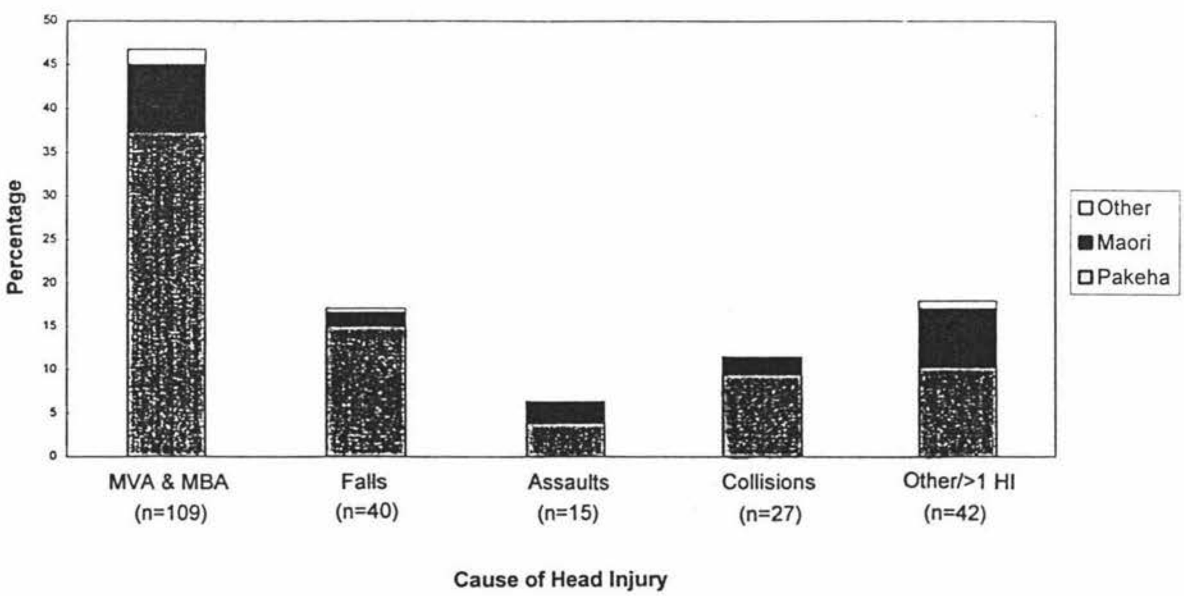


Figure 4.6

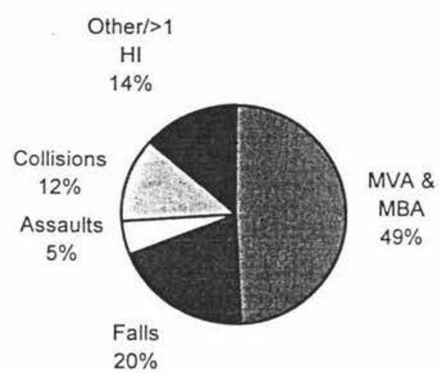
Proportion of Pakeha, Maori and Other Subjects according to the Cause of Head Injury

i) Pakeha

MVA's and MBA's constitute nearly half of the presenting causes for Pakeha subjects, followed by falls, other/more than one head injury, collisions, and lastly assaults.

ii) Maori

Approximately one third of Maori subjects sustained head injuries due to MVA's and MBA's. Another third were in the category other/more than one head injury. Assaults were the next leading cause, followed by collisions, then falls.



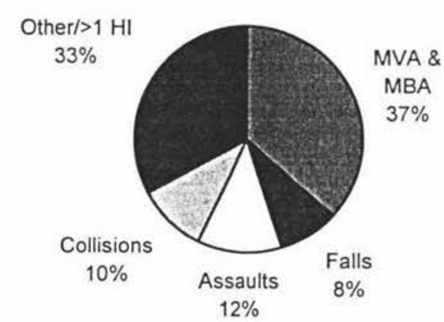


Figure 4.7

a) Proportion of Pakeha Subjects sustaining Head Injuries according to the Cause of Head Injury

b) Proportion of Maori Subjects sustaining Head Injuries according to the Cause of Head Injury

f) Age

Figure 4.8 shows the interaction between age of subjects and cause of accident. The significant feature of this data is that head injuries were most common in the 21-30 age group, regardless of cause. This graph has been developed to display the age of subjects proportional to each cause of accident group. For example, of those sustaining head injuries from MVA's and MBA's, 14.55% were aged 11-20, 42.73% were aged 21-30, 24.55% were aged 31-40, 9.09% were aged 41-50, 7.27% were aged 51-60, and 1.82% were aged 61 or over. This graph shows that the age 21-30 peaks for all cause of head injury categories, in particular other/more than one head injury and MVA's and MBA's. The proportion of falls varies little from age 11 to 41 years.

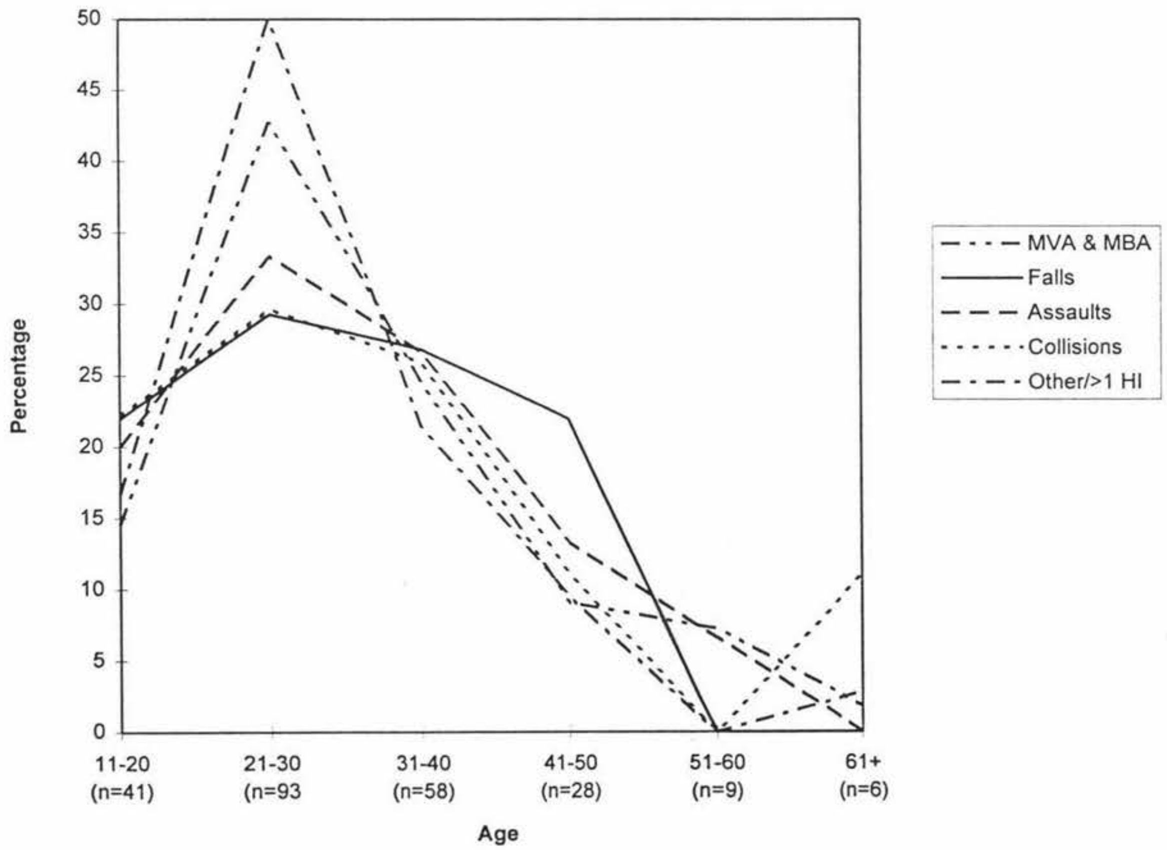


Figure 4.8

Proportion of Subjects' Age according to the Cause of Head Injury

g) Education

Figure 4.9 shows the interaction between years of education and cause of accident. The data indicates that head injuries were most common in people who had 3-4 years of high school education. For example, of people who sustained head injuries from MVA's and MBA's, 28.71% had 1-2 years of high school education, 44.55% had 3-4 years high school education, 9.9% had 5 years high school education, 10.89% had 1-2 years tertiary education, and 3% had 3 or more years of tertiary education. Overall, the majority of subjects had between one and four years of high school education (n=166), and less than one third had more than five years of high school education (n=52).

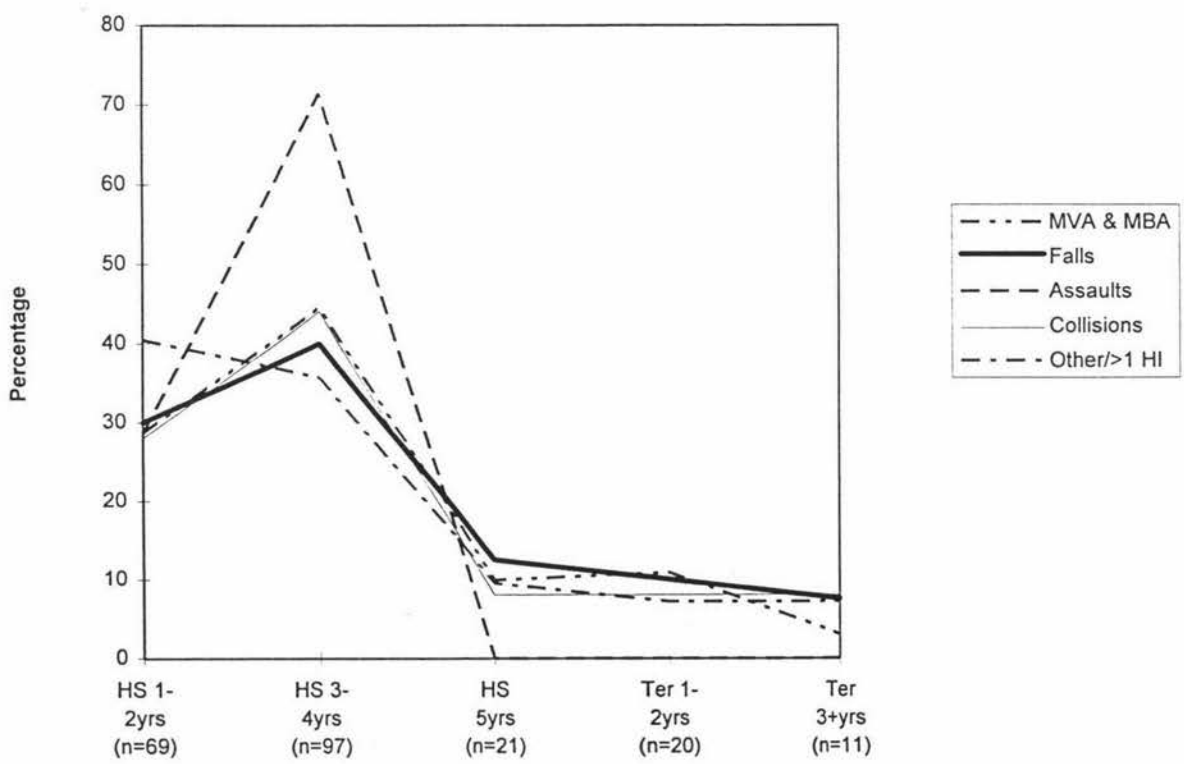


Figure 4.9

Proportion of Subjects' Education according to the Cause of Head Injury

It is possible, for example, that subjects with 3-4 years of high school education are overly represented in the head injury data presented here (and elsewhere e.g. Begali, [1992]). However, it is difficult to equate the current study's figures with general population statistics, because Department of Statistics data provided information only on highest school qualification. Thus, the figure of 21.4% of the general population with School Certificate, and 16.4% with Sixth Form Certificate and University Entrance (Department of Statistics New Zealand, 1994), adding to 37.8%, does not include those who sat School Certificate and University Entrance and failed, or those who have not sat these examinations at all. Had these figures been included, the figure of 44.55% obtained here, may have been no different to the general population figures.

Forces of Head Injury

Figure 4.10 presents the proportions sustaining head injury due to different forces. The data shows that most injuries are due to deceleration forces (82.35%), followed by acceleration (15%) and compression forces (2.14%).

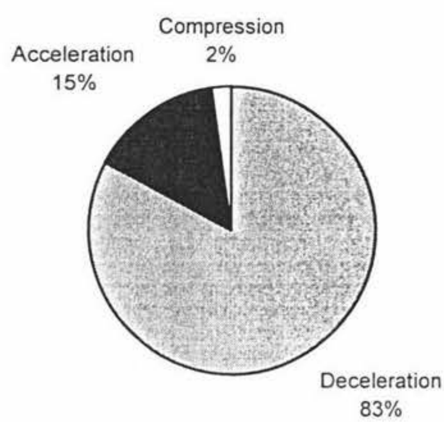


Figure 4.10

Proportion of Subjects sustaining Head Injuries according to the different Forces of Head Injury

Severity and Velocity

The relationship between velocity and severity of injury, is shown in Figure 4.11. The majority of severe head injuries were sustained in high velocity accidents, while the reverse was true for mild head injury.

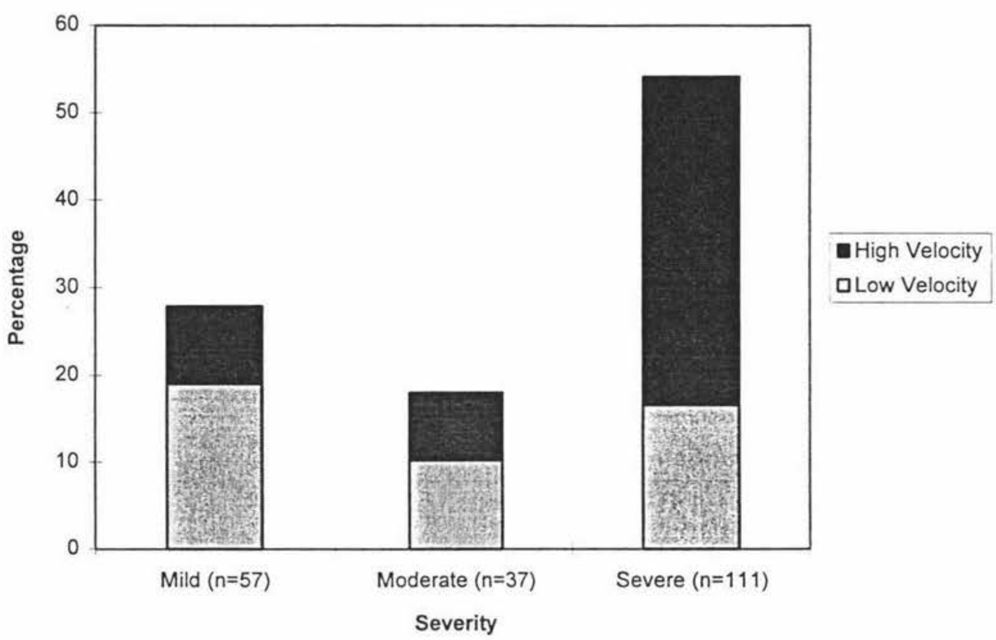


Figure 4.11

Proportion of Subjects sustaining High Velocity and Low Velocity Head Injuries according to Severity

Sequelae

a) Cause of Head Injury

Figure 4.12 shows the interrelationship between the cause of accident categories and the various sequelae. The data indicates that irritability was the most common neurobehavioural complaint across all causes of head injury, followed by depression, headaches, anxiety, dizziness, then epilepsy. This graph shows, for example, that of people who sustained their head injuries from MVA's and MBA's, 6.8% developed epilepsy, 31.07% developed headaches, 11.54% became anxious, 62.5% became irritable, 37.5% developed depression, and 8.74% complained of dizziness.

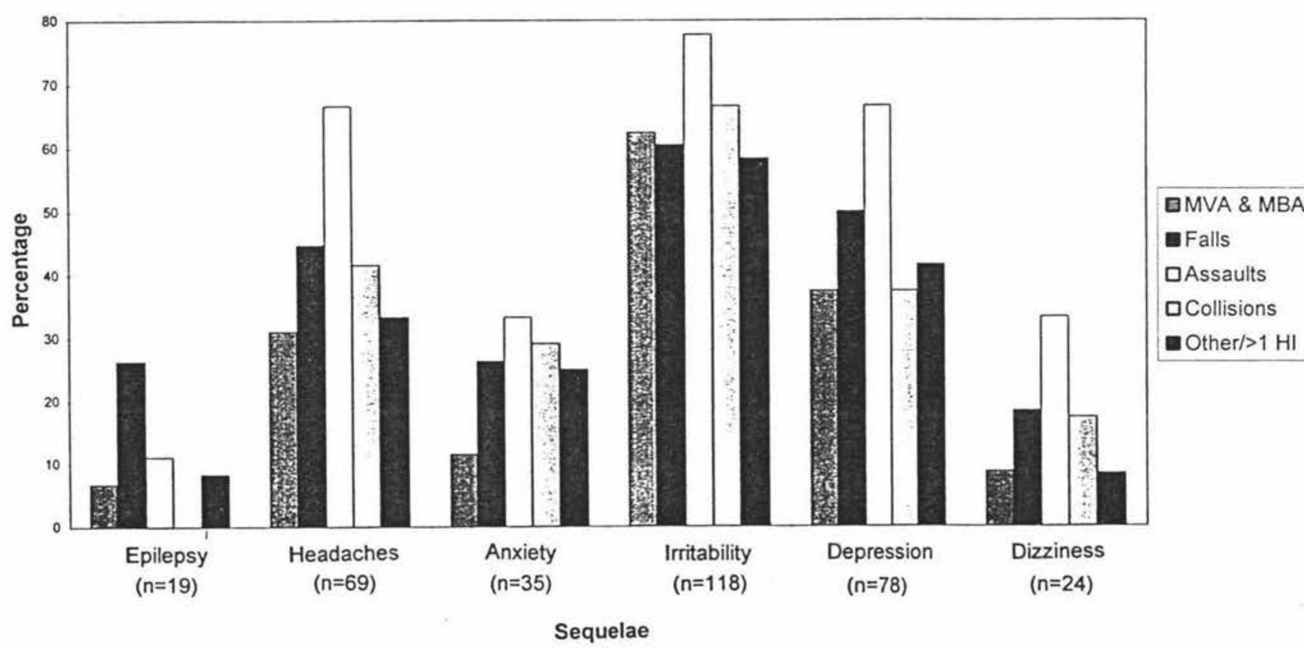


Figure 4.12

Proportion of Subjects sustaining Head Injuries from the different Causes of Head Injury according different Sequelae

b) Severity

Figure 4.13 presents the proportion of subjects sustaining mild, moderate and severe head injuries reporting various sequelae. This graph indicates that epilepsy is slightly more likely to result from severe head injury than mild and moderate head injury, and that anxiety, irritability, depression and dizziness are more common after mild head injuries.

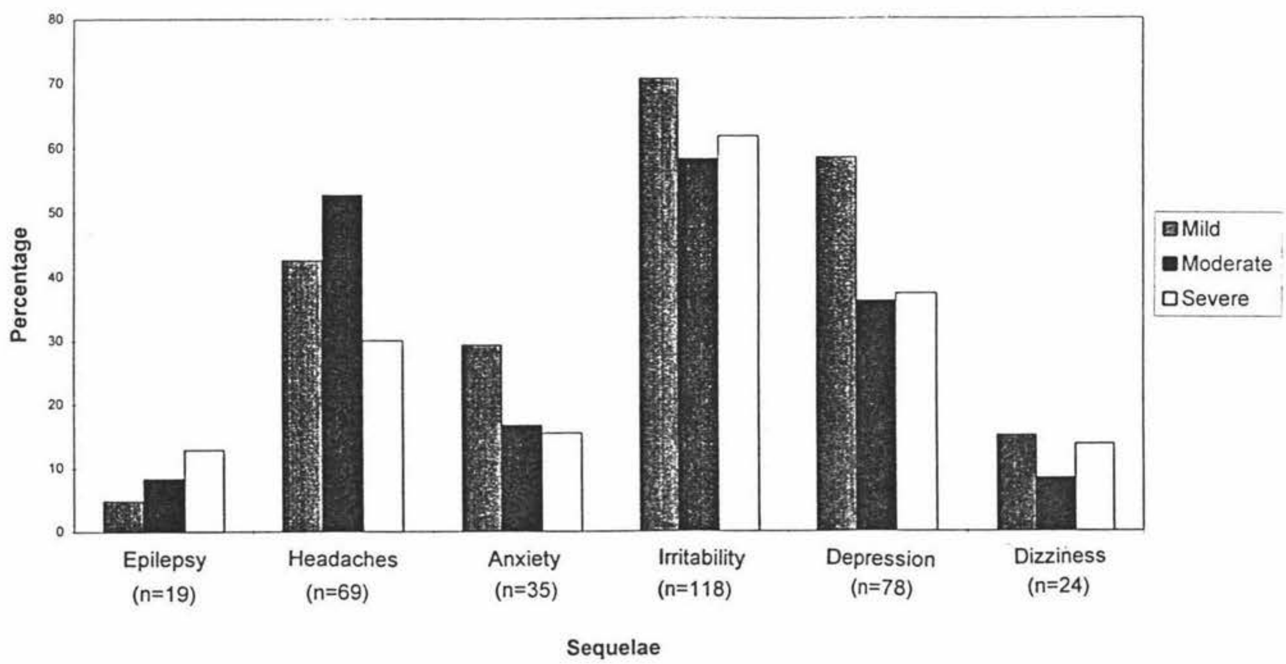


Figure 4.13

Proportion of Subjects sustaining Mild, Moderate and Severe Head Injuries according to different Sequelae

c) Forces of Head Injury

Figure 4.14 shows the proportion of subjects sustaining acceleration, deceleration and compression head injuries reporting various sequelae. This data suggests that epilepsy is slightly more likely to be associated with head injuries caused by deceleration forces, and that headaches, anxiety and irritability are more likely to be reported by those whose head injuries were due to acceleration forces.

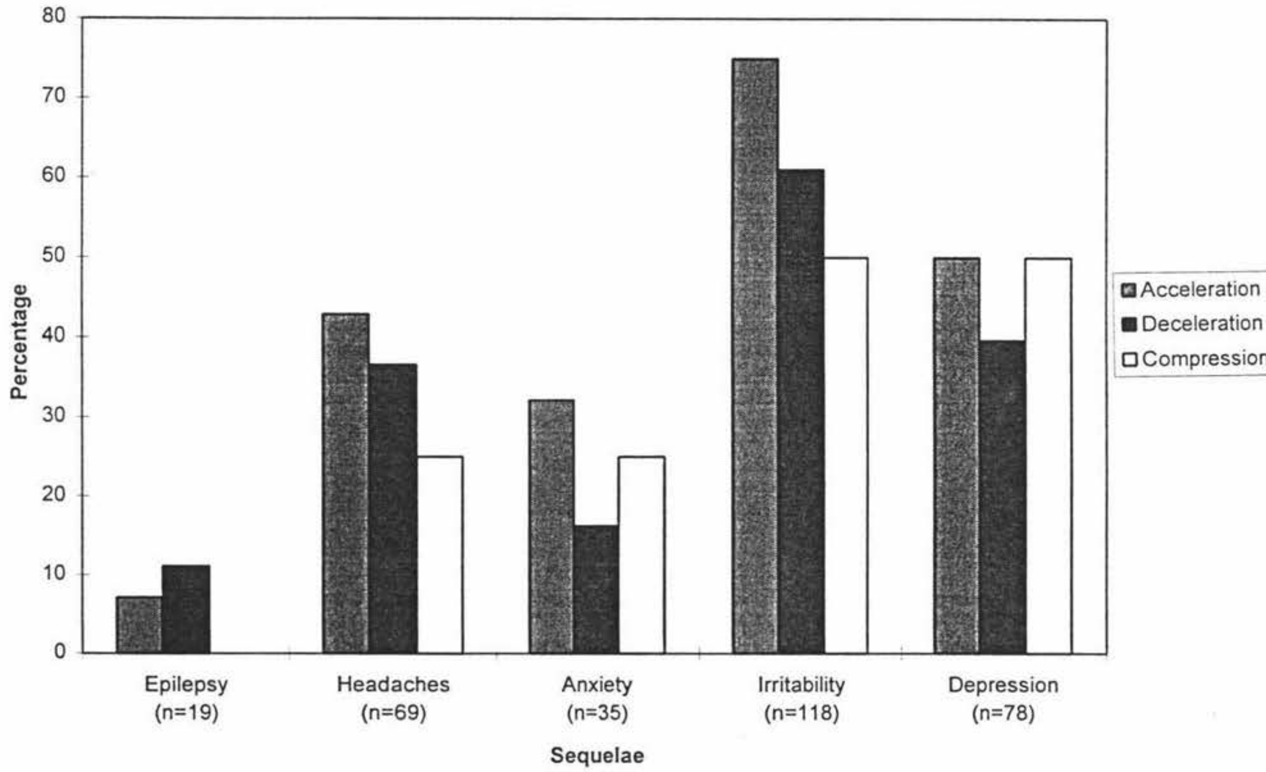


Figure 4.14

Proportion of Subjects sustaining Acceleration, Deceleration and Compression Head Injuries according to different Sequelae

d) Velocity

Figure 4.15 shows the proportion of subjects sustaining high and low velocity head injuries reporting various sequelae. The proportion of high velocity and low velocity accidents is approximately equal for each sequelae category - headaches, epilepsy, irritability, depression and anxiety.

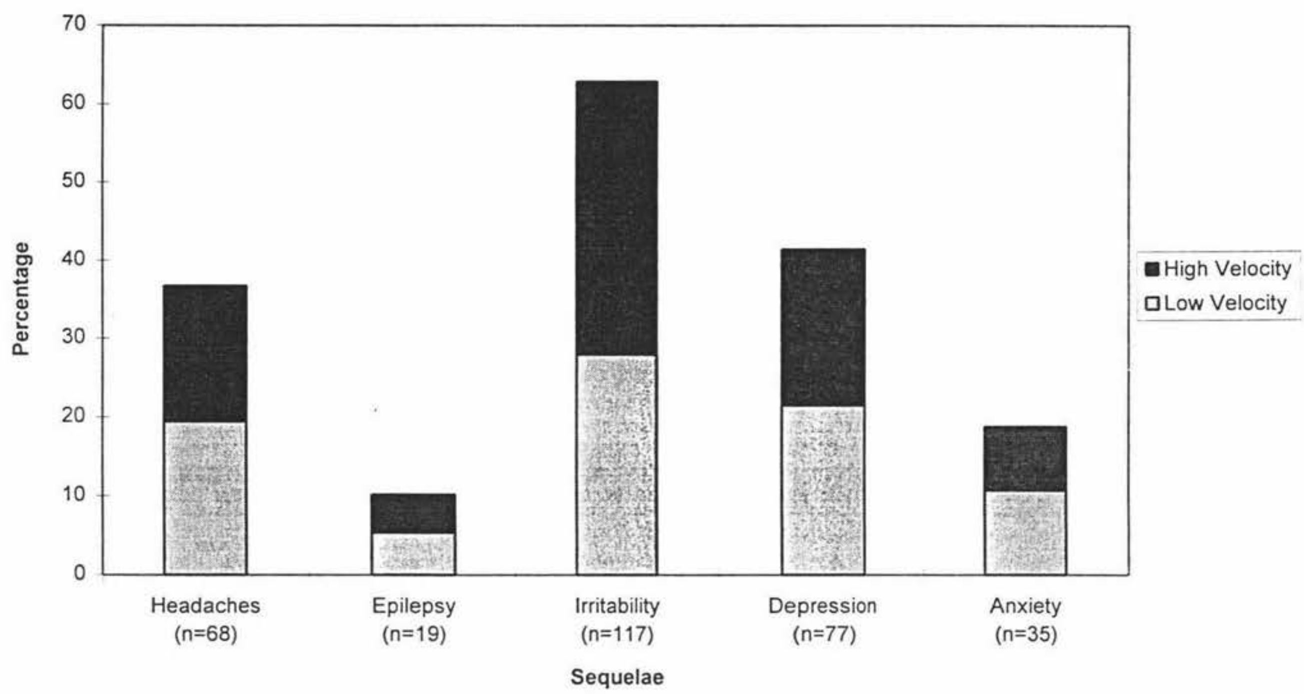


Figure 4.15

Proportion of Subjects sustaining High Velocity and Low Velocity Head Injuries acccording to different Sequelae

In conclusion, the Part One results suggest that young male subjects perhaps of low educational levels, were most likely to sustain head injuries predominantly due to MVA's and MBA's of high velocity, and that focal/sharp head injuries were most likely to result in irritability and other neurobehavioural sequelae than the generalized/blunt head injuries.

PART TWO

Statistical analyses (t-tests) were conducted to compare the performance of different groups on psychological and neuropsychological measures (WAIS-R, RAVLT, RCFT, Logical Memory, Fingertapping, PASAT, SCWT, Trail Making Test, The Milner/Austin Maze and Twenty Questions).

Comparisons were made between groups of subjects as outlined in Table 3.2, and summarized again below.

MVA and MBA / Falls, Collisions, Assaults, Other

a) Whole Sample
b) Assessment Interval
c) Gender, Ethnicity, Education, Severity

Low Velocity / High Velocity

d) Whole Sample
e) Gender, Education

Acceleration / Deceleration

f) Whole Sample

Nonfocal / Focal

g) Whole Sample

Normative Data / Present Study

Post Hoc Comparison:

Nonfocal and Fronto-temporal / Focal

h) Whole Sample

Mild / Moderate / Severe

i) Whole Sample

It was hypothesized that subjects with focal/sharp head injuries and subjects with generalized/blunt head injuries would differ in cognitive function and frontal lobe function.

MVA's and MBA's / Falls, Assaults, Collisions and Other/More than one Head Injury

a) Whole Sample

T-tests were conducted to examine the significance of difference between a group with head injuries from MVA's and MBA's, and a group with all other causes of head injury, on a wide range of neuropsychological measures. Results of these comparisons are shown in Table 4.1. All tests were included except those where the difference between variances was greater than two and a half times the standard deviation. Significant group differences, were found on Object Assembly, Stroop Colour-word, Maze Time 9 and Twenty Questions Constraining Questions 3, with MVA and MBA group scores higher on Object Assembly and Twenty Questions Constraining Questions 3, and lower on the other two measures, than the other causes group.

Table 4.1: T-test Comparison of Neuropsychological Measures of Subjects sustaining Head Injuries from MVA's and MBA's, and Subjects sustaining Head Injuries from Falls, Assaults, Collisions and Other/More than one Head Injury

	MVA's and MBA's			Falls, Assaults, Collisions, Other/more than one HI				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
WAIS-R								
Information	58	8.28	3.04	47	8.53	3.55	-0.39	.696
Digit Span	81	8.75	2.65	64	8.38	3.16	0.77	.444
Vocabulary	62	9.27	3.09	52	9.06	3.30	0.36	.720
Arithmetic	57	8.68	3.07	45	8.29	3.24	0.63	.533
Compreh	57	9.88	3.72	47	10.30	3.40	-0.60	.549
Similarities	74	9.43	3.01	59	8.75	2.87	1.34	.182
Pic Compl	72	9.85	3.02	58	9.48	2.96	0.69	.490
Pic Arrang	46	9.26	2.96	40	9.10	3.06	0.25	.806
Block Design	66	10.17	2.82	51	9.59	2.97	1.07	.288
Obj Assem	36	9.47	2.70	36	8.14	3.01	1.98	.052*
Digit Symbol	74	6.97	2.96	65	7.54	3.05	-1.11	.270
Verbal IQ	38	96.21	15.51	33	94.09	15.96	0.57	.574
Perfor IQ	37	95.97	13.99	32	91.84	14.65	1.19	.238
Full Scale IQ	37	95.78	14.94	32	92.81	15.80	0.80	.427
RAVLT								
Total	59	54.54	15.84	51	55.71	17.90	-0.36	.721
Trial 1	90	5.43	1.79	78	5.69	1.84	-0.92	.358
Trial 2	90	7.20	2.32	78	7.29	2.46	-0.26	.798
Trial 3	90	8.68	2.97	78	9.27	2.85	-1.31	.191
Trial 4	90	9.57	3.02	78	9.76	3.05	-0.40	.687
Trial 5	90	10.08	2.92	78	10.40	2.97	-0.70	.484
Interference	89	5.04	2.21	77	5.04	1.94	0.02	.985
Trial 6	90	7.39	3.69	75	8.13	3.96	-1.24	.217
Trial 7	70	7.01	3.80	55	7.31	4.11	-0.41	.682
Recognition	17	11.88	2.26	30	11.70	3.39	0.22	.826
Total 1-5	61	40.67	11.42	51	41.27	11.82	-0.27	.786
RCFT								
Copy	65	32.31	5.78	57	32.67	5.19	-0.36	.719
Recall	63	19.14	7.16	56	20.07	7.57	-0.69	.495
Delay	58	17.69	7.45	55	18.29	7.75	-0.42	.675

cont.

	MVA's and MBA's			Falls, Assaults, Collisions, Other/more than one HI				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
Logical Memory								
Story A	58	9.10	4.23	57	9.63	3.83	-0.70	.484
Story B	58	9.84	4.66	56	10.59	4.01	-0.92	.362
Recall A	49	6.78	4.31	47	6.38	3.94	0.47	.642
Recall B	45	7.36	4.24	45	7.80	4.04	-0.51	.612
Fingertapping								
Trial 1	46	44.48	11.06	38	43.74	11.85	0.29	.769
Trial 2	43	44.44	12.12	36	45.50	11.78	-0.39	.696
Trial 3	40	45.30	12.19	34	45.50	12.38	-0.07	.945
Trial 4	32	44.50	10.44	29	44.03	14.18	0.14	.885
Trial 5	30	44.17	10.75	24	43.75	13.22	0.12	.901
Trial 6	45	41.20	12.54	38	42.66	10.24	-0.58	.562
Trial 7	42	42.45	11.30	35	40.43	10.85	0.80	.426
Trial 8	41	41.59	11.31	34	42.41	8.99	-0.35	.725
Trial 9	34	39.03	10.44	28	40.29	8.56	-0.52	.605
Trial 10	30	40.20	12.02	23	39.87	9.65	0.11	.912
PASAT								
Trial 1	30	34.17	12.43	27	36.70	12.43	-0.77	.445
Trial 2	26	30.54	11.63	25	29.88	11.10	0.21	.837
Trial 3	24	24.63	9.84	24	23.08	10.79	0.52	.607
Trial 4	19	18.58	8.75	20	17.70	9.80	0.30	.769
SCWT								
Word	59	76.88	19.00	86	70.85	25.23	1.64	.103
Colour	57	57.09	12.02	87	60.69	14.10	-1.64	.103
Colour-word	57	32.82	10.04	87	36.56	13.35	-1.91	.058*
Trail Making								
Time A	36	57.89	52.62	37	52.70	40.80	0.47	.640
Errors A	36	0.03	0.17	38	0.08	0.36	-0.79	.431
Time B	37	114.73	98.46	36	110.03	84.74	0.22	.827
Maze Learning								
Time 3	27	47.22	25.22	28	48.46	32.27	-0.16	.874

cont.

	MVA's and MBA's			Falls, Assaults, Collisions, Other/more than one HI				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
Time 4	26	41.50	23.24	28	40.29	34.44	0.15	.879
Time 5	26	39.08	24.35	27	36.15	23.14	0.45	.656
Time 6	26	35.04	19.64	27	29.52	14.53	1.16	.252
Time 8	21	28.67	10.42	26	24.92	7.62	1.38	.177
Time 9	17	27.82	9.74	21	20.81	6.65	2.53	.017*
Time 10	16	26.00	9.54	21	21.05	7.93	1.68	.104
Errors 3	28	9.36	5.23	30	8.27	3.97	0.89	.378
Errors 4	27	8.44	4.94	30	7.47	5.59	0.70	.486
Errors 5	26	7.35	4.62	29	5.52	3.38	1.66	.104
Errors 7	25	6.16	4.44	28	5.29	3.76	0.77	.974
Errors 8	21	4.48	3.64	27	4.44	2.83	0.03	.974
Errors 9	19	4.16	3.37	22	3.50	2.70	0.68	.500
Errors 10	17	3.29	2.47	22	3.27	2.60	0.03	.979
20 Questions								
Total 1	48	9.38	4.77	41	8.73	3.52	0.73	.467
Total 2	44	12.07	5.50	38	12.05	4.73	0.01	.989
Total 3	33	10.00	4.69	30	10.77	4.93	-0.63	.531
Constr Q 1	12	4.50	1.78	15	4.80	1.47	-0.47	.644
Constr Q 2	12	4.83	2.48	13	5.77	1.96	-1.04	.310
Non-con Q 2	13	3.62	2.22	16	3.38	2.22	0.29	.774
Ps-con Q 2	15	1.93	3.04	17	1.88	2.83	0.05	.961
Constr Q 3	13	6.00	1.68	11	4.27	1.85	2.38	.027**
Non-con Q 3	13	2.62	1.90	12	2.67	1.61	-0.07	.942

* P < 0.1
** P < 0.05

N.B. The number of subjects differs because not all clients on the database were administered the neuropsychological measures.

b) Assessment Interval

T-tests were conducted to compare the two groups matched for assessment interval (less than 36 months) - the length of time between the accident and being seen at the Massey University Psychology Clinic. Although performance was compared across all tests as shown in Table 4.1, only those comparisons reaching significance are shown in Table 4.2. Significant differences between the groups were found on the Vocabulary and Object Assembly subtests of the WAIS-R, Verbal IQ, Performance IQ, and Full Scale IQ, on two of the Maze Learning trials, and on one of the Twenty Questions trials. The significant differences shown on Verbal IQ, Performance IQ and Full Scale IQ were due to MVA's and MBA's being associated with higher scores on seven of the subtests, which did not reach significance.

Table 4.2: T-test Comparison of Neuropsychological Measures of Subjects sustaining Head Injuries from MVA's and MBA's, and Subjects sustaining Head Injuries from Falls, Assaults, Collisions and Other/More than one Head Injury (subjects matched for assessment interval)

	MVA's and MBA's			Falls, Assaults, Collisions, Other/more than one HI				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
WAIS-R								
Vocabulary	30	9.87	3.01	39	8.56	2.79	1.84	.071*
Obj Assem	19	9.58	2.63	27	8.15	2.81	1.77	.085*
Verbal IQ	19	98.16	11.73	26	91.23	15.33	1.72	.093*
Perfor IQ	18	97.00	10.78	26	90.31	14.96	1.72	.092*
Full Scale IQ	18	97.61	11.22	26	90.65	15.95	1.70	.097*
Maze Learning								
Time 8	11	30.73	9.80	15	23.13	9.15	2.01	.058*
Time 9	9	28.78	7.84	13	19.38	7.07	2.88	.011**
20 Questions								
Total 3	15	8.47	4.12	18	11.56	5.00	-1.95	.061*

* P < 0.1
** P < 0.05

The MVA and MBA group scored higher on Vocabulary, Object Assembly, Verbal IQ, Performance IQ and Full Scale IQ than the 'other causes' group, but took longer to complete several of the Maze Learning trials (although only two of these reached a significant level).

c) Gender, Ethnicity, Education and Severity

In this analysis, the groups were matched for gender, ethnicity, education and severity, i.e. the subjects were all male, Pakeha, had less than 5 years of high school education, and had sustained a severe head injury. It was not possible to make other matches because of the small number in the cells. Significant differences were found between the groups on RAVLT (trials 2. 3, 4, 5 and 6, and the sum of trials 1-5) and on two of the WAIS-R subtests, as shown in Table 4.3, with the MVA and MBA group scoring lower on the RAVLT trials than the subjects sustaining head injuries from other causes.

Table 4.3: T-test Comparison of Neuropsychological Measures of Subjects sustaining Head Injuries from MVA's and MBA's, and Subjects sustaining Head Injuries from Falls, Assaults, Collisions and Other/More than one Head Injury (subjects matched for gender, ethnicity, education and severity)

	MVA's and MBA's			**Falls, Assaults, Collisions, Other/more than one HI**				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
WAIS-R								
Compreh	24	9.29	3.10	11	11.55	3.62	-1.79	.092*
Obj Assem	17	9.47	2.72	9	6.89	3.14	2.09	.055*
RAVLT								
Total	20	47.90	12.74	10	62.60	18.33	-2.28	.040**
Trial 2	31	6.13	1.95	17	7.71	2.44	-2.29	.030**
Trial 3	31	7.19	2.48	17	10.18	2.48	-3.98	.000**
Trial 4	31	7.77	2.51	17	9.71	2.34	-2.66	.012**
Trial 5	31	8.52	2.31	17	11.18	2.38	-3.75	.001**
Interference	31	5.71	2.71	17	7.94	3.93	-2.09	.048**
Total 1-5	21	35.19	8.34	10	46.00	9.38	-3.11	.007**

* $P < 0.1$
** $P < 0.05$

Low Velocity / High Velocity

d) Whole Sample

Statistical analyses were conducted to compare a group of subjects sustaining head injuries due to low velocity accidents with a group of subjects sustaining head injuries due to high velocity accidents. The significant differences are shown in Table 4.4. The high velocity group took significantly longer on Maze Learning on two trials, and produced more errors on one trial, but performed at higher levels than subjects involved in low velocity accidents, on Stroop Word and Twenty Questions Constraining Questions 3.

Table 4.4: T-test Comparison of Neuropsychological Measures of Subjects sustaining Head Injuries due to Low Velocity Injuries, and Subjects sustaining Head Injuries due to High Velocity Injuries

	Low Velocity			**High Velocity**				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
SCWT								
Word	59	70.63	23.12	57	77.88	18.23	-1.88	.063*
Maze Learning								
Time 9	20	21.00	6.95	17	27.82	9.58	-2.44	.021**
Time 10	20	20.65	8.02	16	26.75	9.15	-2.10	.044**
Errors 5	28	5.11	3.32	26	7.85	4.45	-2.55	.013**
20 Questions								
Constr Q 3	11	4.36	1.80	12	6.08	1.78	-2.30	.032**

* P < 0.1

** P < 0.05

e) Gender and Education

Examination of differences in neuropsychological test scores for low velocity and high velocity groups, with subjects matched for gender and education (controlling other variables would have made the total number of subjects too low for meaningful analysis) revealed significant results as shown in Table 4.5. Scores for the high velocity group were higher on Object Assembly and Stroop Colour-word, and lower on RAVLT Trial 3 and Interference, RCFT Delay, Maze Time 9, with more errors made on five of the Maze trials.

Table 4.5: T-test Comparison of Neuropsychological Measures of Subjects sustaining Head Injuries due to Low Velocity Injuries, and Subjects sustaining Head Injuries due to High Velocity Injuries (subjects matched for gender and education)

	Low Velocity			**High Velocity**				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
WAIS-R								
Obj Assem	15	7.20	2.48	29	8.72	2.75	-1.86	.073*
RAVLT								
Trial 3	42	8.93	2.88	56	7.63	2.91	2.20	.030**
Interference	42	5.07	1.87	54	4.41	1.80	1.76	.082*
RCFT								
Delay	30	20.03	8.09	34	16.21	7.70	1.93	.058*
SCWT								
Word	32	63.34	23.46	34	74.62	18.56	-2.16	.035**
Maze Learning								
Time 9	9	20.00	7.63	9	29.33	11.06	-2.08	.056*
Errors 2	13	9.77	3.90	14	13.21	5.28	-1.94	.065*
Errors 5	12	5.08	3.78	13	7.46	2.96	-1.74	.096*
Errors 6	12	3.58	2.31	13	7.69	3.90	-3.23	.004**
Errors 7	11	4.45	2.66	13	7.00	3.94	-1.88	.074*
Errors 9	9	2.78	2.44	10	5.40	3.53	-1.90	.081*

* P < 0.1
** P < 0.05

Acceleration / Deceleration

f) Whole Sample

Table 4.6 shows a comparison of results for the groups sustaining head injuries due to acceleration and deceleration forces. Significant differences were found on WAIS-R Digit Span and Arithmetic, RAVLT Total, Maze Time 9, and four of the Maze Errors trials. The acceleration group scored significantly lower on Digit Span, Arithmetic and RAVLT Total, but made fewer errors on maze learning trials, and took less time on Maze Time 9, than the deceleration group.

Table 4.6: T-test Comparison of Neuropsychological Measures of Subjects with Acceleration Injuries and Subjects with Deceleration Injuries

	Acceleration			**Deceleration**				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
WAIS-R								
Digit Span	23	7.78	2.50	118	8.82	2.89	-1.77	.085*
Arithmetic	15	7.40	2.44	86	8.69	3.23	-1.78	.087*
RAVLT								
Total	14	46.07	17.90	94	56.17	16.31	-1.99	.063*
Maze Learning								
Time 9	8	19.25	6.61	28	25.46	9.23	-2.13	.049**
Errors 3	10	6.10	4.80	45	9.42	4.50	-2.00	.067*
Errors 4	10	4.40	4.06	44	8.81	5.28	-2.92	.010**
Errors 5	10	4.10	3.70	42	6.90	3.92	-2.13	.015**
Errors 6	10	3.60	3.75	42	6.29	4.64	-1.94	.070*

* P < 0.1
** P < 0.05

Nonfocal / Focal

g) Whole Sample

T-tests were conducted to compare a group of subjects sustaining nonfocal damage, with a group of subjects sustaining damage in specific, more focal areas - occipital, parietal, temporal and frontal (see Table 4.7). As with other comparison groups, nonfocal and focal overlap with other classification systems. Accordingly, similar differences on the measures were likely. The results show that subjects who sustained head injuries causing nonfocal damage scored lower on four of the RAVLT trials, than subjects with damage in more specific areas.

Table 4.7: T-test Comparison of Neuropsychological Measures of Subjects sustaining Nonfocal damage, and Subjects sustaining damage in specific areas - Occipital, Parietal, Temporal and Frontal

	Nonfocal			**Focal - Occipital, Parietal, Temporal, Frontal**				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
RAVLT								
Trial 2	10	5.80	2.53	58	7.38	2.27	-1.85	.090*
Trial 3	10	6.50	3.27	58	9.38	2.82	-2.62	.023**
Trial 6	10	5.30	3.37	58	8.09	3.64	-2.39	.033**
Trial 7	9	4.00	4.69	44	7.57	3.79	-2.14	.057*

* $P < 0.1$
** $P < 0.05$

Normative / Present Study

While relatively few significant differences were found between the groups of head injured subjects, the group as a whole performed at lower levels than the normative data.

Table 4.8 shows means (and in one case, medians) obtained from neuropsychological measures of the subjects in the present study, and normative data and control data from previous studies. It can be seen, that the subjects in the present study performed at lower levels than the norms on most of the neuropsychological measures.

Table 4.8: Comparison of Means on Neuropsychological Measures between the Present Study and Normative Data

Measure	Norms	The Present Study
WAIS-R (a)		
Information	10.30	8.41
Digit Span	9.80	8.67
Vocabulary	10.10	9.20
Arithmetic	10.30	8.56
Compreh	10.20	10.10
Similarities	9.70	9.09
Pic Compl	9.40	9.60
Pic Arrang	10.30	9.12
Block Design	9.90	9.90
Obj Assem	10.20	8.86
Digit Symbol	9.80	7.20
Verbal IQ	101.80	95.27
Perfor IQ	105.40	94.15
FS IQ	103.80	94.48
RAVLT (b)	(medians)	(medians)
Trial 1	7.00	5.50
Trial 2	11.00	7.00
Trial 3	12.00	9.00
Trial 4	13.00	10.00
Trial 5	14.00	10.00
Interference	7.00	5.00
Trial 6	12.00	8.00
Recognition	14.00	12.00
Total 1-5	56.50	41.00
RCFT (c)	(means)	(means)
Copy	34.72	32.57
Recall	26.71	19.55
Delay	26.58	18.19
Logical Memory (d)		
Story A+B	25.70	19.51
Recall A+B	22.10	13.93

cont.

Measure		Norms		The Present Study	
Fingertapping (e)					
Pref Hand		49.70		44.20	
NPref Hand		47.00		40.40	
PASAT (f)					
2.4 sec		47.40		35.63	
2.0 sec		42.00		30.36	
1.6 sec		36.00		24.82 (1.8 sec)	
1.2 sec		27.40		18.20 (1.4 sec)	
Maze Learning (g)					
Time 1-5		66.00		55.89	
Time 6-10		20.00		28.12	
Trail Making (h)					
		A	B	A	B (this study)
Percentile	90	21	45		110.41
	75	26	55		
	50	32	69	54.09	
	25	42	94		
	10	50	129		

(a) From Wechsler (1991)
(b) From Powell & Cripe (1991)
(c) From Meyers & Meyers (1995)
(d) From Wechsler (1987)
(e) From Spreen & Strauss (1991)
(f) From Spreen & Strauss (1991)
(g) From Milner (1965)
(h) From Davies (1968)

POST HOC RESULTS

Nonfocal and Fronto-temporal / Focal

h) Whole Sample

Table 4.9 is a revised version of Table 4.7, which compared neuropsychological measures for focal and nonfocal damage. The focal group included the following areas - occipital, parietal, temporal and frontal. Another analysis was conducted which excluded 'frontal' from the focal group, and included fronto-temporal damage with the nonfocal group. Because the fronto-temporal area is so large, and is often damaged in MVA's and MBA's, the subjects with this damage were expected to be similar to those with nonfocal damage (also often the result of MVA's and MBA's). The results are shown in Table 4.9. The subjects who sustained head injuries causing nonfocal/fronto-temporal damage scored lower than subjects with more focal damage on the following measures - Digit Symbol, RAVLT Total, trials 1, 3, 5 and 7, and the sum of trials 1-5, RCFT Recall, Logical Memory A and B, Logical Memory Recall B, Fingertapping trial 8, SCWT Word and Colour, and Twenty Questions Total 1.

Table 4.9: T-test Comparison of Neuropsychological Measures of Subjects sustaining Nonfocal and Fronto-temporal damage, and Subjects sustaining damage in specific areas - Occipital, Parietal, Temporal

	Nonfocal, Fronto-temporal			**Focal - Occipital, Parietal, Temporal**				
Measure	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t**	**p**
WAIS-R								
Digit Symbol	16	6.06	3.73	15	8.40	2.64	-2.62	.053*
RAVLT								
Total	12	49.67	10.63	10	59.10	12.90	-1.85	.082*
Trial 1	22	5.18	1.65	17	6.12	1.50	-1.85	.072*
Trial 3	22	8.05	3.24	17	9.71	2.02	-1.96	.058*
Trial 5	22	9.45	3.08	17	11.06	1.85	-2.02	.052*
Trial 7	18	5.67	4.68	13	9.31	3.01	-2.63	.013**
Total 1-5	12	37.58	9.84	10	44.80	6.39	-2.07	.052*
RCFT								
Recall	11	18.82	6.46	13	23.61	5.30	-1.97	.064*
Logical Memory								
Story A	13	8.23	4.36	8	11.25	2.96	-1.89	.075*
Story B	13	8.54	4.86	8	11.63	2.45	-1.93	.069*
Recall B	9	5.44	4.25	6	10.00	3.74	-2.19	.050*
Fingertapping								
Trial 8	7	39.57	7.19	7	45.57	2.76	-2.06	.074*
SCWT								
Word	16	62.31	21.31	12	81.67	14.09	-2.89	.008**
Colour	16	50.44	14.41	12	62.67	9.82	-2.67	.013**
20 Questions								
Total 1	11	7.00	2.68	10	9.50	3.66	-1.77	.095*

* P < 0.1
** P < 0.05

Mild / Moderate / Severe

i) Whole Sample

Post hoc oneway analysis of variance revealed a clear severity effect on a number of neuropsychological measures. These results are summarised in Table 4.10 below.

Table 4.10: Oneway Analysis of Variance Comparison of Neuropsychological Measures of Subjects with Mild, Moderate and Severe Head Injuries

Measure	d.f.	F	p
RAVLT			
Total	2/128	3.24	.042**
Trial 3	2/187	3.85	.023**
Trial 4	2/187	3.81	.023**
Trial 6	2/184	4.14	.017**
Trial 7	2/143	4.02	.019**
Maze Learning			
Errors 1	2/58	3.29	.044**
Errors 3	2/58	4.72	.013**
Errors 4	2/57	5.20	.008**
Errors 5	2/55	5.26	.008**
Errors 7	2/53	5.84	.005**
Errors 9	2/40	3.63	.036**

** $P < 0.05$

In conclusion, the results for Part Two involved comparisons between causes of head injury, low and high velocity, acceleration and deceleration, nonfocal and focal damage, normative and present data, and finally a post hoc comparison between nonfocal/fronto-temporal and focal damage, and a comparison between mild, moderate and severe. Out of approximately 600 analyses, there were 40 significant results at the 0.1 alpha level, and 35 at the 0.05 alpha level.

CHAPTER FIVE

DISCUSSION

PART ONE: EPIDEMIOLOGY

Factors Affecting Head Injury

Comparison between the 1989 figures from the Department of Health and Human Services (cited in Wright, 1993), and the present study, revealed that MVA's and MBA's were the leading cause of head injury in both studies. However, falls, the second leading cause of head injury (Department of Health and Human Services, 1989 (cited in Wright, 1993); Begali, 1992; Lezak, 1995), were not as frequent in the present study, where the second leading cause of head injury was other/more than one head injury. It is likely that the absence of specific classification criteria for the U.S. study resulted in some of these differences. Also, multiple head injuries were sustained by over half of the subjects from the Manawatu Prison.

The 'collisions' category in this study (which accounted for 11.5% of head injuries) included injuries sustained in sporting accidents as well as injuries, such as being hit by a roller door, and is therefore appropriately compared to the data from The Department of Health and Human Services (1989) (cited in Wright, 1993), which reported that 10% of the various causes of head injury were attributed to sports and recreation.

The difference in the proportion of assaults for the present study (6.4%), and for the study by The Department of Health and Human Services (1989) (cited in Wright, 1993) (12%) can be explained by the number of subjects in the current study who had sustained head injuries from assaults, but whose previous head injuries from assaults resulted in them being re-classified from 'assault' to 'other/more than one head injury'. The category 'other/more than one head injury' included in the current study (not in the U.S. study), may be important for assessment and rehabilitation of individuals with head injuries. The cumulative effect known to occur after successive head injuries would mean different outcomes, and therefore different rehabilitation needs.

The majority of MVA's and MBA's in this study resulted in severe head injuries, mostly due to high velocity, deceleration accidents. This is consistent with Gronwall's (1991) report that high velocity accidents are more likely to produce severe head injuries. Falls also accounted for a high proportion of severe head injuries. Gronwall's (1991) findings that a large proportion of mild head injuries are caused by assaults, sports injuries, falls or hitting the head on a solid surface, were also replicated in the current study. These injuries (including falls) accounted for the majority of low velocity accidents.

The ratio of more than 2 males to 1 female, previously reported by Begali (1992) was also replicated in the present study, where males were dominant in every cause of accident category, with an overall male to female ratio of 2.67:1. MVA's and MBA's are the leading cause of head injury for females and males, from both the figures given by the Department of Health and Human Services, 1989 (cited in Wright, 1993), and in the current study. This study also suggests that males are more likely to have more than one head injury, where females were more likely to have suffered head injuries in falls.

Of the subjects in this study, 75% were Pakeha and 21% were Maori. As already noted, since only 13% of the general population, identify as New Zealand Maori (Department of Statistics New Zealand, 1994), Maori subjects were clearly over-represented in this head injury study. A possible reason for this could be the fact that Maori are also overly represented in other factors associated with head injury, such as lower socioeconomic status, unemployment, lower educational levels (Begali, 1992). Over half of Maori people, for example, received income support in the year before the 1991 census, and the mean income of Maori is lower than the mean income of Pakeha. The unemployment rate of Maori exceeds the Pakeha rate by more than two and a half times, and over half of Maori people had no qualifications (Department of Statistics New Zealand, 1994).

Further, of those sustaining head injuries from assaults, 40% were Maori, as were 38.1% of subjects in the category other/more than one head injury. These high proportions were partly due to Maori accounting for half of the subjects from the Manawatu Prison. Over half of these subjects had sustained multiple head injuries.

Head injury is most common in the 15-24 age group (Begali, 1992), and the present study showed similar findings with the majority of head injuries sustained by subjects aged 21-30 years. The age categories used in this study (i.e. 21-30, 31-40, 41-50..) made it impossible to make a direct comparison to previous studies. It was an oversight that these categories were not consistent with the published data.

Finally, and also consistent with other studies (e.g. Begali, 1992), head injuries are more commonly sustained by people with lower educational levels, the majority of subjects (76%) in the present study had 1-4 years of high school education. However, since Begali (1992) did not state what criteria was used to determine 'lower educational levels', it is difficult to make a direct comparison.

Sequelae

Examination of the relationship between the cause of head injury and resulting sequelae, revealed that subjects sustaining head injuries from assaults were more likely to suffer from headaches, anxiety, irritability, depression and dizziness, than subjects with head injuries from MVA's and MBA's. Head injuries from assaults, such as a punch to the head or being hit on the head by a bottle, are generally low velocity focal injuries, whereas head injuries from MVA's and MBA's are mostly high velocity blunt injuries. The data provided support for the hypothesis proposing that subjects with focal/sharp head injuries would exhibit more irritability than individuals with generalized/blunt head injuries.

It had been also hypothesized that subjects with focal/sharp head injuries would be more likely to develop post-traumatic epilepsy than subjects with generalized/blunt head injuries. Although the data from the present study provided some support for this hypothesis, the number of subjects suffering from post-traumatic epilepsy was too low to draw any significant conclusions. Data suggested though, that head injuries due to falls (generally low velocity accidents, with the major damage occurring at the site of impact), were most likely to suffer from post-traumatic epilepsy.

Anxiety, irritability, depression and dizziness were associated more with mild head injuries. These sequelae, along with headaches may also be referred to as the PCS. However, since there was little difference between mild, moderate and severe for each sequelae, no stable conclusions could be drawn. Headaches are very common after mild head injuries (Currie, 1993), but in the present study they were more common after moderate head injuries, followed closely by mild and severe. Taken together, the data suggests that subjects sustaining head injuries from assaults (which were mostly mild head injuries) were most likely to suffer from the symptoms associated with PCS, than the other subject groups.

Further, headaches, anxiety and irritability were associated more with head injuries sustained due to acceleration forces. However, the difference between acceleration, deceleration and compression forces for these sequelae was not large. No clear differences were found between high and low velocity head injuries in relationship to the various sequelae.

It has been hypothesized that subjects with focal/sharp head injuries would have more post-traumatic stress than subjects with generalized/blunt head injuries. Common symptoms of PTSD from a head injury are sleep disturbances and nightmares, concentration difficulties, irritability, anger and extreme alertness to danger (Rubinstein, 1993). There is clearly an overlap here with PCS, which is often seen as having a structural base. Many subjects in the present study suffered from concentration difficulties, and subjects with focal/sharp head injuries were more likely to have irritability than subjects with generalized/blunt head injuries. There had been very few reports of nightmares or of re-experiencing the accident from head injured subjects in this study. It would appear then, that the presence of some PTSD features should not imply that the subject suffers from PTSD. If these symptoms alone are used, it is possible that some individuals would be misclassified as having PTSD. Future studies looking at PTSD from head injuries would need to specifically ask the subjects about sleep disturbances, nightmares and flashbacks.

PART TWO

Clinical observations and the recent research by Dunlop et al. (1991), suggesting that those with sharper head injuries occurring at lower velocities, constitute a different group than those with blunt head injuries more often sustained at higher velocity, were not supported in this study on neuropsychological test result grounds. While some significant results were found, these were no more than might have been found by chance alone, i.e. of the seven comparisons each with 75 t-tests, significant results range from 1-7 at the 0.05 level, and a further 1-7 at the 0.1 level. Further, specific scrutiny of the neuropsychological measures specifically targeting those cognitive areas susceptible to blunt injuries, particularly due to MVA (memory, higher executive functioning, speed of information processing), also revealed non-significant results. Although comparisons between the MVA/MBA and other causes groups revealed more difficulty for the former group on the RAVLT, this was for learning trials only, and at delayed recall there was again no significant differences between groups.

Post hoc comparison of subject groups according to whether their head injuries were mild, moderate and severe revealed significant differences between the groups on tasks of verbal and motor learning. These results are similar to those reported by Morse and Montgomery (1992), which suggests that evaluation of head injury outcome along the mild/moderate/severe continuum may still be the most appropriate method.

Also in line with previous findings (Levin, Eisenberg & Burton, 1989; Morse & Montgomery, 1992), was the difference found in this study between the performance on a number of neuropsychological assessment measures of head injured subjects as a combined total group and normative groups. These results would appear to suggest that while there is no difference in outcome between groups divided according to cause, velocity and force of head injury, these groups as a combined group differ from normal controls. On WAIS-R subtests this was seen particularly on the digit symbol subtest (2.80 scaled score points below the mean) in the same way as reported by Lezak (1995), object assembly (1.14 scaled score points below the mean) and arithmetic (1.44 scaled score points below the mean). The remainder of the subtests were within one scaled score of the mean. It was noteworthy that there was no difference between the current data and normative data on block design, which has often been held as an indicator of cognitive impairment (Lezak, 1995). Rey Complex Figure results were also indicative of impairment similar to those reported by Spreen and Strauss (1991), as was logical memory where figures corresponded to the brain injured group reported by Spreen and Strauss (1991).

Suggestions for future research include looking more closely at individuals with more than one head injury. The cumulative effect of multiple head injuries requires this group to be studied separately. Finally, this study suggests that head injuries should be grouped according to a severity index. The most common form is mild/moderate/severe, but there are issues surrounding the use of this, the PTA scale and the GCS (e.g. not knowing when the GCS was administered), which suggest that another form of assessment is necessary.

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