Correlative Study into Injury Epidemiology, use of Protective Equipment and Risk-taking among Adolescent Participants in Alpine Snow Sport

A thesis submitted in partial fulfillment of the requirements for the award of the degree of

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By

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DECLARATION

This thesis is submitted in accordance with the regulations of the University of Canberra in partial fulfillment of the degree of Masters of Arts (Research). It does not include any material published by another person without due reference within the text. The field work presented in this thesis was performed by the author, except where acknowledged. The thesis has not been submitted for a degree at any other university.

Nadine Cooper

February 2010
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ABSTRACT

Risk taking and sensation seeking are common daily phenomena that every person experiences to some degree. Sensation seeking behaviours have been found to be common among those engaging in activities such as mountaineering, deep sea diving, skiing and snowboarding. All of which may be considered relatively high-risk activities for accidental injury.

Risk-taking behavioural characteristics have been identified as a possible explanation for the higher incidence of snowsport injuries. These snowsports attract a proportion of the population, including many children and adolescents, who have been introduced to the sport through school-sponsored ski programs and local community clubs. The number of children and adolescents participating in snow sports continues to rise and therefore it is important to have snow safe programs implemented within ski resorts and in place in schools participating in alpine sports programs.

In Australia, New South Wales (NSW) and Australian Capital Territory (ACT) Interschool Snowsports entries have increased by more than threefold since 2001, from 465 entries in 2001 to 1452 entries in 2007. In line with this increase in participation, the occurrence of alpine injuries may have increased substantially, which is not only a problem for the participating groups, but also represents a potential public health issue.

An exploratory questionnaire based study of Southern NSW and ACT Interschool Alpine Racing Teams was conducted during the 2007 winter season. Prior to this a pilot study was conducted in the 2006 winter season to test the reliability of the questionnaire.

The aim of the study was to analyse and evaluate the effects of the combined psychological characteristics of risk-taking and sensation seeking on injuries sustained. A second purpose of the study was to quantify the protective equipment habits and attitudes of secondary school participants.

The rationale behind the study incorporates the benefits of having greater knowledge of higher risk taking groups and how they relate to injury. The results of the study can be used to design and employ more appropriate training, risk management and injury prevention programs within the Interschool participants.
There were 345 participants (four excluded from data analysis) who undertook the questionnaire. Participants’ ages ranged from 10-18 years old, with a mean of 14 years of age. Alpine skiing accounted for 58.3% of the participants, snowboarding 25.4% and 16.3% cross-country.

Of the 341 participants analysed, 116 suffered alpine snowsport injuries. Of these, 22 males and 20 females participates sustained two or more injuries, with one participant being injured 11 times. There were a total of 208 injuries amongst the 116 participants who suffered alpine snowsport injuries.

Of those injured, 63.6% were injured while free skiing or snowboarding, 18.5% during training and 17.9% while racing. Of the participants’ injuries 40.0% were sustained while skiing with friends, 21.5% skiing with family, 26.2% with a coach and 11.9% skiing alone.

The most common area injured was the knee, which accounted for approximately 21.3% of all injuries. This was followed by wrist fractures, which resulted in 14.7% of injuries. The third most common area to be injured was the head (including two fractured cheek bones, and two face lacerations), with 22 injuries that accounted for 10.4% of all injuries.

There was a gender differences in the anatomical areas injured, with males sustaining more head and face injuries, and having a greater frequency of fractured wrists and a significantly higher proportion of knee injuries than females, with approximately two-thirds of all knee injuries (66.7%) being suffered by males. Females sustained more shoulder dislocations (52.4%) and fractured humerus than males and a significantly higher frequency of thigh muscle injuries (88.9%) than males.

Overall, males had a slightly higher frequency of injuries than females, but there were no significant differences between the two. There was an average of 0.61 injuries per person or broken down my gender, males had an average 0.63 injuries and females an average of 0.57.

From the results there appears to be a direct and significant relationship between risk taking scores and alpine injuries. The higher individual scores in risk taking and sensation seeking, the more likely he or she was to have sustained an injury.
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CHAPTER ONE: INTRODUCTION

1.1 Background
Alpine winter sports may be enjoyed all over the world and provide a significant financial contribution to the worldwide tourism industry. Closer to home, the Australian winter alpine sport scene provides support to a viable tourism industry. To obtain this growth and to continue to welcome back previous customers it is essential to identify factors that may prevent this growth from occurring. Two significant factors that may hinder an individual’s or family’s alpine experience, participation and/or be a factor when choosing a holiday destination is the occurrence and perception of potential injuries that may be sustained while participating in alpine sports.

Winter alpine enthusiasts include a large proportion of children and adolescents who embrace all manner of activities in the Australian alpine regions. The most popular sports include alpine skiing, snowboarding, cross-country skiing and telemarking. These activities combine to create a large portion of the Australian alpine tourism industry. Despite the importance of the industry and the potential impact of injuries on participation, very little academic attention has focused on understanding injuries through epidemiological studies, particularly in relation to children and adolescents and potential injury reduction programs.

This chapter introduces the thesis and the research being presented. It sets out the context by examining the increasing importance of alpine epidemiology knowledge, injury reduction and prevention techniques. The results presented in this thesis support the alpine tourism industry by increasing their knowledge of the prevalence of injuries, thus allowing the tourism industry and relevant associated companies to attempt to reduce the incidence of injuries.

While the welfare of tourists has emerged as a growing area of interest for researchers from a wide range of disciplines, particularly those related to more adventurous activities such as bungee jumping, heli-skiing/snowboarding, scuba diving and white water rafting,
to date there has been limited literature published concerning tourism accidents. This is surprising in light of the growing evidence that adverse experiences such as accidents can have significant negative effect on the image of the tourism industry (Page, Bentley and Meyer, 2003).

Adventure tourism has become an increasingly popular form of holiday pursuit. In the past decade it has also become a major factor in growing tourism industry (Swarbrooke, Beard, Leckie, and Pomfret, 2003). Alpine sports form part of the adventure tourism industry as a type of outdoor recreation, and in Australia represents a significant part of the nation’s tourism industry (Ritchie and Adair, 2004; Weiler and Hall, 1992). There is a great variety of adventure tourism opportunities that one can participate in with the following section clarifying and providing examples of different adventure and leisure activities.

Millington in 2001 stated that adventure tourism is now seen as one of the most dynamic sectors or tourism worldwide (Millington, 2001). The travel industry has reported to become increasingly segmented and specialised with the development of new styles of adventure and leisure tourism (Ritchie, 2000). The New South Wales tourism industry reports that the adventure tourism industry is quickly developing in Australia (Hossain, 2004). This is supported by data that shows that in 2003 approximately 2.2 million international adventure tourists travelled to Australia and contributed in excess of 6.7 billion Australian dollars to the national economy. This amount corresponds to 60% of the total expenditure of all international travellers. In 2004, 17 million Australians participated in domestic or international adventure travel (Hossain, 2004; Tschapka, 2006; Tschapks, 2006).

There are substantial economic benefits from alpine activities, which are part of adventure tourism, and according to The National Institute of Economic and Industry Research 2006 report on The Economic Significance of the Australian Alpine Resorts the total collective summer and winter profit for the New South Wales alpine resorts in 2005 was $812 million and in Victoria the benefit was $505 million (Dickson and Faulks, 2007).
1.1.2 Clarification of Adventure Tourism

There are a wide, and continually increasing, variety of activities or pursuits that may be classified under the heading ‘adventure or leisure tourism’. Millington, Locke and Locke (2001) stated that adventure tourism can be extremely diverse.

*It can be used to describe anything from taking a walk in the countryside to taking a flight into space.*

(Millington, Locke and Locke, 2001, pp 84)

Table 1.1 provides evidence of the broad spectrum of activities that can be classed as adventure and leisure tourism. There are a number of alpine snowsports listed including skiing, snowboarding and snowshoeing (indicated with an *).

<table>
<thead>
<tr>
<th>Table 1.1 Examples of adventure and leisure activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abseiling</td>
</tr>
<tr>
<td>Arctic Trips</td>
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<tr>
<td>Arduous Treks</td>
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<tr>
<td>Backpacking</td>
</tr>
<tr>
<td>Ballooning</td>
</tr>
<tr>
<td>Bicycling</td>
</tr>
<tr>
<td>Bird Watching</td>
</tr>
<tr>
<td>Bungee Jumping</td>
</tr>
<tr>
<td>Camping</td>
</tr>
<tr>
<td>Canoeing</td>
</tr>
<tr>
<td>Caving</td>
</tr>
<tr>
<td>Climbing Expeditions</td>
</tr>
<tr>
<td>Dog Sledding</td>
</tr>
<tr>
<td>Fishing</td>
</tr>
<tr>
<td>Four Wheel Drive Trips</td>
</tr>
<tr>
<td>Hang Gliding</td>
</tr>
<tr>
<td>Hiking</td>
</tr>
<tr>
<td>Horseback Riding</td>
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<tr>
<td>Hunting</td>
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<tr>
<td>Jungle Exploring</td>
</tr>
<tr>
<td>Kayaking</td>
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<tr>
<td>Motorcycling</td>
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<tr>
<td>Mountain Climbing</td>
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<tr>
<td>Nature Trips</td>
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<tr>
<td>Orienteeing</td>
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<tr>
<td>Paragliding</td>
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<tr>
<td>Rafting</td>
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<tr>
<td>Rappelling</td>
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<tr>
<td>Rock Climbing</td>
</tr>
<tr>
<td>Rogaining</td>
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<tr>
<td>Safaris</td>
</tr>
<tr>
<td>Sailing</td>
</tr>
<tr>
<td>Scuba Diving</td>
</tr>
<tr>
<td>Sea Kayaking</td>
</tr>
<tr>
<td>Skiing*</td>
</tr>
<tr>
<td>Snowboarding*</td>
</tr>
<tr>
<td>Snow Mobiling</td>
</tr>
<tr>
<td>Snow Shoeing*</td>
</tr>
<tr>
<td>Soaring</td>
</tr>
<tr>
<td>Spelunking</td>
</tr>
<tr>
<td>Surfing</td>
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<tr>
<td>Survival and Wilderness Training</td>
</tr>
<tr>
<td>Trekking</td>
</tr>
<tr>
<td>Walking Tours</td>
</tr>
<tr>
<td>White-water Kayaking</td>
</tr>
<tr>
<td>White-water Rafting</td>
</tr>
<tr>
<td>Wilderness Survival</td>
</tr>
<tr>
<td>Windsurfing</td>
</tr>
</tbody>
</table>

One of the activities that has grown since the 1970s is the winter alpine sports and tourism market (Kiandra Historical Society, 2000). Further, studies of the international snowsport industry estimate the existing international market is in excess of 65 million skiers, with an estimated 360 million skier visits annually (Hudson, 1998; 2000). Therefore, it can be concluded alpine sports are extremely popular worldwide and contributes to a very viable adventure tourism sector.

Australia accounts for 0.67% of all skier days worldwide (Hudson, 2000) and in 2007 2,034,000 Australian skier days were recorded (Australian Ski Areas Association, 2008). A skier day is defined as one person purchasing a lift ticket for one day’s participation in pursuits such as alpine skiing or snowboarding. Some assumptions are made as to how many days the purchaser of a season pass skis or rides (Australian Ski Areas Association, 2008).

At present in Australia there are 14 resorts located in three states: New South Wales (NSW), Victoria (VIC) and Tasmania (Tas) (Australian Ski Areas Association, 2008). As in many countries, an accurate estimate of the size of the snowsport industry is difficult to ascertain with only two sources of collection. In Australia these sources are the Australian Ski Areas Associations (ASAA) and the Australian Bureau of Statistics (ABS). The Australian Ski Areas Associations estimate of ‘skier days’ is displayed in Figure 1.1.

Figure 1.1 presents the ASAA data for the last eight seasons from 2000 until 2007. Dickson and Faulks (2007) noted that “the 2006 snow season was the worst on record with resorts being dependent upon snowmaking to operate effectively throughout the season”. Despite this poor season, the trend line indicates an increase in skier days over the period of 2000 to 2007.
The second source of data is from the Australian Bureau of Statistics (ABS). This organisation uses the broader category ‘Ice and Snow Sports’ for research purposes and includes ice-skating and ice hockey along with skiing and snowboarding. Data from ABS is analysed by the Australian Sports Commission and published in “Participants in Exercise, Recreation and Sport Annual Report”. Table 1.2 summarises the data published in 2001, 2005 and 2006 annual reports.
Table 1.2  Australian ice and snowsport participations: 2001, 2005 and 2006.

<table>
<thead>
<tr>
<th>Age Range</th>
<th>2001</th>
<th>2005</th>
<th>2006</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Participants</td>
<td>196,200</td>
<td>228,000</td>
<td>177,800</td>
<td>200,667</td>
</tr>
<tr>
<td>Female</td>
<td>32%</td>
<td>36%</td>
<td>36%</td>
<td>34.7%</td>
</tr>
<tr>
<td>Male</td>
<td>68%</td>
<td>64%</td>
<td>64%</td>
<td>65.3%</td>
</tr>
<tr>
<td>15-24 years</td>
<td>25.8%</td>
<td>22.8%</td>
<td>24.9%</td>
<td>24.5%</td>
</tr>
<tr>
<td>24-34 years</td>
<td>36.1%</td>
<td>30.4%</td>
<td>23.6%</td>
<td>30.0%</td>
</tr>
<tr>
<td>35-44 years</td>
<td>19.8%</td>
<td>19.3%</td>
<td>26.3%</td>
<td>21.8%</td>
</tr>
<tr>
<td>45-54 years</td>
<td>9.1%</td>
<td>18.2%</td>
<td>19.8%</td>
<td>15.7%</td>
</tr>
<tr>
<td>55-64 years</td>
<td>5.5%</td>
<td>5.6%</td>
<td>4.2%</td>
<td>5.1%</td>
</tr>
<tr>
<td>65 years +</td>
<td>3.6%</td>
<td>3.6%</td>
<td>1.2%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Annual Participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 6 times per year</td>
<td>47.7%</td>
<td>47.0%</td>
<td>43.9%</td>
<td>46.2%</td>
</tr>
<tr>
<td>7 – 12 times</td>
<td>17.5%</td>
<td>20.2%</td>
<td>21.8%</td>
<td>19.8%</td>
</tr>
<tr>
<td>13 - 26 times</td>
<td>15.0%</td>
<td>18.2%</td>
<td>13.9%</td>
<td>15.7%</td>
</tr>
<tr>
<td>27+ times</td>
<td>19.8%</td>
<td>14.6%</td>
<td>20.4%</td>
<td>18.3%</td>
</tr>
</tbody>
</table>

Source: Recreation and Sport Annual Reports 2001 (p43-55), 2005 (p42-51) and 2006 (p48-56).

The data from these three annual reports suggest there was an increase in participation rates between 2001 and 2005 of 1.1%, yet between 2005 and 2006 there was a decrease in participation of 1.2%. An explanation for a decrease in participation rates in 2006 could be because of the poor snow condition over that season. Therefore, participation levels over the six years have remained steady.

Table 1.2 also illustrates that there is an ageing ice and snowsport population as those under the age of 35 years represented 61.9% of the total snowsport population in 2001, declining to 53.2% and 48.5% in 2006.
Figure 1.1, from the Australian Ski Areas Association, indicates that there was a 1.2% increase in participants from 2006 to 2007, while Table 1.2 indicates similar participation rates over different years. The small discrepancy between the two governing bodies provides an indication of the reliability of the data.

In addition to there being economic benefits of activities such as skiing, there are also documented health-related benefits of participating in both sport and exercise (Purvis and Burke, 2001). However, it has also been shown that injury is a potential consequence of such participation (Scheidt, Harel, Trumble, Jones, Overpeck and Bijur, 1995). For example, a population survey conducted in America, and similarly in Australia, revealed that sport and exercise was the leading source of physical injury experienced by respondents, which accounted for approximately one third of all injuries sustained (Australian Bureau of Statistics, 2006; Kraus, 1984; Purvis, 2001; Scheidt, 1995).

In New Zealand, a country with a population of approximately four million people, the national no-fault injury compensation scheme, Accident Rehabilitation Compensation and Insurance Corporation (ACC, 2002), had over twelve thousand claims for sporting injuries from July 2001 until June 2002. These claims represented a cost of almost NZ$47 million, which accounted for 16% of all new claims (Accident Rehabilitation & Compensation Insurance Corporation, 2008).

Similarly, a report released by the ABS stated that approximately 498,000 children aged five to 14 are injured each year, with 51% of these being related to leisure activities (253,980) and one third (27%, 134,460) while children were playing sport. These injury rates provide evidence of how important children’s injury prevention programs could be. The significance of this information is that prevention programs in leisure activities such as the skiing industry may have the capacity to reduce the number of children injured per year.
1.1.3 Alpine Sports

Skiing and snowboarding are no more dangerous than other high-energy participation sports or extreme tourist activities, and less so than some common activities such as swimming (National Ski Areas Association, 2008b). The difference is that skiing and snowboarding are very demanding activities which require physical skills that are only learned over time with practice (National Ski Areas Association, 2008a).

According to the American National Ski Areas Association over the past 10 years, approximately 39.8 people have died skiing and snowboarding per year. The latest American data for the 2007/2008 season indicated that 53 fatalities occurred out of the 60.5 million skier/snowboarder days. Of the 53 fatalities, 44 were skiers (38 males and six females) and nine were snowboarders (eight males and one female).

The rate of fatality for the 2007/2008 winter converts to 0.88 per million skier/snowboarder visits which is higher than the 2004/2005 winter seasons (National Ski Areas Association, 2008a). When compared with the swimming fatalities in 2006 (includes drownings of person swimming or playing in water, or falling into water, except on home premises or at work but excludes drownings involving boats, which are in water transportation), there were 3,800 deaths, with a fatality rate of 1.83 fatalities per million participation days, thus giving a perspective on the danger of the alpine sports compared with swimming (National Ski Areas Association, 2008b).

Alpine sports involves inherent risks, but in some incidents, it is that risk and adrenalin that may entice participants to pursue the sport. For example, alpine participants on open slopes can obtain speeds of approximately 40 to 50 kilometres per hour (Pray, 2008).

Whatever it is that attracts individuals to snow sports, there is always the potential for an injury to occur. This may in turn affect a participant’s decision to participate in the sport in the future. Fear of injury is a potential participation barrier similar to a phobia that may affect an individual’s participation in alpine sports. Statistics reveal that for every thousand individuals participating in skiing and snowboarding on the slopes, there are
typically two or three injuries that require medical attention (Langran and Selvaraj 2002; National Ski Areas Association, 2008b).

The incidence of injury for those less than 18 years of age can be three times higher than that of an individual over the age of 18 (Cadman, 1996; Langran and Selvaraj, 2002; PhysioRoom, 2008). Therefore, this is an important problem that needs further investigation.

From Australian data and literature available it is very difficult to ascertain the rate of serious injury in snowsports, which can include paraplegia, head injury, musculoskeletal injuries, broken limbs, quadriplegia and other spinal injuries. American research reports that the number of serious injuries is approximately 43.6% of the total snowsport injuries on average per year in addition to 39.8 fatalities (National Ski Areas Association (NSAA), 2008b). According to the NSAA in the 2007/2008 season, there were 41 serious injuries. Of these, 31 were skiers (25 males and seven females) and nine were snowboarders, all male. The rate of serious injury in 2007/08 was 68 per million skier/snowboarder visits (National Ski Areas Association, 2008a).

The number of fatalities and serious injuries is not as high in Australia as it is in America because there are far fewer skier days. Death when participating in snowsport is very uncommon but it does occasionally occur. In Australia the author located the first study of skiing-related deaths in Australia, which was a 32-year study of skiing-related deaths in the Snowy Mountains, where it was reported 29 fatalities had occurred. Of these 29 fatalities, eight subjects died of trauma, 15 subjects died of cardiovascular causes, and six subjects died of hypothermia. The over-all incidence of death was 0.87 deaths per million skier-days; the specific incidence for trauma-related deaths was 0.24 deaths per million skier-days; for cardiac-related deaths the rate was 0.45 deaths per million skier-days; and for hypothermia-related deaths the rate was 0.18 deaths per million skier-days. These findings compare most favorably with US figures. Death that is associated with skiing in Australia’s Snowy Mountains is a rare event (Sherry, 1988a).
1.2 **Study Objectives**

1.2.1 **Statement of the problem**

With the economic importance of snowsport tourism being nearly $1 billion in Australia and the risk that people may not participate due to fear of injury, there is a need to increase the understanding of injury rates and contributing factors to injuries. The international literature on alpine skiing and snowboarding overwhelmingly suggests an injury incidence rate of between two and 3,000 skier visits (Bladin, Giddings and Robinson, 1993; Ekeland and Rødven, 2006; Langran and Selvaraj, 2002; National Ski Areas Association, 2008a). Additionally, the literature indicates that children and adolescents are over-represented in the injured population (Cadman and MacNab, 1996). A substantial amount of literature reports similar findings. It is estimated that children and adolescents have an incident rate of injury between 1.86 and 3.00 times higher than that of the total population (Hagel, 2005a; Langran, 2007a). This higher incidence rate of injury warrants an investigation to determine if there are certain individuals in this targeted population who sustain more injuries and to determine if there is an explanation for the higher rate of injuries.

1.2.2 **Aims and objectives**

The aim of this research is to investigate and evaluate the effects of the combined psychological characteristics of risk-taking and sensation seeking on alpine injuries sustained in a targeted adolescent population. This sense of risk-taking, and its associated psychological characteristics, may be a possible explanation for the higher incidence rate of snowsport injuries in children and adolescents.

Little is known about risk-taking and sensation seeking in adolescent populations in conjunction with alpine winter sports injuries. With an increasing number of Interschools participants and the growing number of ski based excursions to the snowfields, injury trend may have changed. Interschools are a series of school based ski and snowboard races held throughout winter with participants from all over Australia. This study provides information needed to develop injury control and prevention programs for an adolescent
population. It will establish if a pattern exists with alpine based injuries in an adolescent population with risk-taking and sensation seeking. If able to ascertain high risk injury potentials that are more likely to injure themselves, a more specific target audience for injury prevention programs will have been acknowledged.

This alpine winter sports research aims to determine the injury rate, injury epidemiology, analyse the pattern of risk-taking and sensation seeking behavioural characteristics among adolescents during alpine activities, and their perceptions of risk-taking and to identify the social factors which effect occurrences of injuries and severity. The rationale behind the study incorporates the benefits of identifying higher risk-taking groups to target prevention programs. Their application can be used to design and implement more appropriate Interschools training programs and school based excursions and injury prevention programs.

The principle objectives of this study were to:
(i) Evaluate the participants' demographics in comparison to other studies;
(ii) Collect and analyse alpine epidemiology injury data and compare with risk-taking and sensation seeking characteristics;
(iii) Identify adolescents with high risk-taking and sensation seeking characteristics;
(iv) Quantify protective equipment usage, failure and attitudes among participants;
(v) Compare injuries, risk-taking scales and race placing over a season; and
(vi) Investigate hydration and food consumption over a day skiing/snowboarding.

The researcher hypothesizes that individuals who score higher in risk-taking and sensation seeking scales will have a higher number of injuries sustained overall.

In this study the research intends to investigate how and why (analytical epidemiology) participants were injured, and if there are possibilities of creating injury prevention programs in the future. The research is aimed to help develop injury prevention programs which can be than be implemented in schools prior to their alpine winter excursion to the snow. This will be achieved by conducting a questionnaire based survey addressing
demographics, previous snow sport injuries and risk-taking behaviours at the snow, and injuries sustained at the snow over the current season.

The three main objectives of this thesis were to:

- Gather adolescent alpine epidemiology data to determine if the targeted group has similar injury trends to reported scientific literature;
- Collect risk-taking and sensation seeking characteristic data; and
- Compare the collected alpine epidemiology data and risk taking data with participants’ demographics, previous experience, hydration and food intake and event level to identify any relevant patterns.

To achieve the aim and objectives the following four phases or research were undertaken:

1. Relevant literature related to the adventure tourism sector, alpine epidemiology and risk-taking was reviewed;
2. A questionnaire able to gather data to obtain the three previously stated research objectives was created;
3. A pilot study to assess if the questionnaire created is viable, understandable for target audiences and reliable was undertaken; and
4. Protective equipment usage among adolescents was investigated and quantified and compared with international data.

1.2.3 Scope of study and contribution

This thesis is focused on alpine epidemiology in a selected population. The target populations are adolescents from NSW and ACT Alpine Interschools racing teams who participated in the 2007 racing season. This audience was selected because it was under the direction of a governing body which agreed to participate in the research project and included participants within the target population. Data was collected through a questionnaire that examined demographics, previous experiences in alpine sports, previous injuries in alpine sports, injury perception, protective equipment usage, risks in alpine sports, type of event, equipment breakage and failure and hydration and food intake while participating in alpine sports. The study has inherent limitations which will be explored in chapter four.
Risk and sensation seeking characteristics were chosen as a study topic because of the author’s involvement in the alpine industry as a ski and snowboard instructor. It became apparent to the author that a number of children do not appear to have any concept of fear which may lead to reckless behaviour on the slope. Some unskilled children and adolescents appear to have no fear and are unaware of the danger to themselves and others. Their lack of skills and misbehaviour are common occurrences in the snow and in some cases lead to injury.

In conducting this research, the author aimed to contribute to knowledge regarding children and adolescents’ alpine epidemiology and specific groups that maybe targeted with future injury prevention programs. This study provides information that can inform and help the alpine adventure tourism industry to continue to grow. Essentially, the research was designed to add to the scientific body of alpine epidemiology research that will be able to reduce snowsport injuries overall, but in particular children and adolescents. The author knows all too well the pain and subsequent problems of minor and major injuries in this target group from personal experience.

By satisfying the above mentioned objectives this thesis not only makes contributions to the development of the alpine tourism industry in Australia, but can assist in injury prevention more broadly in sport and recreation. Findings from this research may be beneficial to two different industries, the tourism industry and the health industry. It may provide valuable information for commercial purposes and also health and injury prevention.

1.3 Definitions

The following definitions derived from the tourism and snowsport industry will be used throughout this thesis.

1.3.1 Tourism industry definitions, and definitions of a tourist vary with respects to the organisation defining them, generally it is suggested that a tourist is an individual that has
an overnight stay (Ritchie and Adair, 2004). If an individual’s trip does not incorporate at least one overnight stay than the term excursionist is usually applied. Therefore this definition can be applied to international and domestic travellers.

1.3.2 Sports Tourism includes travel to participate in a passive sports holiday (e.g. sports events and sports museums) and/or an active sports vacation (skiing, cycling, golf), and it may involve instances where either sport or tourism is the dominant activity or reason for travel (Ritchie and Adair, 2004). Standeven and De Knop (1999) therefore defined sports tourism as “all forms of active and passive involvement in sporting activity, participated in casually or in an organised way for non-commercial or business/commercial reasons that necessitate travel away from home and work location” (Standeven and De Knop, 1999, p. 12).

1.3.3 Adventure tourism is “characterised by its ability to provide the tourist with relatively high levels of sensory stimulation, usually achieved by including physically challenging experiential components” (Muller and Cleaver, 2000, p. 155) which incorporates snowsports.

1.3.4 Winter alpine sports include any type of sport participated in winter in the mountains. Alpine sports can be sub-divided into three key general categories: downhill skiing (including telemarking); Nordic skiing (including cross-country and touring); and snowboarding. Research by ASAA and ABS provide evidence that downhill skiing and snowboarding are Australian’s most popular winter alpine activities. In Australia, alpine skiers comprised 69% of the total slope population, while snowboarders make up 28% and telemarkers comprise 2% (Bladin, McCrory, and Pogorzelski, 2004).

In alpine skiing and snowboarding participants use chair lifts, rope pulleys and cabled T-bars for the slope ascent, where prepared and marked runs are used for the descent. It is common to have small shrubs and trees growing on the side of the prepared slope. Cross-country skiing involves skiers who use prepared trails over rolling or hilly terrain. The skis used are longer, narrower and lighter than those used in alpine skiing.
1.3.5 **Risk-taking** has been defined by Zuckerman (1994, p 124) as “the appraised likelihood of a negative outcome or behaviour”. Zuckerman (1994) reported a relationship between risk taking and sensation seeking and noted that high sensation seekers are generally risk takers.

1.3.6 **Sensation seeking** is the continual search for risky, complex or novel experiences (Rossi and Cereatti, 1993).

1.3.7 **Adolescent risk-taking and injury** - unintentional injury has been identified as the leading cause of death during late adolescence and young adulthood in 2006 (Australian Bureau of Statistics, 2006). One factor that has been reported to contribute to increased rates of injury during adolescents is risk-taking (Irwin and Millstein, 1991). Whilst risk-taking behaviour is considered by many to be a normal part of development (Jelalian, Spirto, and Rasile, 1997), this behaviour may place the adolescent at a greater risk of injury.

Irwin and Millstein (1991) defined risk-taking behaviour as behaviour which “must have potentially no injurious outcomes as well as one that may result in harm, and the behaviour must be volitional” such as risk-taking while skiing (Irwin and Millstein, 1991, p7).

Alpine sports involve skills, risk-taking and occasionally injuries. In some sense the risk-taking choices in alpine sports may be similar to risk-taking when driving a car, choosing to take drugs or other high-risk activities, yet the majority of the target populations would not have experienced such risks. Misinterpretation of risk may be another factor associated with risk-taking behaviour and injury. It may reflect a lack of awareness of risk associated with certain behaviours, and or be associated with a lack of experience with certain behaviours. All these can be applied to risk-taking and skiing (Jelalian, Spirto and Rasile, 1997).
1.4 Thesis Content and Structure

The thesis content and structure of the proceeding chapters is presented in five sequential chapters. This chapter provided the background of the present research and has endeavoured to explain both the problems and associated purposes of this thesis. Supplementary to this, the aims and objectives have been introduced and the contribution of the thesis to research in alpine tourism and injury epidemiology were discussed. To conclude, an outline of the five key chapters has been provided.

Chapter two explores the historical development of winter alpine sports and its subsequent growth into a profitable adventure tourism industry. In particular, it is aimed to place the presented research project within a framework of current and past understanding by reviewing relevant scientific, technical and informal work on alpine epidemiology and risk-taking. The review considers what has already been learned about alpine epidemiology, those who participate in alpine sports and a profile of injured participants. Central to the development of injury prevention strategies is the knowledge of the profile of injured participants, understanding those who are at particular risk and, if possible, the biomechanical factors involved in each injury type.

Chapter three describes the research methods used for the research project. It establishes the research paradigm from which the research method subsequently follows. The methods employed for creation of the questionnaire, ethical considerations and issues, outcomes of the pilot study and distribution methods of the questionnaire are presented and discussed.

Chapter four presents the research project results and provides the statistical analysis of the major findings. This chapter is divided into nine sections where each result topic is presented.

Chapter five provides an interpretation of the results and explanation of the findings.
Chapter six concludes by providing general and more specific recommendations for future research and projects in the field of winter alpine injury investigations. A reference bibliography and appendices follows chapter six. In the appendix the pilot study results are presented in the form of a published journal article.

1.5 Summary
It has been reported that children and adolescents appear to have a higher alpine sports injury rate than the total population. Alpine sports involve skills, risk-taking and occasionally injuries. In some sense the risk-taking choices in alpine sports may be similar to risk-taking when driving a car, choosing to take drugs or other high-risk activities, yet the majority of the target populations would not have experienced such risks. Typically, reported risks for the target population include skiing or riding at high velocities, missing school without parental permission and stealing money from family or friends. Alpine sports are not trivial activities as in some sports, or hypothetical situations; they involve very real risk, physical danger and the possibility of injury.

An advantage in researching alpine sports is that it has a wide range of participants; both males and females participate, the age range is wide, and the different sports have been studied previously in relation to injury rates. Numerous studies have acknowledged that on average, alpine sports produce approximately two to three injuries per 1,000 skier days. The effects of age, skill, sex, and experience have been extensively studied yet little attention has been paid to selected age brackets and the influence of psychological and personality characteristic variables, which is the objective of the current research.

This alpine winter sports research project aims to analyse the pattern of risk-taking and sensation seeking behaviour characteristics among adolescents during alpine activities, and their perceptions of risk-taking and to identify if social factors affect the occurrences of injury frequency and severity. The rationale behind the study incorporates the benefits of knowing higher risk-taking groups and how they relate to injury. The results can be used to design and implement more appropriate training and injury prevention programs.
CHAPTER TWO: LITATURE REVIEW

2.1 General Introduction

The first evidence of skiing originates from the Stone-Age and therefore the art of skiing is over 5,000 years old (Lund, 1996). Skiing and snowboarding are activities practiced by millions of people worldwide. Unfortunately, various studies have identified alpine sports as one of the leading causes of paediatric sport-related injuries in countries such as Canada, Austria and France (de Leös, 1995; Health Canada, 1997). Alpine epidemiology investigations have found that children and adolescents suffer from some of the most severe sports-related injuries (Marchie, Di Bello, Messi and Gazzola, 1999; Sahlin, 1990; Ytterstad, 1996). By examining the patterns of injury epidemiology in skiing and snowboarding, associated risk-factors may be identified to develop injury preventive strategies can be implemented to target specific population groups.

The literature review presented in this chapter includes over 200 articles and documents. Approximately half of these relate directly to alpine based sports. The published corpus of literature is dominated by clinical-based epidemiological investigations and more specifically alpine injury trends around the world. Both published and unpublished research and studies is examined.

The author attended and presented research at two international conferences in Japan (April 2005), and Scotland (April 2007) at the 16th and 17th International Conference on Skiing Trauma and Safety of the International Society of Skiing Safety (ISSS) respectively.

Literature was assemble via an electronic database review using the following subjects: alpine injuries, ski injuries, snowboard*, adolescent risk-taking, risk-taking, sensation seeking, teenage risk-taking adventure tourism, accidents and tourist*and snow safety. In addition to this electronic database review, personal correspondence with the New South Wales and Australian Capital Territory Interschools organisers was conducted.
The literature review begins with the history of alpine sports, followed by alpine tourism aspects, injury epidemiology including alpine epidemiology, an analysis of risk-taking and sensation seeking literature, and a conclusion.

Any discussion regarding sports injury must first establish injury and accident definitions (Cadman, 1996). Injury can be defined as an insult to the body resulting in hurt, damage or loss (Cadman, 1996). An accident, on the other hand is a sudden, unintentional event which is apparently unpredictable and which may or may not result in injury (Cadman, 1996). Injury differs from accident in that injury does infer preventable causation, including bodily harm.

2.2 Alpine History
The first location where skiing took place is a disputed issue, with anthropologists and historians of ancient skiing debating two main origins. The dispute may be due to the concept being simultaneously thought of and put into practice in both Scandinavia and China.

Scandinavia is where the oldest preserved skis have been found (Marquand, 2006), while Stone-Aged rock carvings, dating back to 2,000 BC, were discovered around the Arctic perimeter in Norway. These carvings depict ski-shod hunters, sometimes disguised in skin and horn in pursuit of game. The time-frame of these rock carvings has been placed in the same era as that of the Egyptian pyramid-building (Lund, 1996).

Central Asians, Mongols, and Kazaks living in the remote Altay Mountains of the Xinjiang providence have also claimed to have developed the first primitive form of skiing. Cliff paintings 200 centuries old in rugged remote north-western China portray hunters on planks of wood with poles in their hands, chasing cattle and horses (Marquand, 2006). Research suggests that the Altaic people learned to ski at the age of three, and by seven were confident skiers (Marquand, 2006 located on internet with no page number).
The Altaic people still use wooden curved planks based on designs that existed over 2,000 years old. Until a recent discovery by an explorer in 2006 (Lund, 2006), no western ski society was aware that the Altaic communities were still using the ancient ski style which involves using planks of wood (skis) with animal-skin attached to the bottom of the skis (Marquand, 2006). Wang Bo, a researcher from the Xinjiang Autonomous Regional Museum, was reported seeing a rock painting of four people chasing cattle and horses, three of them on a long rectangular board with poles in their hands. According to the Chinese Xinhua News Agency’s article, paintings in Altay in Xinjiang Autonomous Region have been verified as “humans hunting while skiing” and, therefore, archaeologists confirm the Altay region to be a place of skiing some hundred to two hundred centuries ago (Marquand, 2006).

In the Stone-Age skiing was used for practical purposes rather than for sport or a leisure activity. For more than 4,000 years skis have been used as a form of utility, and from the 10th century and beyond it has been recorded that the Vikings used skis for farming, transport and warfare. For Scandinavian countries with long distances between small isolated communities and hard winters, skiing became an important means of transport (Lund, 1996).

The first evidence of skiing being used other than for utilitarian purposes is a mere thousand years old. In a collection of Eddas poetry composed approximately 1,000 A.D. an author alluded to fast skiing as an accomplishment of the Viking King Harald Hadrade (1046-1066) (Lund, 1996). Eddas advocated that skiing is not merely for hunting, but an attribute of an aristocrat, for racing and placing wagers.

In the 15th, 16th and 17th centuries, skis were used in warfare in Norway, Finland, Sweden, Poland and Russia (Lund, 1996). Scandinavian skiing of the middle ages gradually developed into a complex activity. Early ski designs were crude and inefficient, with the skis being stiff and straight-sided, with an unstable toe-strap used as bindings to attach shoes to the ski. A single pole was used to turn and stop and this technique became known as stick-riding (Lund, 1996). By the 18th century units of Swedish, Norwegian and
Danish military trained and competed on skis. The first skiing manual ever to be published was by a Norwegian Ski troop captain in 1733 (Lund, 1996).

Norwegian skiing was revolutionised in the 1800s (Lund, 1996) on the plateau of Telemark, 80 kilometres northwest of Oslo, now the Norwegian capital. Early skiers who carved their own skis found that by carving out the middle of the skis into an hour glass shape, the skis were easier to turn on. Telemark skiing transformed rudimentary skiing to a more dynamic and controllable practice. By changing the ski shape, binding style and the angle of the undersides on the ski, skis gained more stability and control. From here stick-riding was phased out almost entirely (Masia, 2005).

The rise of Telemark skiing in the Scandinavian countries created an interesting contrast the long-board skiing styles being utilised in the United States. It is believed that skiing was introduced into the United States and spread by Swedish, Finnish and Norwegian miner migrants. Miners who left the Scandinavian region in the late 1800s and found their way to California, Colorado, Utah and even Australia spread the long-board skiing style (Walkom, 1991). These individuals, typically men, carved their own skis out of wood. During the winter when transport to remote mining villages became impossible due to the heavy snowfall, skiers became the mail couriers (Mølster, 1996). The most famous of these men born in the region of Telemark, was John Snowshoe. He carried mail 129 kilometres from Nevada to California.

The long-board skiing style was used in the first form of alpine ski competitions in mining towns in the 1800s. Downhill ski races were held in mining communities around the world where competitions were held for ‘glory and gold’. Speeds were clocked at up to 140km/h (Lund, 1996) and this velocity was not reached again on skis for a century. Scandinavian miners can be thanked for the introduction of skiing to Australia in the early 1860s (Walkom, 1991).
2.2.1 The Birth of Skiing in Australia

The first documented evidence of skiing in Australia was at Kiandra, New South Wales. Documented evidence appeared in the Monaro Mercury local newspaper in the winter of 1861 (Walkom, 1991). The newspaper reported that

Bored fortune seekers, under the guidance of the Scandinavian miners, had taken to strapping fence palings to their gumboots and were sliding down hills.


The sport continued to flourish into what is now a multimillion dollar tourism enterprise.

2.3 The Alpine Tourism Industry

2.3.1 The Relationship between Sport, Tourism and Alpine Winter Sports

Sport has become an instrument that possess the ability to attract an international market of huge proportions since the early 1960s. It has the capacity to attract a significant amount of “media attention, money, endorsements, participants, and political interest” (Standeven and De Knop, 1996, p vii).

Coupled with this is tourism, with in excess of a billion participants and billions of dollars generated in revenue annually, it is the world’s largest industry as well as the fastest growing (Standeven, 1996). Therefore, it is hardly surprising that a relationship exists between sport and tourism. Sport and tourism both promote and complement each other and a relationship exists between the two.

Realising the potential of sports tourism, of which alpine sports are an integral part, the tourism industry can expand to fulfil a wider variety of human wants and needs (Delphy, 1998; Williams, 2000). Kurtzman and Zauhar (2000) recommended that there are six main sports tourism categories:

- sport tourism attractions;
- sport tourism resorts;
- sport tourism cruises
- sport tourism tours;
- sport events tourism; and
- sport adventure tourism.

To increase the complexity numerous researchers have derived different explanations. Gibson (1998) suggested there are three main categories in the tourism research field, including:
- active sports tourism;
- event sports tourism; and
- nostalgia sports tourism.

An integral part of the success of the tourism industry is activity based travel. According to Standeven and De Knop (1999) this segment of the travel industry accounts for approximately 10% to 30% of the market. Active or recreational based travel accounted for 45% of international travel by Australians and for 46% of domestic visitor nights in 2003 (Australian Bureau of Statistics, 2005).

The World Tourism Organization (WTO) (2001) noted that favourite physical activities on active holidays ranged from skiing and snowboarding in winter, to hiking, mountaineering, climbing, water sports (scuba diving, snorkelling, swimming) and cycling in summer (World Tourism Organization (WTO), 2001). Sport can be a powerful motivator for travel, whether to participate in an activity or to watch an event (Williams, 2000).

Sports participation can also provide meaning and purpose to ones ‘travel experience’ (Gibson, 1998; Kurtzman et al, 1997; Ritchie et al, 2004; Standeven et al, 1996; World Tourism Organization (WTO), 2001). James (1995) stated that tour operators and wholesalers report rising levels of interest in sport-related tours and adventures, indicating that sports has the capacity to act as a stimulus for resort development (Spivack, 1997), investment, expansion and regeneration (Williams and Fidgeon, 2000).
Physical legacies of key sporting events and venues can also act as important tourist attractions as illustrated by Olympic Park at Homebush (Sydney, New South Wales) and other iconic sporting venues.

Standeven and De Knop defined sports tourism as ‘travel for non-commercial reasons, to participate or observe sporting activities away from the home range’ (Standeven and De Knop, 1996, p.147), while Williams and Fidgeon in 2000 noted that

*With the development of sport, sports tourism has come to be a recognised subset of the tourism industry and as an academic field of study.*

(Williams and Fidgeon, 2000, p 380)

Alpine sports are some of the most important economic sectors of the alpine tourism industry and have consistently illustrated that these winter activities are an important travel motivator. The alpine Australia regions generate $1,319 million per year with additional gross state product and 17,050 annual equivalent employment opportunities (National Institute of Economic and Industry Research, 2006).

Table 2.1 lists the more traditional winter sports along with those that are gaining popularity in the twenty-first century (Hudson, 2004). Sports with an asterisk beside them in Table 2.1 are accessible in Australia; the majority of winter sports activities included in the table are more readily available in the northern hemisphere. There is a reported range of between 65 million (Hudson, 2000) to 200 million (Skokan, Junkins and Hadish, 2003) alpine enthusiasts worldwide, and in Australia literature shows that 20% of the population ski or snowboard and that an estimated 600,000 have reported having participated in a skiing holiday at some stage of their life (Bennett, Clark and Benton, 1997). In 2006 114,100 males and 63,700 females aged 15 years and over reported to have participated in ice and/or snowsports (Australian Sports Commission, 2007). Alpine sports are not a typical sport the majority of the world would readily associate with Australia, but around 2,039,000 skier-days are registered each year in Australia (Australian Ski Areas Association, 2008).
Table 2.1 The diversification of winter sports activities

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<tr>
<th>Traditional winter sports activities</th>
<th>Contemporary winter sports activities</th>
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<td>Skiing*</td>
<td>Snowboarding*</td>
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<tr>
<td>Cross-country skiing*</td>
<td>Snowmobiling*</td>
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<td>Telemarking*</td>
<td>Snowshoeing*</td>
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<td>Cat-skiing</td>
<td>Heli-skiing</td>
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<td>Winter sports events</td>
<td>Parapente / handgliding</td>
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<td>Ice-skating</td>
<td>Tubing*</td>
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<td>Horse-drawn sleigh rides</td>
<td>Dog sledging*</td>
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<td>Curling</td>
<td>Snowcycling</td>
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<td>Tobogganing</td>
<td>Thrill-sled / extreme sledding</td>
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<td>Ice-climbing*</td>
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<td>Snowskating</td>
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The International alpine industry has had a rapid proliferation of alpine sports from small mountain European towns to developments in remote corners of the earth. This was a completely unforeseen phenomenon to the sports pioneers (Hudson, 2004). The spread of winter sports has created a valuable and highly profitable industry. Several thousand lift-served slopes are in service during the winter season, stretching from Alaska to the Chilean Andes and from the Spanish Mediterranean west to the Pamirs (Lund, 2005).

In the Pacific region skiing is possible in Japan, China, Australia and New Zealand. Unknown to some, alpine sports exist in places as unlikely as Manchuria, Kazakhstan, Eastern Europe, South Africa, Greece, India, Iran and even Antarctica. Alpine sports are of vital importance economically for over a hundred resort based communities around the
world and are a major factor in many more (Hudson, 2004). Alpine sports give crucial support to the winter economies of alpine regions of Chile, Argentina, Switzerland, Germany, France, Italy, Austria, Russia, Japan, New Zealand and Australia (König, 1997).

Hudson (1998) reported that the industry growth from the late 1980s has been remarkable and breaks down the international market as 43% of the alpine industry being located in Europe, 34% in the Americas and 20% in Asia (Hudson, 1998). The globalization of skiing is quite apparent with the influx of foreign visitors to international destinations increasing dramatically every year (Hudson, 1998). Today, skiing denotes immense business and capital gain for those involved in the operation of resorts, whether it is the running of hotels, rental apartments, chalets, restaurants ski-lifts or clothing and equipment shops (Hudson, 2004). Other areas that derive substantial proportions of their business from the skiing include ski equipment and clothing manufacturers, tour operators, ski schools and transport companies. These characteristics make alpine sports a prime example of adventure tourism, and at the same time a sport that depends on the development of tourism.

How much the ski industry is worth worldwide is difficult to gauge. The United States indicates in excess of US$3 billion (1999) (The US Adventure Travel Industry, 1999) in annual revenues for American resorts, split between the sales of lift tickets and ski shops. Alpine sports are the third most popular adventure activity behind camping and hiking (The US Adventure Travel Industry, 1999). In the United Kingdom the industry is worth two hundred million pounds to operators, and directly employs 3,000 individuals, while sales of ski goods, selling from 700 outlets, were valued at 54.1 million pounds in 1999 (The US Adventure Travel Industry, 1999).

Despite its economic importance to the tourism industry, skiing has been poorly addressed in academic circles. In Australia, the economic significance of the Australian alpine industry is only beginning to attract research in the twenty-first century. The Australian winter tourism industry today is one of the largest industries in the Australian Alps.
There are ski resorts situated in southern New South Wales, Victoria and Tasmania (see Figure 2.1). An alpine resort is defined as an area which has been developed for snow sports activities. Such an area may include diverse supporting infrastructure such as accommodation, ski lifts, ski hire, restaurants and other businesses; alternatively an alpine resort may simply comprise snow sports areas with little or no other supporting infrastructure.

Figure 2.1 Location map of the Australian Alps of New South Wales and Victoria.


The National Institute of Economic and Industry Research in Australia reported that Alpine resorts are an important part of the Australian tourism industry and provides
significant benefits not only in the resort areas themselves but also to the surrounding towns, many of which have come to rely quite heavily on the industry for employment and local business activity.

(National Institute of Economic and Industry Research, 2006, p 1)

The report also stated that the alpine industry

*provides significant employment, especially for younger people who might not otherwise be attracted to these regions from larger cities.*

(National Institute of Economic and Industry Research, 2006, p 1)

The alpine industry also sustains many specialist businesses that supply clothing and equipment for the variety of alpine activities. These businesses are not only located in alpine regions but many major cities have businesses that provide a range of equipment and clothing. A report prepared for the Alpine Resorts Co-ordination Council in 2006 reported that the combined summer and winter benefits for the New South Wales, Victorian and Tasmanian alpine resorts in 2005 to be $1,319 million of additional gross product and 17,050 additional annual equivalent employment opportunities (National Institute of Economic and Industry Research, 2006).

The winter tourism industry is the primary economic contributor to the alpine region in Australia (König, 1997; National Institute of Economic and Industry Research, 2006). The New South Wales winter snow industry in 2005 generated 8,045 annual full-time equivalent employment positions and 15,800 seasonal job opportunities. The Victorian winter industry created 4,694 annual positions and 9,600 seasonal employment opportunities and Tasmania 20 annual equivalent employment opportunities (National Institute of Economic and Industry Research, 2006).

In New South Wales, 624 million dollars was generated to contribute to the gross state product, in Victoria 361 million dollars and in Tasmania two million dollars in total state product (National Institute of Economic and Industry Research, 2006). Compared with the majority of European ski resorts, the Australian ski resorts all have moderate vertical decent with lower elevations and annual snow fall. The lower elevation and latitude of the resorts creates highly variable snowfall and leads to higher solar
radiation respectively which both impact on the conditions of the snow (Ruddell, Budd, Smith, Keage and Jones, 1990). Inadequate snow fall considerably affects the economics of the winter tourism industry because fewer lifts can be opened and seasons are shortened (Ruddell et al, 1990).

The impact of greenhouse climate change will also affect the Australian winter tourism industry. Studies suggest that the greenhouse effects will produce increasingly inadequate snowfall seasons. These changes will have a serious impact on the Australian winter tourism industry.

2.3.2 Changes in the Alpine Industry

Alpine recreation and tourism have reached a high level of popularity and global recognition. It has been revolutionised over the last 5,000 years. Ineffective equipment has been removed, together with outdated styles such as short broad skis and ‘stick-riding’ on a single long pole. More alpine sports now exist such as snowboarding along with the development and advances in equipment. Technically the sports continue to evolve, and now with artificial snowmaking, indoor snow parks, advanced grooming machinery and other aids, seasons can be lengthened, thus lessening dependence on natural climatic factors.

Initially in the 1970s and 80s, when snowboarding was first introduced, many ski resorts were reluctant to allow snowboarders on the slopes and some banned the sport in the resort. Today only one US resort still prohibits snowboarders and that is Alta. Alta is a ski resort located in the Wasatch Mountains just east of Salt Lake City, Utah (www.alta.com). Alta’s web site and other online searchers including Wikipedia report that “It is one of the few remaining ski resorts in the world that prohibits snowboarders (Wikipedia, 2008). Wikipedia and the snowboarding magazine Transworld Snowboarding reported that the resort has for many years been the ‘subject of protest action by snowboarders’, such as the ‘Free The Snow’ campaign in the late 1990s (Transworld Snowboarding, 2006). It is currently the target of a campaign by a group who claim in their manifesto that discriminating against them is a blatant disregard for the Constitution
of the United States of America (Transworld Snowboarding, 2006). The approach to prohibit snowboarders was largely due to the lack of injury knowledge, and liability insurance concerns.

Typically snowboards are shorter than a ski set, with both feet fixed into a board with a non-releasable binding. This distinction produces a different injury pattern between the two sports. Snowboarding continues to be a popular winter sport practiced in alpine regions around the world. Today, snowboarders account for approximately 31.9% of the visitors to United States ski resorts (Kelley, 2008). The most current published research available indicates that snowboarders represented between 20% and 30% of ticket sales in Australia (Bladin et al, 1993).

The snowboarding surge has made the ski industry assess its effects on the market (Hudson, 1998) as it appears to attract a different subset of the alpine participant population. With the increased popularity of snowboarding and twin tip skis (upward curve at either end of the ski to allow to travel forwards or backwards) primarily from the adolescent age bracket, came the introduction of terrain parks. Today, nearly every resort has some type of terrain park; normally a number of them are placed throughout the resorts. Terrain parks are defined by the US National Ski Areas Association as a designated area constructed and maintained by the ski resort for patrons (National Ski Areas Association, 2005). Objects are built on a run (ski slope) and include, but are not limited to, table tops, quarter/half/super pipes, jumps, boxes and rails.

Terrain parks are not only increasing in number but in size and difficulty. Recent increases in terrain parks and half-pipes may be linked to increased injury rates and lead to changes in anatomical injury patterns in skiing and snowboarding (Cooper and Greenwald, 2006). Results from a terrain park based research project revealed that 20% to 34% of downhill runs in a terrain park resulted in a fall. This high fall rate may be an indication of why the injury rates may be changing (Cooper et al, 2006).
2.3.3 Why Alpine Sports Injuries are relevant to the Australian Alpine Industry

Globally ski resorts are committed to teaching alpine sports and have programs designed to cover all sports and ability levels, from beginners through to advanced participants including racing teams. Gilbert and Hudson (2000) reported that “it is important to understand the constraining as well as the facilitating factors associated with tourism in alpine participation” (Gilbert and Hudson, 2000, p 906).

By understanding the constraining factors one can gain a fuller understanding of the participation demands (Gilbert and Hudson, 2000). In the last decade, a growing body of research has emerged regarding tourism constraints. Gilbert and Hudson (2000) classified participation constraints in alpine sports into three categories: ceasing participation, constraints facing nonparticipants, and the constraints facing existing participants. Qualitative analysis revealed that non-skiers faced a number of intrapersonal obstacles, whereas skiers were more likely to be constrained by time, family, or economic factors (Gilbert and Hudson, 2000).

Injury prevention in ski resorts should be a key aspect not only because of the health and safety of patrons but it is also beneficial to the business within the resort. If patrons have an enjoyable experience they are more likely to return the following season. A range of different factors including risk-taking and sensation seeking have been linked together as a probable cause for accidental injuries (Cadman, 1996). The public’s perception of alpine injuries and the rates may also influence their decision to participate in alpine sports or not, therefore it is an important area that needs to be addressed.
2.3.4 Injury Perception as a Significant Participation Constraint

Williams and Fidgeon (2000) referenced Marktrend Marketing Research Inc., (1990) and stated that traditionally in Canada:

*Skiing has been presented to the public as a ‘fun’ physical activity. The ‘fun’ aspect of skiing is thought to be derived from sharing the experience with family and friends, reliving embarrassing mistakes with companions; participating in after-ski activity; achieving improvement in skiing technique and the exhilaration of being outside in a mountain environment.*

(Williams and Fidgeon, 2000, p 5)

The researcher believes this statement holds true for the majority of the alpine countries. Yet along with many positive images of skiing, negative components are involved that may affect participation. For the non-skier such negative components may outweigh the positive aspects of skiing. A common occurrence in winter areas are postcards or similar articles with depictions of injured skiers and snowboarders. The following illustrations depict common postcards displaying injured alpine participants.

**Figure 2.2 Common pictures depicting injured alpine participants.**

Source online at www.cartoonstock.com
A Canadian study reported in 2000 by Williams and Fidgeon indicated that for non-participants the thought of skiing conjured up images of injury, pain, accidents and risk. Their overall perception of skiing was that it was dangerous with a likelihood of sustaining an injury. Williams and Fidgeon found that non-skiers’ fears related to several dimensions of the ski experience including:

..... its location (e.g. on steep and high mountain slopes), learning to ski (e.g. poor instruction leading to injury), manoeuvring on the slopes (e.g. going too fast, out of control) and using the lift facilities (e.g. mounting and dismounting from the lifts and falling off the ski lift at great heights) (see Table 2.2).

(Williams and Fidgeon, 2000, pp 5)

These perceptions of the dangers of skiing were consequential from the experience of friends, relatives, associates and media publications (Williams and Fidgeon, 2000).

Table 2.2 Perceptions of the dangers of skiing

<table>
<thead>
<tr>
<th>Non-Skier perceptions of Skiing</th>
<th>Mean Level of Agreement *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ski hills are very steep</td>
<td>4.68</td>
</tr>
<tr>
<td>Skiing is very physically demanding</td>
<td>4.68</td>
</tr>
<tr>
<td>Afraid of being out of control</td>
<td>3.59</td>
</tr>
<tr>
<td>A very fast sport</td>
<td>3.52</td>
</tr>
<tr>
<td>Chances of serious injury are much less than five years ago</td>
<td>3.41</td>
</tr>
<tr>
<td>Skiers take more risks than non-skiers</td>
<td>3.30</td>
</tr>
<tr>
<td>Harder to learn than other sports</td>
<td>3.27</td>
</tr>
<tr>
<td>Ski lifts are scary</td>
<td>3.08</td>
</tr>
</tbody>
</table>

* Rated on a six-point scale: 1 = strong disagree, 6 = strongly agree.

For many non-skiers or alpine enthusiasts their overall impression of skiing and snowboarding was a “treacherous activity not to be attempted without considerable preparation and thought” (Williams and Fidgeon, 2000, p. 383). If potential alpine participants are concerned about personal safety, as demonstrated in Williams and Fidgeon, a study on perceived danger, overcoming the reality of injury must be a priority and linked to ski promotions highlighting that alpine sports have statistically reduced alpine injuries and the dangers of these sports.

The publics’ overall opinion of the number of alpine injuries varies a lot and is normally grossly overestimated. Dickson (2008) investigated the behaviours and attitudes towards snowsport safety in Australia. The exploratory study, using on-line surveys found that between 80% to 90% of participants overestimated the injury rates per 1,000 skier days (Dickson, 2008b).

If an injury can be prevented, avoided or its severity reduced, it is an advantage for the individual, families and in turn the resort. Given this, it is important to investigate alpine epidemiology and it is through this research that we can gain a better understanding of the underlying causes of sports injuries specific to different age groups and equipment types from which targeted prevention programs may be developed.

### 2.4 Alpine Injury Epidemiology

#### 2.4.1 Epidemiology

Epidemiology is the study of the distribution and determinates of varying rates of disease, injury or health states in the human population for the purpose of identifying and implementing measures to prevent their development, spread or occurrence (Caine Lindner and Caine, 1997). In this case it is the study of alpine injuries and how often they occur in different groups of people and by type of alpine sports equipment. This epidemiological information can be used to plan and evaluate strategies to prevent and reduce alpine injuries, and be used as a guide for injury management.
The initial development of the theory and methods of epidemiology focused on infectious and communicable diseases (Caine et al, 1997). Alpine sportsepidemiologists are concerned with quantifying alpine injury occurrence (how much), with respect to who is affected by injury, where and when injuries occur, what is their outcome, for the purpose of explaining why and how injuries occurred and identifying strategies to control and prevent them (Caine et al, 1997).

The study of the distribution of varying alpine injury rates (who, where, when, what) is referred to as descriptive epidemiology, whilst the study of what the determinates are of an exhibited distribution of varying rates (how, why) is referred to as analytical (Caine et al, 1997). Both of these types of epidemiology will be used in the current research. The components of the two inter-related types of epidemiologic research are shown in Figure 2.3. Both descriptive and analytical epidemiology relate to the prevention of injury.

Figure 2.3 provides a graphical representation of epidemiology research in relation to determinate and prevention areas of alpine snowsports injuries. The larger body of alpine epidemiology has focused on how many injuries, who, where and when. Analytical epidemiology is harder to measure because the researcher typically knows the exposure status of the study participants therefore may be more rigorous in determining disease/injury rate in the exposed group compared to the unexposed group, thus introducing observation bias.
Figure 2.3 Epidemiology Descriptive and Analytical explanation for Alpine Injury

**EPIDEMIOLOGY**

### Descriptive Epidemiology
- **How many Alpine injuries?**
- **Who?** (Person factors)
- **Where?** (Place factors)
- **When?** (Time factors)
- **What is the outcome?** (Time Factors)
- **Why?** (Causal factors)
- **How?** (Causal factors)

### Analytical Epidemiology
- **Injury Definition**
- **Occurrence**
- **Frequency**
- **Prevalence rates**
- **Incidences rates**
- **Biological**
- **Participation level**
- **Participant role/function**
- **Anatomical**
- **Situational**
- **Surface/Terrain**
- **Snow conditions**
- **Equipment**
- **Geographical location**
- **Injury onset**
- **Sudden**
- **Gradual**
- **Chronometry**
- **Duration of alpine participation before injury**
- **Time of day**
- **Time of season**
- **The activity itself**
- **Injury severity**
- **Injury Type**
- **Time loss**
- **Cost**
- **Residual symptoms**

### Prevention
- **Injury severity**
- **Injury Type**
- **Time loss**
- **Cost**
- **Residual symptoms**
- **Intrinsic risk factors**
- **Physical**
- **Motor/Functional**
- **Psychological**
- **Psychosocial**
- **Extrinsic risk factors**
- **Exposure**
- **Training methods and conditions**
- **Experiences**
- **Skill level**
- **Environment**
- **Equipment**
- **Inciting event**
- **Injury mechanism**

Adapted from Caine et al 1997
Epidemiology research into sports injuries often aims to determine the frequency and information surrounding the injuries that participants or players sustained. However, most sports related injuries are rarely accredited to a single risk factor (Gissane, White, Kerr, and Jenning, 2001). Gissane, White and Kerr (2001) noted that a mixture of intrinsic and extrinsic risk factors can contribute to an individual’s injury. Intrinsic (personal) risk factors are inherent characteristics of an individual that influence injury risk such as lower ability/less experiences, age, gender and personality characteristics. Extrinsic risk in sports science is a risk that is not inherent in the individual. They increase the risk of sustaining an injury include inappropriate training (e.g. too frequent or too intense), improper equipment, inappropriate clothing or protective gear, and poor technique. Table 2.3 links Gissane and colleagues (2001) summary with recent research on alpine sports.

<table>
<thead>
<tr>
<th>Intrinsic Risk Factors</th>
<th>Extrinsic Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical characteristics</td>
<td>Exposure (Lysens, 1991b)</td>
</tr>
<tr>
<td>Age (Langran, 2002) (Michael Tuggy, and Ong, 2000)</td>
<td>Type of alpine sport (Lysens, 1991b)</td>
</tr>
<tr>
<td>Sex (Langran, 2002) (Michael, Tuggy, and Ong, 2000)</td>
<td>Participation time(Lysens, 1991b)</td>
</tr>
<tr>
<td>Somatotype (Lysens, 1991b)</td>
<td>Level of experience (Langran, 2002), (Michael L. Tuggy, and Ric Ong, 2000)</td>
</tr>
<tr>
<td>Body size (Watson, 1997)</td>
<td>Warm up (Watson, 1997)</td>
</tr>
<tr>
<td>Previous injury (Cadman, 1996a; Hagel, 2005a)</td>
<td>Training and Coaching (Lysens, 1991)</td>
</tr>
<tr>
<td>Physical fitness (Lysens, 1991b)</td>
<td>Refereeing/Judging</td>
</tr>
<tr>
<td>Joint mobility (Lysens, 1991a, 1991b)</td>
<td>Other alpine participants</td>
</tr>
<tr>
<td>Muscle tightness (Lysens, 1991a)</td>
<td>Environment (Scher, 2006)</td>
</tr>
<tr>
<td>Ligamentous laxity (Lysens, 1991a)</td>
<td>Snow conditions (Scher, 2006)</td>
</tr>
<tr>
<td>Dynamic and Static strength (Lysens, 1991a)</td>
<td>Lifts and trail design</td>
</tr>
<tr>
<td>Skill level (Hagel, 2005a; Langran, 2002)</td>
<td>Weather condition/Visibility (Scher, 2006)</td>
</tr>
<tr>
<td>Psychological characteristics</td>
<td>Time of season</td>
</tr>
<tr>
<td>Psychosocial characteristics</td>
<td>Time of Day (Hagel, 2005a; Watson, 1997)</td>
</tr>
<tr>
<td>Willingness to take risks (Watson, 1997)</td>
<td>Equipment (Langran, 2002), (Michael L. Tuggy, and Ric Ong, 2000)</td>
</tr>
<tr>
<td>Interaction with other participants (Watson, 1997)</td>
<td>Protective equipment (Hagel, 2005a; Watson, 1997)</td>
</tr>
<tr>
<td>Experience of sport (Hagel, 1999), (Michael L. Tuggy, and Ric Ong, 2000)</td>
<td>Equipment condition/settings (Hagel, 2005a; Watson, 1997)</td>
</tr>
</tbody>
</table>
Study design

Study design is the procedure under which a study is carried out. There are two main categories employed in alpine research; observational and experimental.

Observational research identifies subjects, observes and records certain characteristics. An example of observational research is Cooper (2006), where the research data were collected observing falling and injury patterns in alpine terrain parks.

The second type of research is experimental, where participants are identified, placed in a common context than an ‘intervention’ carried out followed by an observation to determine the affect of the intervention. Observational studies are readily undertaken, but subjected to bias because of systematic errors. Experimental designs are typically harder to undertake but can answer narrow questions meticulously.

Four main types of observational studies exist: case series, case-control studies, cohort studies and meta-analyses. Case series studies are beneficial for identifying unusual situational data and are good for generating hypotheses. Disadvantages of case-studies include the bias related to the researcher selecting subjects and generally there are no controls and this type of research is typically short term.

Case-control studies identify a cases which a condition of interest such as injury. Preceding this, research tries to match with injury free control that is similar with respect to known risk factors for the injury. Finally a comparison is undertaken between the degrees of exposure to possible risk. A control is a standard for comparison of effect and variability.

Cohort studies provide prospective, control and can be used to determine cause and on incidence of diseases/ injury as well as identifying key risk factors. They are characteristically expensive and difficult to carry out.
Studies that account for the calculation of risk-factors are known as case-control studies. These studies use a case-series as well as a denominator series known as the control group. Many of these studies however fail to adjust fully for factors that are likely to influence crude associations (i.e. the proportion of a given characteristic in the ‘case’ group compared with the proportion in the ‘control’ group).

The only information typically available on incidence of injury is based on a denominator of lift-ticket sales. This method has limitations as it calculates injuries per 1,000 tickets sold (known as skier days), yet it only estimates the number of days participation for season ticket holders, or those who do not buy lift tickets and differential participation that can occur with the purchase of a single lift-ticket. This method of data gathering also does not take into account the actual amount of skiing done each day by a participant. An individual may have a lift ticket, but spend the majority of their time inside a restaurant or bar, whilst another individual may be at the other end of the scale and ski non-stop the whole day. This being said it is the typical way alpine epidemiology is presented when ticket numbers are available.

2.4.2 Ski and Snowboard Injury epidemiology

Downhill skiing and snowboarding are very popular winter sports practiced by a heterogeneous and growing group of participants (Australian Ski Areas Association, 2008). Generally speaking alpine injury statistics are extremely difficult to ascertain for a number of reasons. Resorts are very reluctant to let research be carried out within their given resort area and when it is undertaken both because of incomplete reporting (by-pass effect where many minor injuries go untreated or are treated by family physicians away from ski resorts) and because of the approximate calculations of skier-days based upon the ticket sales (Sacco, Sartorelli and Vane, 1998) data can only be used as estimates. Nevertheless, there is an extensive amount of literature published on alpine sports epidemiology, where different research methods try to overcome the problems just addressed.
Bladin, McCrory and Pogorzelski in 2004 stated that methodological issues common to alpine sports epidemiology injury studies are that “case ascertainment is problematic and accurate measurement of exposure is limited” (Bladin, McCrory and Pogorzelski, 2004, p 134).

It is well documented that many injured skiers or snowboarders do not seek medical attention within a ski resort where data is collected with estimates of up to 40% of alpine injuries going unreported (Idzikowski Janes and Abbott, 2000). A study carried out in Colorado, USA (1996-97) found 31% of skiers and 29% of snowboarders refused medical attention after an encounter with ski patrol (Idzikowski et al, 2000). With this in perspective, no study is going to be able to fully account and identify all alpine injuries sustained.

To review the incidence of alpine injuries one needs to know and recognise that there is a difference in the style of injury data that is being collected and analysed. The incidence of injury in skiing and snowboarding participants is largely a function of the injury definition and the nature of the particular study design (Hagel, 2005). For example, if the injury rate is based on a more severe injury definition (e.g. hospital admission), the total number of injuries will be lower than if the research is based on more wide-ranging injury definition (e.g. ski patrol reports or self reports).

Publications on alpine injuries will vary depending on collection methods and injury definition. There are a large number of different methods of collecting data and the majority of alpine injury studies are epidemiologically based. These studies typically utilise mountain physicians, databases from a number of medical centres in an alpine area (often focusing more on selected injury types), ski patroller accident reports (which have a greater range of injuries but less accurate injury diagnosis), hospital accident, emergency department records, or ski industry research to conduct post-event statistical analyses (Bladin et al, 1993; Drkulec, and Letts 2001). This type of research is classically descriptive cohort studies or case-series investigations where the demographics and characteristics of injured individuals are examined. Case-series investigations permit a
comprehensive account of types of injuries and severity witnessed, but does not allow for calculations of incidence rates or the identification of risk-factors unless denominator (control) data (e.g. ski or snowboard lift-tickets) is available (Hagel, 2005a). Nevertheless, these alpine studies are valuable tools as they analyse injury trends and the occurrences across different demographics.

An alternative type of research strategy employed by other epidemiologists is to obtain data by surveying a broad cross-section of alpine participants at a given point in time (Fulham et al, 1999; Machold Kwansy and Gaeler, 2000). There are advantages and disadvantages for utilising different epidemiological approaches. Advantages of this type of design include that they are relatively inexpensive and take up little time to conduct; can estimate prevalence of outcome of interest because sample is usually taken from the whole population; many outcomes and risk factors can be assessed; and it is useful for public health planning, understanding disease epidemiology for the generation of hypotheses. Disadvantages of cross-sectional studies include difficulties in making causal inference; the studies represent only a snapshot and the situation may provide differing results if another time-frame had been chosen; prevalence-incidence bias may exist and researcher may be unable to assess the influence of countermeasures on injury rates (Kelsall and Finch, 2006; Levin, 2006).

All these matters aside, there are some well conducted studies and published literature from which to draw from in terms of describing the patterns, rates, and risk-factors in alpine activates for the paediatric age group (Hagel, 2005a). Three good studies include, but are not limited to, Hagel et al.’s (2003) case control and case series with exposure estimation in Canada; Machold et al.’s (2000) retrospective cohort study with self reported snowboard days and medically reported injuries in Austria, and Skoksn et al.’s (2003) case-series study investigating admission to a paediatric trauma centre in America.

In Australia few studies in alpine epidemiology exist, while in the northern hemisphere alpine injury epidemiology (descriptive epidemiology) (Cooper, 2006), studies in snowboarding (Cooper, 2006; Langran, 2004; National Ski Areas Association, 2005) and downhill skiing (Greenwald, 2003; Shealy, 1993) have been widely reported, describing
injury, particularly with respect to injury diagnosis and the demographics of the injured (Ueland, 1999).

When examining the results of epidemiological studies of injuries, it has become quite clear that there have been dramatic changes over the past 50 years as the sport and equipment have evolved. Alpine sports injury rates are typically investigated independently from each other as the different types of sports have different injury profiles.

While there are similarities for the total number of injuries sustained when compared to each other there is a different injury pattern in relation to anatomical location and the demographics of the injured. Downhill skiing and snowboarding injury rates have been compared by many researchers, including but not limited to Conci (2004), Langran (2004), Greenwald (2004), Hagel (2005), and Ekeland and Rødven (2006). While there is not an exact figure of injury rates there is a general consensus that the incidences of injury have declined over time (Hagel, 2005). Koehle and his team grouped downhill skiing and snowboarding injury rates into three time periods; Before 1970, 1970s to the 1990s and 1990s to the present (Koehle, Lloyd-Smith, and Taunton, 2001).

Prior to the 1970s ski injury rates were estimated to be between approximately five to eight per 1,000 skier-days (Koehle et al, 2002). “Incidence rates dropped through the early part of the next decade to approximately three to six per 1,000 skier/boarder days” (Koehle, 2002).

Current literature suggests an injury rate for both downhill skiing and snowboarding of between 1.5 and 2.05 injuries skiers/boarders per 1,000 skier/boarder days (Ekeland and Rødven, 2006). Most of the decline in the incidence of injury can be related to improvements in ski equipment, especially downhill boots and bindings systems. At the same time as the dramatic injury reduction, there has been an anatomical redistribution of injury sites and the demographics of those being injured.
2.4.3 Gender

Prior to the 1970s the majority of alpine enthusiasts were males. Today there is a greater distribution of gender and age participation reported in the literature (Cooper, 2006). Findings are inconclusive regarding gender and alpine injury rates. Some studies report that the majority of injuries are sustained by males, while others report that the injury risk is higher for female participants or the same for both sexes (Goulet, 1999). It is hard to draw major conclusions because when lift tickets are sold gender is not recorded. The difference in injury rates may be as easily explained since there are a higher number of male injuries because there are more males participating in the sport.

Child and adolescent alpine research concerning ski racers at a world junior competition reported injuries for girls at a rate of 8.9 injuries per 1,000 runs while there were no injuries for boys in 546 runs (Bergstrøm, Bergstrøm and Ekeland, 2001). Garrick (1979) and Requa (1978, cited in Hagel 2005), in their retrospective cohort study of children and adolescents observed a substantially higher rate in girls in almost every age group and ability level (Garrick, 1979; Hagel, 2005a; Requa, 1978). These differences were mostly manifested in those under 12 years old and the lowest ability level categories. A case control study focusing on lower extremity injuries in skiers reported a lower injury rate in males, than females but it was not found to be statistically significant (Ungerholm, 1984). It is not acknowledged whether these results represents an actual increase in injury rates for females or simply a greater likelihood of reporting an injury (Machold, 2000). Interesting, when participants injuries and than anatomical locations are the focus of the research considerable differences between males and females emerge. Females appear to be at greater risk of lower extremity injury (Hagel, 2005a; Ungerholm and Gierup, 1984).

2.4.4 Typical Downhill Ski Injuries

Since the 1970s, downhill ski injury rates have dropped dramatically from five to eight per 1,000 skier days to approximately two to three per 1,000 skier days. In comparison to snowboarding alpine skiing tends to have a greater diversity in the age range of participants. The average age of a skier reported in US research is 32 years old.
(Greenwald, 2003), with literature reporting an age range between three and 73 (Dohjima, Sumi, Ohno, Sumi and Shimizu, 2001).

The majority of injuries that occur in downhill skiing involve the lower extremity. Specific studies involving children and adolescents consistently show that knee and lower leg, are the most common anatomical injury location (Goulet, 1999; Heir, 2002). While lower leg injuries are less common in comparison to 30 years ago, the incidence of knee sprains and upper extremity injuries are more prominent in downhill skiing (Koehle, 2002).

Much of the change in injury location and rates can be attributed to advancements in ski-binding technology. These technological effectively reduced, but not removed, lower leg injury. It is important to understand the function of ligaments, tendons and muscles surrounding the knee to comprehend the mechanism of ski injuries. Figure 2.4 illustrates the muscles, ligaments and tendons on the knee.

*Figure 2.4 Diagram of the human knee (articulatio genus)*

![Diagram of the human knee](source)

*Source Wikipedia online encyclopaedia, 2008*
Worldwide knee sprains are the most common injury in downhill skiers, accounting for approximately 30% of all downhill skiing injuries in adults (Koehle, 2002; Warme, 1995). The medial collateral ligament (MCL) and anterior cruciate ligament (ACL) have similar incidence at 18% and 16% respectively (Warme, Feagin, King, 1995). The incident of ACL sprains have increased while there has been no reported rise in MCL injuries.

Three common mechanisms exist for knee ligament injury (Ettinger, 1995; Warme, 1995). The knee and lower leg injuries are largely due to the lower extremity torsion mechanism in skiing (Hagel, 2005a). In Figure 2.5(a) the valgus-external rotation sequences leads to primarily MCL injuries (valgus deformity is a term for the outward angulations of the distal segment of a bone or joint, in the knee the tibia is turned outward in relation to the femur, resulting in a knock-kneed appearance) (Wikipedia, 2008a). This valgus-external rotation type of fall also involves the ACL 20% of the time (Koehle, 2002). Koehle et al describe this type of fall to occur when the skier falls forward while catching the inside edge of one of their skis. The “ski then rotates outward, forcibly abducting (motion that pulls a structure or part away from the midline of the body) and externally rotates the leg” (Koehle, et al 2002, p788).

Figure 2.5(b) is typically referred to as a boot-induced anterior mechanism and occurs when the skier lands from a jump or becomes wobbly with the knee extended. The “rear of the ski contacts the snow first, acting as a ‘lever’ on the boot-binding system, forcibly drawing the tibia forward on the femur” (Koehle, et al. 2002, p788).

The phantom-foot is the most frequent mechanism of knee injuries where the skier falls backward between the skis (Figure2.5(c)) (Koehle, 2002). Koehle describes the phantom-foot as:

*The knees are flexed with the hips dropping below the level of the knee, the upper body faces the downhill ski and the uphill ski is weight bearing. The injury occurs when the inside edge of the downhill ski digs into the snow behind the skiers. The ski then levers outward, applying an internal rotation force on the hyper-flexed (downhill) knee.*

(Koehle, 2002, pp 788)
Upper extremity injuries constitute approximately one-third of all downhill skiing injuries (Koehle, 2002). The literature has reported a range of between less than five percent (Cadman and MacNab, 1996) to 42.3% (Molinari, Bertoldi and Zucco, 1994). The results differ largely depending upon the injury definition and research method used. Overall the literature shows there is a substantial difference in the anatomical regions specific to injury depending upon both the participants and research characteristics such as injury collection method. Table 2.4 details the injuries to ski participants for particular anatomical body regions. It displays the overall results for seven studies undertaken in different countries from 1984 to 2007. In the table the column with the heading N, indicates the number of participants in each study. It can been seen that over the 21 years there was not a significant change in the percentage of upper and lower limb injuries. Although in lower limb injuries a notable trend of an increasing overall percentage can be seen.
Table 2.4  Injury profile from a representative sample of ski injury studies 1991-2006. Results presented as a percentage

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>N</th>
<th>Country</th>
<th>Mean Age (y)</th>
<th>Head/Neck/Face</th>
<th>Upper Limb</th>
<th>Lower Limb</th>
<th>Spine</th>
<th>Abdomen/Pelvis</th>
<th>Chest</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>Shoulder</td>
<td>Arm/Elbow</td>
<td>Wrist/Hand</td>
<td>Thigh</td>
<td>Knee</td>
<td>Ankle/Foot</td>
</tr>
<tr>
<td>Blitzer et. al.</td>
<td>1984</td>
<td>138133</td>
<td>USA</td>
<td>6.1</td>
<td>11-17</td>
<td>23.8</td>
<td>46.7</td>
<td>22.8</td>
<td>10.6</td>
<td>13.3</td>
<td>29.5</td>
</tr>
<tr>
<td>Ueland et. al.</td>
<td>1998</td>
<td>7966</td>
<td>Norway</td>
<td>22</td>
<td>16</td>
<td>34</td>
<td>35</td>
<td>28</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Dohjima et. al.</td>
<td>2001</td>
<td>5048</td>
<td>Japan</td>
<td>23</td>
<td>28</td>
<td>15</td>
<td>8</td>
<td>5</td>
<td>55</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Langran &amp; Selvara</td>
<td>2002</td>
<td>674</td>
<td>Scotland</td>
<td>&lt;25</td>
<td>24</td>
<td>7</td>
<td>3</td>
<td>14</td>
<td>53</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>Corra et. al.</td>
<td>2004</td>
<td>794</td>
<td>Austria</td>
<td>36</td>
<td>22</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>31</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Langran</td>
<td>2004</td>
<td>1095</td>
<td>Scotland</td>
<td>22</td>
<td>27</td>
<td>9</td>
<td>5</td>
<td>13</td>
<td>48</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>Ekeland et. al.</td>
<td>2006</td>
<td>7252</td>
<td>Norway</td>
<td>≥20</td>
<td>26</td>
<td>10</td>
<td>4</td>
<td>12</td>
<td>45</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>VISC~</td>
<td>2007</td>
<td>724</td>
<td>Australia</td>
<td>15-19</td>
<td>22</td>
<td>10</td>
<td>12</td>
<td>53</td>
<td>5</td>
<td>48</td>
<td>10</td>
</tr>
</tbody>
</table>

~Victorian Injury Surveillances Unit, * Age group
2.4.5 Typical Snowboarding Injuries

Snowboarding has grown into a predominant alpine sport. This growth and popularity is especially in the adolescent population (Bladin, et al., 2004; Yamagami, Ishihara, and Kimura, 2004). The growth of the sport has been accompanied with an increasing amount of research and literature available (Yamagami, 2004). Research ranges from small case serious investigations such as Duma, Boggess, Crandall and MacMahon’s investigation of risk fractures with 16 participants (Duma Boggess, Crandall and MacMahon, 2004), through to large database studies, which can have thousands of injury recordings like Dohjima, Sumi, Ohno, Sumi, and Shimizu’s (2001) research: The Dangers of Snowboarding: A 9-year prospective comparison on snowboarding and skiing injuries.

Over the past 15 years the popularity of snowboarding has increased dramatically, and it is now an Olympic sport, appears in’ Extreme Games’ and even has video and arcade games. These broadcasting and games profiling the top athletes in the sport showcase the strong visual appeal of the sport including youth-oriented lifestyle, the stereotypically profile of a snowboarder and the cultures that can accompany it (Bladin et al, 2004).

With the introduction of snowboarding has come a dramatic change in the participants’ demographics and injury profile, along with equipment advances in the boot and binding system. Snowboarding was initially considered a dangerous, uncontrolled, alpine sport, which was an opinion generated or based on little or no scientific evidence. Literature has grown since snowboarding’s introduction and while some research still claim snowboarding participants are reckless (Yamagami et al, 2004), the majority of research provides strong evidence that similar injury rates exist between downhill skiing and snowboarding, yet with differences in participants mean age and anatomical injury locations (Hagel, 2005a; Langran, 2008).

Previous research has indicated that snowboarders constitute between one-third to half of participants in alpine resorts (Langran, 2008). The participants are predominantly male and youth oriented. Two-thirds of participants are under the age of 23 years old and up to 80% of children who participate in alpine sports will have ridden a snowboard by their
twelfth birthday (Bladin et al, 2004; Sacco et al, 1998). Bladin et al stated that a snowboarder is male typically (greater than 70% chance), aged in his late teens or early twenties. The authors quoted, ‘over recent years the demographics have slightly changed with many older individuals and women beginning to participate in the sport’ (Bladin, McCrory, and Pogorzelski, 2004, p134).

Beginner snowboarders constitute 40% to 60% of those injured compared with 18% to 34% of individuals injured in skiing (Bladin et al, 1993, 2004; Langran et al, 2002). In a number of studies, more than half of the injured beginners had never had any type of formal or professional lessons (Langran, 2002). In general, snowboarding has been estimated to have an injury rate of four per 1,000 snowboarder days (Bladin et al, 1993, 2004), while some studies have recorded the injury rate to be as high as 16 per 1,000 snowboarder days (Machold, Kwasny and Gaeler, 2000). O’Neill and McGlone found no significant differences between the numbers of injuries sustained for first-time snowboarders and skiers. However, snowboarders had a higher incidence of severe injuries and injuries to the upper extremity than skiers (O’Neill and McGlone, 1999). Beginner snowboarders, especially first-timers, are at a particularly higher risk of sustaining a wrist fracture. One-third of first-time snowboarder injuries affect the wrist joint, generally due to the fact that first-time snowboarders have less trained balance and fall more often than their more experienced peers (Langran, 2004).

The majority of snowboarding injuries are said to be caused by ‘human error’ (Bladin et al, 2004), with equipment failure reported to be responsible for less than one percent of all injuries (Davidson and Laliotis, 1996). Snowboarders are injured three times more frequently from jumping than alpine skiers (Davidson and Laliotis, 1996). Snowboarder injuries as a result of a collision with object or other alpine participants accounts for 10% of all injuries which is less frequent than skiers (Bladin et al, 2004; Chow Corbett and Farstad, 1996). Beginners and novices with less than one year experience represent almost half (44%) of those injured, with 20% to 36% of injuries occurring while learning to snowboard for the first time (Fulham and McGlone, 1999).
Table 2.5 illustrates anatomical location of the common injury profile of snowboarders from a range of published studies. It can be seen quite clearly that there is a substantial variation between upper and lower extremity injuries. Out of 13 of the 15 presented studies displays participants mean age and number of injuries divided into anatomical areas including; upper limb (shoulder, arm and elbow and wrist and hand) lower limb (thigh, knee, ankle and foot and lower leg), abdomen and spine, chest and other. In comparison to the skiing injuries presented in Table 2.4, snowboarding had a larger number of abdomen and spinal injuries and a greater frequency of upper limb injuries.

Typically snowboarder’s have a significantly higher proportion of upper limb injuries especially the wrists when compared with downhill skiers who have a higher number of knee injuries. Studies demonstrate a two to three fold greater risk of upper to lower limb injury, with approximately two-thirds of all injuries involving the upper extremity and upper body. This is the opposite of what is typically seen in downhill skiers (Bladin et al, 2004).

The wrist accounts for anywhere between 16% to 54% of all injuries, and approximately two-thirds of these are fractures (Bladin et al, 2004). Wrist fractures and sprains are the most common in beginner participants and especially women and younger participants. Intermediate snowboarders, practically males, are more likely to sustain hand, elbow and shoulder injuries (Bladin et al, 2004).

Literature reports that advanced snowboarders injuries tend to be more serious and research has shown that they tend to fall on their back and neck at high velocities, from large heights when performing jumps and using terrain parks including boxes, rails and half-pipes (Cooper, 2006). As a result, there is an increasing incidence rate of spinal cord injuries in snowboarding participants, partly due to the increasing popularity and size of jumps, aerial manoeuvres, boxes and rails located in terrain parks. Table 2.5 clearly show that over the last 14 years spinal injuries have dramatically increased, accounting for 6% of the total injuries in 1996 and 19% in 2004.
Table 2.5  Injury profile from a representative sample of snowboard injury studies 1991-2006.
(Results presented as a percentage)

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>N</th>
<th>Country</th>
<th>Mean Age (y)</th>
<th>Head/Neck/Face</th>
<th>Upper Limb</th>
<th>Lower Limb</th>
<th>Abdomen/Spine</th>
<th>Chest</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper Limb%</td>
<td>Lower Limb%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shoulder</td>
<td>Arm/Elbow</td>
<td>Wrist/Hand</td>
<td>Thigh</td>
<td>Knee</td>
<td>Ankle/Foot</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bladin et.al.</td>
<td>1993</td>
<td>276</td>
<td>Australia</td>
<td>22</td>
<td>11</td>
<td>29</td>
<td>8</td>
<td>5</td>
<td>16</td>
<td>52</td>
</tr>
<tr>
<td>Calle et.al.</td>
<td>1995</td>
<td>487</td>
<td>US</td>
<td>11</td>
<td>46</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>Chow et.al.</td>
<td>1996</td>
<td>355</td>
<td>US</td>
<td>20</td>
<td>18</td>
<td>56</td>
<td>20</td>
<td>16</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Davidson &amp; Laliotis</td>
<td>1996</td>
<td>931</td>
<td>US</td>
<td>21</td>
<td>11</td>
<td>40</td>
<td>10</td>
<td>7</td>
<td>23</td>
<td>39</td>
</tr>
<tr>
<td>Sutherland et.al.</td>
<td>1996</td>
<td>757</td>
<td>Scotland</td>
<td>20</td>
<td>14</td>
<td>48</td>
<td>16</td>
<td>32</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Pigozzi et.al.</td>
<td>1997</td>
<td>106</td>
<td>Italy</td>
<td>2</td>
<td>46</td>
<td>16</td>
<td>5</td>
<td>25</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>Idzikowski et.al.</td>
<td>1998</td>
<td>7430</td>
<td>US</td>
<td>23</td>
<td>33</td>
<td>49</td>
<td>15</td>
<td>34</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Machold et al.</td>
<td>2000</td>
<td>107</td>
<td>Austria</td>
<td>15</td>
<td>11</td>
<td>61</td>
<td>6</td>
<td>63</td>
<td>52</td>
<td>21</td>
</tr>
<tr>
<td>Dohjima et al.</td>
<td>2001</td>
<td>2552</td>
<td>Japan</td>
<td>23</td>
<td></td>
<td>78</td>
<td>11</td>
<td>19</td>
<td>48</td>
<td>10</td>
</tr>
<tr>
<td>Langran &amp; Selvara</td>
<td>2002</td>
<td>674</td>
<td>Scotland</td>
<td>&lt;25</td>
<td>22</td>
<td>45</td>
<td>9</td>
<td>6</td>
<td>30</td>
<td>22</td>
</tr>
<tr>
<td>Corra et al.</td>
<td>2004</td>
<td>294</td>
<td>Austria</td>
<td>20</td>
<td>17</td>
<td>44</td>
<td>10</td>
<td>3</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>Yamagami et al.</td>
<td>2004</td>
<td>3102</td>
<td>Japan</td>
<td>22</td>
<td>25</td>
<td>38</td>
<td>12</td>
<td>10</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Langran et al.</td>
<td>2004</td>
<td>567</td>
<td>Scotland</td>
<td>22</td>
<td>17</td>
<td>48</td>
<td>14</td>
<td>6</td>
<td>28</td>
<td>22</td>
</tr>
<tr>
<td>Made et al.</td>
<td>2004</td>
<td>568</td>
<td>Sweden</td>
<td>19</td>
<td>15</td>
<td>54</td>
<td>15</td>
<td>15</td>
<td>39</td>
<td>20</td>
</tr>
<tr>
<td>Ekeland et al.</td>
<td>2006</td>
<td>7252</td>
<td>Norway</td>
<td>≤20</td>
<td>18</td>
<td>53</td>
<td>12</td>
<td>9</td>
<td>32</td>
<td>15</td>
</tr>
</tbody>
</table>
Half of the snowboard spinal injuries involved jumping, whereas as few skiing spinal injuries are associated with this activity (Bladin et al., 2004). The majority of these spinal cord injuries were fractures of the transverse process. A conjecture is with snowboarders’ increasing confidence and expertise that they are attempting greater aerial manoeuvres and stunts. Compared to downhill skiing where as 70% of spinal injuries are a result of a simple fall (Yamakawa, Murase and Sakai, 2001), but this difference is diminishing with recent terrain parks aerial manoeuvres being attempted by skiers (Koehle, 2002).

Fortunately, severe, life-threatening injuries in snowboarding are infrequent but as snowboarding participation rates increase so too are severe injuries (Bladin et al., 2004). Research from Colorado (1995) indicates that severe injuries represent approximately 0.03 injuries per 1,000 snowboarding days, with the mechanism of injury evenly divided between falling onto the snow and collisions with another object (e.g. trees and other skiers) (Bladin et al., 2004; Prall, 1995). Traumatic brain injury and intra-abdominal injuries account for over 80% of severe injuries, in comparison to downhill skiing where 70% of serious injuries relate to skeletal trauma (Prall, 1995).

### 2.4.6 Injury Severity

The severity of an alpine injury can be measured by using existing severity scales or length of hospital stay indicators. No matter how injury severity is measured, the injuries can have significant associated effects on an individual and family including medical difficulty, financial and personal cost.

There is consensus among investigators that the paediatric age groups participating in alpine sports are at an increased risk of injuries (Corra, Conci, Conforti, Sacco et al., and De Giorgi, 2004; Goulet, Réginer, Grimard, Valois, and Villeneuve, 1999). Non-fatal injuries associated with skiing and snowboarding in both adults and children have been studied extensively (Bladin et al., 1993, 2004; Cadman, 1996b; Cooper, 2006; Corra et al., 2004; de Leös, 1995; Dohjima et al., 2001; Ekeland et al., 2006; Ettinger et al., 1995; Fulham et al., 1999; Goulet et al., 1999; Greenwald et al., 2003; Hagel, 2005a; Hagel, 2005b; Heir et al., 2002; Idzikowski et al., 2000; Koehle et al., 2002). Severe injuries has
been reported to be between 0.036 (Corra et al, 2004) to 0.9 (Ekeland et al, 2006) injuries requiring physician or hospital treatment per 1,000 skier(boarder) days. Corra et al (2004) defined a severe injury as those patients requiring hospitalisation for their injury sustained by skiing or snowboarding. An injury severity score (ISS) was assigned to each patients based on criteria from Baker, Neil, Haddon and Long (1974).

An Australian study by Ashby and Cassell, (2007) provides an overview of unintentional fatal and non-fatal injuries in alpine snowsports. It used data from the National Coroners Information System (NCIS) and the Victorian hospital-based injury surveillance database (the Victorian Admitted Episodes Dataset (VAED) and the Victorian Emergency Minimum Dataset (VEMD) (Ashby and Cassell, 2007) to inform its findings. Fatality data were extracted for the NCIS database from a three-year period from January 2004 to December 2006. In 2005, within a 10 day period, there were two fatalities directly related to snowsport participation in Victoria. Both skiers (a 30 year old experienced male not wearing a helmet and 12 year old boy whose death is still under coronial investigation) died from head injuries that occurred when they lost control and collided with trees.

Over the three year period there were 1,404 hospital treated snow sport injuries, 817 hospital admissions and 587 emergency department presentations (non-admission). The frequency of hospital admission decreased over the period. In 2004 there were 360 hospital admissions to 273 in 2005 and 184 in 2006. These figures are related to the amount of snow cover in season. The pattern of injuries that resulted in hospital admission over the three year study period is summarised in Table 2.6.
Table 2.6 Pattern of Hospital-treated snowsport injury, Victoria Jan 2004 to Dec 2006

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Admission N=817 Victorian Admitted Episodes Dataset</th>
<th>Presentations N= 587 Victorian Emergency Minimum Dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male (66%) Female (34%)</td>
<td>Male (67%) Female (32%) Missing (1%)</td>
</tr>
<tr>
<td>Age group in years</td>
<td>0-14 years (12%) 15-29 years (46%) 30-44 years (25%) 45-59 years (14%) 60 + (3%)</td>
<td>0-14 years (10%) 15-29 years (61%) 30-44 years (23%) 45-59 years (5%) 60 + (1%)</td>
</tr>
<tr>
<td>Activity</td>
<td>Skiing (62%) Snowboarding (32%) Tobogganing (5%) Snowmobiling (&lt;1%) Other/unspecified &lt;1%</td>
<td>Skiing (37%) Snowboarding (58%) Tobogganing (5%)</td>
</tr>
<tr>
<td>Cause</td>
<td>Fall (72%) Hit/Struck/crush object (8%) Collision with person (3%) Transport (1%) Other/unspecified (16%)</td>
<td>Fall (79%) Stuck by/collision with object (7%) Struck by/collision with person (2%) Transport (2%) Other/unspecified (6%)</td>
</tr>
<tr>
<td>Body site injured</td>
<td>Lower Extremity (41%, mostly knee/lower leg 88%) Upper extremity (30%, forearm/wrist 42%, shoulder/ upper arm 39%) Head, face and neck (16%, mostly head 78%) Trunk (12%) Other/ unspecified (16%)</td>
<td>Lower Extremity (30%, mostly knee/lower leg 49% and ankle 31%) Upper extremity (46%, mostly forearm/wrist 48%, shoulder 22%, hand/finger 18%) Head, face and neck (4%) Trunk (14%) Other/ unspecified (6%)</td>
</tr>
<tr>
<td>Nature of injury</td>
<td>Fractures (53%, mostly tibia/fibula 27%, forearm 21%) Dislocations/sprain/strain (22%) Intracranial injury (8%) Muscle/tendon injury (3%) Injury to internal organ (2%) Open wound (2%) Other/ unspecified (10%)</td>
<td>Sprain/stain (36% mostly knee 26% wrist 17% and ankle 16%) Fractures (32%, mostly wrist 26% hand/fingers 14%) Dislocations (2%) Intracranial injury (2%) Muscle/tendon injury (9%) Injury to internal organ (2%) Open wound (3%) Other/ unspecified (10%) Superficial (6%)</td>
</tr>
</tbody>
</table>


A total of 59% of cases stayed in hospital for less than two days, 36% stayed between two and seven days, 4% stayed eight to 30 days. Three cases had longer stays: 61 days for a pelvic injury, 64 for an intracranial injury and 105 for an injury to the cervical spine (Ashby and Cassell, 2007).
Table 2.7 Hospital Admission from alpine sports and alpine recreation injuries by activity and length of hospital stay: Victoria, Jan 2004 to Dec 2006

<table>
<thead>
<tr>
<th>Length of Stay (days)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOTAL</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Skiing</td>
<td></td>
</tr>
<tr>
<td>&lt; 2 days</td>
<td>287</td>
</tr>
<tr>
<td>2-7 days</td>
<td>175</td>
</tr>
<tr>
<td>8-30 days</td>
<td>20</td>
</tr>
<tr>
<td>31+ days</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>483</td>
</tr>
</tbody>
</table>

Source: Victorian Admitted Dataset (VAED) January 2004 to December 2006

Compared to other sports injuries alpine snowsport injuries tend to be more serious and require longer hospital stays (Ashby and Cassell, 2007; State Government Victoria Australia Department of Health, 2007). About 40% of snow sport hospital admissions stayed in hospital two or more days compared with 28% of all admitted snow sports injury cases. The average length of stay for a snow sport injury was 2.5 days (SD 5.2, range 1-105), compared with 1.7 days for all sport injuries (SD, 5.0, range 0-297).

As previously reported two individuals died while participating in alpine skiing in one Australian state. Data on the total recent mortality frequency for Australia could not be found but in August 2008 there were three alpine related deaths that the author was aware of. Three unrelated deaths occurred on August 17th 2008. All three were male skiers, with the first being a 22 year old from the Blue Mountains who was killed when he skied onto a cornice which collapsed causing an avalanche of snow and ice in the Kosciuszko National Park (Blue Lake). The second case was a 59 year old man who died when he skied into a tree on a run at Blue Cow. Three hours later the third man, 48, died when he hit a tree while skiing (Ramachandran, 2008).

Few studies look at fatal injuries associated with alpine injuries. Although fatal injuries are located at the far end of the severity scale they need to be addressed. A study conducted from 1956 to 1988 into skiing-related deaths in Australia conducted in the Snowy Mountains was the only published literature the author could find (Sherry and
Clout, 1988). Over the 32 years, 29 alpine participates died while skiing. Although this study is out of date because equipment and population participating have changed the research provides insight into the number of skiing deaths. Of the 29 deaths, eight individuals died of trauma, 15 died of cardiovascular causes, and six died of hypothermia (Sherry et al, 1988b). The over-all incidence of death was 0.87 per million skier-days while the specific incidence for trauma-related deaths was 0.24 per million skier-days, 0.45 per million skier-days for cardiac-related deaths and there were 0.18 hypothermia-related deaths per million skier-days. These findings compare lower than the United States figures. Death that is associated with skiing in the Snowy Mountains is a rare event (Sherry et al, 1988b).

*Downhill Skiing Injury Fatalities among Children* by Xiang, Stallones and Smith concentrates on this theme (Xiang, 2004). The research is set in Colorado, United States, and uses death certificates to examine the type and external cause, time, week day of injury, gender and residency of the decedents. There were 149 fatal injuries associated with downhill skiing recorded from 1980-2001 in Colorado. Overall, 21 (14.1%) occurred among children 17 years and under. The highest proportion of fatal downhill ski injuries, 36 (24.2%), occurred in the 18 to 24 years age group. Traumatic brain injuries were the leading cause and collision was the leading external injury mechanism of death among skiing children (67% of all deaths), while multiple internal injuries and traumatic brain injuries accounted for almost equal proportions of fatal injuries among adults (Xiang, 2004).

**2.4.7 Children and Adolescents Alpine Injuries**

Injuries are the leading cause of death and life-years loss for children and adolescents in the United States and Australia (Australian Bureau of Statistics, 2006; Damore, 2003; Skokan, 2003). In Australia over a five year period, 1999-2003, 41% (1,260) of all deaths of children aged one to 14 were due to injury (Australian Bureau of Statistics, 2006). Annually in the United States of America 6000 children’s deaths are related to unintentional injuries sustained through sports and recreation (Skokan et al, 2003). In the United States each year there are approximately three million injuries incurred during
sports participation among children and adolescents. In this case injury is defined as one that causes time lost from sports participation (Hergenroeder, 1998). Approximately 770,000 of these sports injuries require physician visits and 45,000 to 90,000 leads to hospitalisation (Hergenroeder, 1998).

High rates of preventable injuries among children relative to other age groups are of concern to health families, professionals, the community and governments (Australian Bureau of Statistics, 2006). An important goal for the World Health Organization is to substantially reduce sports injuries (Backx, 1991).

An American study (Damore, Metzl and Ramundo, 2003) examined relative frequency of sports related musculoskeletal injuries in patients five to 21 years old at four New York Hospitals. Patterns of injury in children and adolescents presenting to the emergency paediatrics department with musculoskeletal injuries in October 1999 and April 2000 were studied. Data collected included age, sex, injury type, anatomical injury site and cause of injury (sports-related or otherwise).

There were a total of 1421 injuries in 1274 patients. Musculoskeletal injuries were more common in male patients (790/62%) than in female patients. The mean age of patients injured was 12.2. Sprains, contusions and fractures were the most common injury types (34%, 3% and 25% respectively). Female patients experienced a greater percentage of sprains (44% vs. 36%) and contusions (37% vs. 33%) and fewer fractures (22% vs. 31%) than males. Sports injuries accounted for 41% (521) of all musculoskeletal injuries and were responsible for 8% (495/6173) of the total patient visits to the emergency department in the research periods (Damore et al, 2003). It is very difficult to gauge the percent of hospitalisation for alpine sports injuries in comparison to other sports. The major difficulty is that each hospital will be different depending upon where the hospital is in relation to the snowfields, and the overall number of alpine participants in the region.
Research suggests that in some areas around the world alpine injuries account for almost 100% of hospitalisation, depending upon the location of the hospital in regards to the snow fields (Hagel, 2005a).

Alpine winter sports attract many children and adolescents, who have been introduced to the sport through school sponsored ski programs, local community clubs, and their families. While recreational activities including sports can be important to a child’s healthy development, they can also have a detrimental effects on health in the form of injuries and related medical problems (Gissane et al, 2001). Injuries create individual and social pains and accrue costs to society (Skokan et al, 2003). As the number of children and adolescents participating in alpine sports continue to rise, it is important to have snow safe programs in place within ski resorts and at schools participating in alpine sports. Snow safe programs and advertisements included: knowing the alpine responsibility code (set of 10 rules for participation in alpine sports (see Table 2.8) and safe driving to and from snow fields campaigns. The Snow Safety Education Program involved the production and distribution of 30,000 Snow Safe booklets and 30,000 Snow Safe pocket guides to all NSW/VIC Ski Resorts, also Snow Safety Courses are run by various ski patrols.
### Table 2.8 Alpine Responsibility Code, Falls Creek Australia

<table>
<thead>
<tr>
<th>Alpine Responsibility Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Know your ability and always stay in control and be able to stop and avoid other people or objects. It is your responsibility to stay in control on the ground and in the air.</td>
</tr>
<tr>
<td>2. Take lessons from qualified professional instructors, to learn and progress.</td>
</tr>
<tr>
<td>3. As you proceed downhill or overtake another person, you must avoid the people below and beside you.</td>
</tr>
<tr>
<td>4. Do not stop where you obstruct a trail or run, or are not visible from above.</td>
</tr>
<tr>
<td>5. When entering a trail or run or starting downhill, look uphill and give way to others.</td>
</tr>
<tr>
<td>6. When riding chairlifts use the restraining devices. Always use suitable restraints to prevent runaway skiing/boarding equipment. Ensure your equipment is in good condition.</td>
</tr>
<tr>
<td>7. Observe and obey all signs and warnings. Keep off closed trails or runs and out of closed areas.</td>
</tr>
<tr>
<td>8. Before using any lift you must have the knowledge and ability to load, ride and unload safely.</td>
</tr>
<tr>
<td>9. Do not ski, snowboard, ride a lift or undertake any other alpine activity if your ability is impaired by drugs or alcohol.</td>
</tr>
<tr>
<td>10. If you are involved in, or witness an accident, alert Ski Patrol, remain at the scene and identify yourself to the Ski Patrol.</td>
</tr>
</tbody>
</table>

**Failure to observe the Alpine Responsibility Code may result in CANCELLATION of your ticket by the Ski Patrol or other authorised personnel**
The winter sports injuries that are of greatest concern to the individual, families and health care system are those serious enough to result in hospitalisation, serious morbidity and mortality. An estimated 135,000 skiing accidents occurred in the United States annually (Josefson, 1998). The author is unaware of comparable data of this type for Australia. In 2000, 2.24 million medically treated musculoskeletal injuries were accounted for in United States children aged five to 14 years. Skiing was ranked as one of the top eight leading causes of injury and the cost to the United Sates society is more than $33 billion (Purvis, 2001).

Although many children’s recreation injuries including snow sport injuries are minor and eventually heal, some can lead to permanent impairment. Even minor injuries cause anxiety and pain for both the child and parent and may result costs in terms of money and time lost. If an injury can be prevented or avoided it is an advantage for families and society. This is why it is important to investigate alpine epidemiology. It is through research that we can gain a better understanding of the underlying causes of injuries and therefore develop more effective preventative strategies.

2.4.8 Children and Adolescent Injury Alpine Epidemiology

A breakdown by age group of snow sports participants currently on the slopes in Scotland is shown in Table 2.9. No similar data could be found for Australia.

Table 2.9 Scottish Un-injured Snow Sport Participants

<table>
<thead>
<tr>
<th>Age group</th>
<th>Per cent of total population</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;17 yrs</td>
<td>21%</td>
</tr>
<tr>
<td>17-24 yrs</td>
<td>33%</td>
</tr>
<tr>
<td>25-40 yrs</td>
<td>31%</td>
</tr>
<tr>
<td>&gt;40 yrs</td>
<td>15%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: http://www.ski-injury.com/specific-risk-groups/kids
The international literature in alpine skiing and snowboarding overwhelmingly suggests an injury incidence rate of between 2 and 3.5 per 1,000 skier visits (Ekeland et al, 2006). These epidemiology studies advocate that children are over-represented in the alpine injury data (Shealy, 1997). Moreover, Canadian literature reports children to have an injury rate almost twice that of the total ski injury population (Goulet et al, 1999) and European literature reports individuals younger than 17 to be more than three times more likely to be injured than those aged 17 to 25 (Langran, 2004).

However, it is difficult to draw the same conclusion as that of the Northern Hemisphere children’s epidemiology studies for a number of reasons. Firstly many Canadian, American and many European children have skied by the age of five and have school based programs through their entire primary and secondary schooling years. This is vastly different to the situation here in Australia where a school excursion or camp to the snowfields may be the first visit for children or adolescents. Alpine resorts are much easier to access, in Canada and other northern countries. With this in mind you would expect Australian children to have an even higher rate of injury. This over representation of injured children and the increased risk of injury among this aged group has been observed in many countries where alpine sports are popular. Table 2.10 represents the main literature on children’s alpine injuries.

Notable trends exist between contributing factors to injury and severity including age, experience and risk taking. Langran (2004) found several independent risk factors for alpine injury among first-time participants; these include age, snow sport, equipment source, and the use of professional instructors (Langran, 2004).

There are physical, physiological and social differences between children and adults that may cause children and adolescents to be more vulnerable to injury. Factors that contribute to these differences include: children have a proportionately larger head and body surface area to mass ratio (BSA) than adults do - predisposing to heat loss; children have thinner skin than adults. Their epidermis is thinner and under-keratinized, compared with adults - predisposes to sun (radiation) damage, children are more prone to
dehydration than adults, children have larger heads proportionately, children may be too small or not fitted correctly for protective equipment, growing cartilage may be more vulnerable to stress, children may not have the complex motor skills needed for certain levels of alpine sports until after puberty. Subjectively children exhibit reduced levels of risk awareness compared to adults and may take more risks, potentially placing them at higher risk of injury (Adirim, and Cheng 2003). The current research will address risk-taking and sensation seeking characteristics in an effort to determine if they influence participant’s injury frequencies.

Table 2.10 Children Alpine Literature

<table>
<thead>
<tr>
<th>Children’s Alpine Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garrick, and Requ, (1979) Injury Patterns in Children and Adolescent Skiers.</td>
</tr>
<tr>
<td>Mac Nab, Smith, Gagnon, and Mac Nab,(2002). Effect of helmet wear, on the incidence of head/face and cervical spine injuries in young skiers and snowboarders.</td>
</tr>
<tr>
<td>Sahlin (1990) Sport Accidents In Children.</td>
</tr>
</tbody>
</table>
2.4.9 Risk factors Associated with Alpine Sports Injuries in Children

A number of factors have been found to influence the amount of injuries, severity and anatomical location of downhill skiing and snowboarding. Listed below are a number of factors which can increase the risk of injury in alpine participants:

(i) Experience level of the individual;
(ii) Professional lessons from a qualified teacher;
(iii) Rented versus their own equipment;
(iv) Equipment condition, recently serviced or untuned;
(v) Snow conditions and terrain classification;
(vi) Weather conditions and the effect it may have on snow conditions and visibility;
(vii) The use of protective equipment by the participant;
(viii) Hydration and food consumption.

Experience level of the individual

Low skill or technical skill experience levels have consistently been reported to influence injury (Cooper, 2006; Garrick and Requa, 1979; Goulet, Régine, Grimard, Valois and Villeneuve, 1999; Greenwald, Nesshoever and Boynton, 2003). Studies found skiers and snowboarders with less experience have a higher incidence of injury compared with more experienced participants. In Australia, two dated studies found that less ability to ski or snowboard was a contributing risk factor for injury (Bladin et al., 1993; Giddings, McCullum and Duff, 1993). Around the world injury rates for beginner and novice skiers and snowboarders have been reported to be as high as nine or 10 times that of advanced or expert participants (Bladin et al., 2004).

When children first become involved with an alpine sport they have no experience, which therefore greatly increases their risk of injury. Studies suggested that experience, and skill level may be independent of each other (Bladin et al., 2004; Garrick, 1979). For example, Garrick and Requa 1979 observed that more experienced downhill skiers fall less and get injured less often even if they remain at a low level of ability. Yet in other research Ungerholm, Gierup, Gustavsson and Lindsjö (1984) showed that low skill level skiers aged 16 or younger are injured more often than highly skilled young skiers, regardless of
their respective level of experience (Ungerholm, Gierup, Gustavsson and Lindsjö, 1984). In the present study the researcher considers the influence of experience level of participation on injury.

**Professional lessons from a qualified teacher**

The influence of having professional alpine lessons from a qualified instructor is less clear with respect to injury. Two older studies suggest the risk of children sustaining a alpine injury is increased by not having any type of formal instruction (Requa, 1978; Shealy, 1996).

Langran demonstrated that the number of professional lessons were not neccessarly correlated to with an increased risk of injury across all snowsports in Scotland (Langran et al, 2002). In the research first day participants for both downhill skiing and snowboarding who had taken professional lessons were nearly three times more likely to be injured compared to those who had not. Shealy concluded that the rapid skill acquisition through lessons together with very little experience did not reduce the injury rate. Building from this Garrick and Requa observed that having professional lessons was related to a reduction of injury only when combined with the accumulation of significant experience (Shealy, 1996). Langran supports this observation that first day participants who had taken professional lessons were more likely to attempt “too much, too soon”. Individuals who had lessons were more likely to attempt slopes and/or travel at speeds beyond their ability level more frequently than those who did not have any lessons.

The current research aims to try and identify if the number of professional lessons children have, impact or affect the amount of injuries and severity.

**Rented verse their own equipment**

Research provides evidence that equipment (ski, boots, binding) that is not well-adapted or adjusted to individual increase the risk of injuries Problems with correct equipment condition and setting, use of rental equipment has been shown to correlate to higher injury rates (Hagel, 2005a).
**Equipment condition, recently serviced or untuned**
Deficient binding adjustment is one of the most documented risk factors for childhood ski injuries. Improper adjustment of bindings, or bindings in poor condition significantly increase the risk of injuries in young skiers (Hagel, 2005a).

**Snow conditions, terrain classification weather conditions**
Limited research examines the rate of environmental factors in alpine injuries (Machold, 2000). One would assume that the environmental conditions would influence and impact the types and frequencies of injuries sustained. Machold (2000) found surfaces like hard packed snow or icy terrain play a key role in falls related to injury. Levy and Smith (2000), identified that advances in slope maintenance were linked to injuries by making previously inaccessible areas to skiers with less experience accessible (Levy, 2000). Decreased visibility also can increase the likelihood of a participants colliding with another participant or objects such as a trees.

**Hydration and food consumption**
The importance of good hydration and adequate food intake while participating in alpine sports has received limited attention. But in other sporting activities, research illustrates that decreased levels of hydration effect an individual skill level and performance (Shirreffs, 2005). This dehydration effect is also seen to be more apparent in extreme cold environments (5°C to -10°C) and hot weather conditions (20°C plus).

An issue that has not been addressed in alpine literature is the effect limited/ no food and dehydration during the day on participant’s performance. This may have a relationship on the influences on injuries sustain.

Alpine sports are unique activities in terms of the physiological and environment stresses they place on the human body. Participating in sport in a cold environment increases the body’s energy requirements and therefore requires that participant’s eat more. Alpine sports are often performed in cold temperatures around or well below the freezing point. The temperature in itself presents numerous metabolic, thermoregulatory and
cardiovascular challenges to the body (Seifert, 2005), which could increase the risk of injury by affecting performance levels.

Hydration status and water consumption and its effects on exercise performances are discussed in the literature (Seifert, 2005). The majority of research in this area relates to long distance race events such as cycling and running, and the effect of dehydration on performances (Dietary Reference Intake, 2004).

While participating in sport, mild dehydration in children can impair physical performances more dramatically than in adults (Barr, 1999). In adults there is a reduction in physical work capacity at 2% dehydration of between 8% and 25% (Dietary Reference Intake, 2004). When exercising at 1% to 2% dehydration, children experience a greater increase in core body temperature than adults, thus suggesting that the same level of dehydration may have greater adverse effects on children’s physical performances (Dietary Reference Intake, 2004). Children should be well hydrated when performing any type of physical exercise, a standard guideline is that every 20 minutes during the activity a 40 kilogram child should drink 150ml of water and a 60 kilogram child 250ml of water even if they do not feel thirsty (Dietary Reference Intake, 2004).

### 2.5 Injury Prevention Strategies

It has been suggested (Goulet, 1999) that the development of tailor-made prevention strategies aimed at children and adolescents would significantly help reduce the incidence of alpine injuries. WHO states to significantly reduce the number of injuries a systematic plan of preventative measures must be developed. Such a plan would include four steps (Van Mechelen, and Kemper, 1987).

1. Acquiring data and analysing the magnitude of the problem, the nature, extent and severity of the injuries (alpine descriptive epidemiology).
2. Identifying the behavioural risk factors by studying behavioural determinates (alpine analytical epidemiology) involved in the injuries.
3. Applying one or more preventative program measures, based on the identification of the behavioural factors, to prevent the injury or reduce their severity.
4. Evaluating the applied prevention measure in order to compare the incidence and severity before and after the intervention (Van Mechelen W., 1987).

Goulet et al (1999) states that to manipulate demonstrated behavioural risk factors in a prevention program, it is important to first find the origins or determinates of such behaviours. This research determines to find, what extent risk-taking and sensation seeking characteristics influence the occurrence of alpine injuries. Alpine research generally does not proceed past the first step, this research aims to move to the second step, and to provide enough data to, in the future, move through to the third and fourth step.

2.6 Alpine Protective Equipment
The most frequently used protective equipment is a helmet. Other equipment includes, wrist guards, back braces, padded shorts, knee guards and elbow guards.

The issue of ski helmets remains controversial while evidence for their efficacy remains under debate (Shealy, 2005a). Helmet manufacturers and alpine epidemiologists do agree that they reduce head lacerations, traumatic brain injury and the impact forces to the skull in low velocity crashes. The argument remains open if, at high velocity, a helmet will prevent injury/death.

The United States Consumer Products Safety Commission (CPSC) commissioned a report to assess the potential for helmets to reduce the incidence of head and neck injuries associated with alpine snowsport injuries during a proportion of the 1998 winter season. The CPSC report indicated that almost half (48%) of the head and neck injuries were a direct result of contacting the snow surface and they concluded that 44% of all head injuries (estimated 7700 injuries in the United States annually) and 11 deaths per year could be mitigated with a protective helmet.

Since the CPSC report was issued, there have been a number of studies reporting the rapid increases in the use of helmets during recreational skiing and snowboarding (Fuchs, 2005; Shealy, 2005a, 2005b). Internationally the highest incidence of helmet usage appears to be
in the United States at a Vermont resort. There it was reported that in the total alpine population the use of helmets has increased over a nine year span (1999 to 2006) to approximately 24% (Shealy, 2005a). Switzerland follows with approximately 20% of all recreational participants wearing helmets (Fuchs, 2005).

Current studies have reported that helmet usage has decreased the incidence of head injury (Scher, 2006). Hagel, Pless, Goulet, Platt and Robitaille (2005) reported that there had been a 29% reduction in the risk of any head injury with the use of a helmet (Hagel, 2005c). Additionally as a percentage of all injuries sustained, head injuries have decreased by approximately 30% (Shealy, 2005a). Scher, Richards, and Carhart (2006) found in snowboarders that recreational snow helmets offer valuable protection against the ‘opposite-edge-phenomenon’ (where the downhill edge on the snowboard catches, causing snowboarder to rotate abruptly and fall backward onto the posterior aspect of the pelvis, torso and head) on icy snow, reducing the probabilities of skull fracture and severe brain injury from approximately 80% to 20% (Scher, 2006).

However, there is also debate from a small proportion of leading researchers over whether or not helmets mitigate more severe head injuries (Scher, 2006; Shealy, 2005a, 2005b). According to Shealy, Ettlinger and Johnson (2005), helmet use has significantly reduced the incidence of mild head injury including lacerations, abrasions, and mild concussion, but has not reduced the incidence of potentially serious head injuries. They also believe that helmet usage may in fact increase certain individual’s risk-taking behaviour increasing their chance of injury.

2.6.1 Use of protective equipment by children

The rate of helmet use in the general children's population on the slope is not comparable for different countries. In Scotland it is estimated to be over 30%, yet in Australia in has been recorded to be only 8% (Cooper, 2008). Logistic regression reveals that children not wearing a helmet have a 66% increased risk of an injury compared to those children who do (Langran, 2008).
Many countries encourage children to wear helmets. Some offer free helmet loans, whilst others provide free skiing to those wearing a helmet. In France, during the 2007/08 season, almost 90% of children under 11 years of age wore a helmet. The National Ski Areas Association has also been proactive in this area with its Lids on Kids campaign, supported by the National Ski Patrol (National Ski Areas Association, 2008a).

Whist helmet usage is continuing to increase, wrist guard use amongst children remains low (Langran, 2008). Langran (2007a) conducted a snowboard wrist examination where injured children who sustained wrist fractures patterns of protective equipment were detailed. Of the children who incurred a wrist fracture less than 3% of them were wearing guards (Langran, 2007a). This may be a reflection of difficulties in finding suitably sized wrist guards.

2.7 Interschools Competitions

Interschools Snowsports is a series of organised competitions for both primary and secondary school children in Australia. Interschools events are conducted over a number of days with six disciplines: Alpine Giant Slalom, Cross Country, Skiercross, Moguls, Snowboard Giant Slalom and Boardercross. The events are open to public and private schools and each state has their own series of races; teams begin in regions and can progress through to State and Australian Championships. In 2006, the total number of NSW Championship event days was 19 (12 at Perisher Blue and seven at Thredbo) (Interschools Newsletter, 2006), while the total number of NSW competition entries were 9,883 (Interschools, 2008). Secondary school entries accounted for were 6,288, whilst primary school entries were 3,395. Broken down into regions, Southern NSW secondary school participants had a total of 1,415 entries from 42 schools. Southern NSW and ACT Interschool Snowsports entries since 2001 have increased dramatically by 312%, from 465 entries in 2001 to 1,452 entries in 2007. In 2007 there were 1,452 entries. Table 2.11 outlines the Southern Division entry number and estimates for 2008. At the time of writing Interschools had yet to publish actual numbers for the winter 2008 session.
With the growing number of participants the occurrence of alpine injuries may have increased substantially, which is not only a problem for the participating groups, but may represent a public health challenge.
2.8 Risk-Taking and Sensation Seeking

2.8.1 Introduction

Explanations for risk-taking are many and varied. Risk-taking has been explained as a ‘function of an evolutionary relic’ (Llewellyn, 2003); a biologically predetermined force (Jones, 2000); a function of a specific gene (D4DR) (Ebstein and Belmaker, 1997); a personality trait (Zuckerman, 1984); a pathological disease (Llewellyn, 2003); a cultural phenomenon (Lightfoot, 1997); gender issues (Lois, 2001); and a search for aesthetics and transcendence (Stranger, 1999).

The notion of risk has been classified in terms of adventurous risk, antisocial risk and prosocial risk (Cheron, 1982). The activity of risk-taking has also been considered as a negative to positive range (Brymer, 2005). It can be associated with delinquent negative risk-taking behaviour (Farley, 1991) and the positive side has been considered as “probably the most positive force in the human race; our creative side” (Farley, 1991, p.375).

Zuckerman (1979, 1984) describes sensation seeking as the search for novel, varied, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, and/or financial risks for the sake of such experiences (Zuckerman, 1979, 1984). Sensation seeking behaviour can be seen as the outcome of a conflict between states of anxiety that vary as a function of novelty and appraised risk (Yates, 1992). Zuckerman (1984) believed that as some individuals become more confident through gained experience at a given task like skiing, they may eventually push their limits and seek novel sensations.

Risk-taking and sensation seeking in sporting terms is “a very complex phenomenon” (Rossie and Cereatti, 1993 p 420). Rossi and Ceretti report that risk-taking in relation to sport has two dimensions: the physical danger involved and unforeseeability (Rossi, 1993). Brymer (2005) reported in his PhD that “risk-taking has objective elements and is dependent on subjective perceptions, which involves an analytic (probabilities, formal
logic risk assessment and so forth) system, an experiential (cited intuitive, fast, automatic, and weakly accessible to the conscious awareness) system and emotions” (Bymer, 2005, p. 92).

Risk-taking may also have different constructs depending on culture, subculture or individual difference (Bymer, 2005). One example of risk-takings different constructs is research investigating risk-sports include a study on elite climbers by Robinson (1985). Participants ranked themselves on their risk-taking behaviours. The majority of participants (85%) ranked themselves as moderate risk-takers, 10% ranked themselves as low and three percent as high risk-takers (Robinson, 1985). Yet the general population, who normally have little or no contact with climbers, would typically rank these elite climbers as high risk-takers. Albert (1999) also found risk to be a constituent of the culture of sport. Cyclists were found to accept that risk as part of their daily training and racing (Albert, 1999).

The literature presents a variety of theories that endeavour to explain risk-taking and sensation seeking traits in individuals. Risk-taking behaviour can be analysed from several different perspective including dispositional traits and biological (genetic) view points.

Risk-taking theories based on *dispositional traits* examine individual differences between people that may account for a propensity to take risk (Botvin, 1986; Kaplan, 1980; McCord, 1990; Petersen, 1993b). Research in this domain tends to be inconclusive and not strong enough to state that dispositional traits are more than causal factors in adolescent risk-taking (Millstein, 1995).

Biological models of adolescents’ risk-taking examine genetic factors, neuroendocrine (hormone) influences, and pubertal events (Udry, 1990). The biological model accommodates a number of different theoretical explanations of risk-taking. Because there is a large number of these only two main concepts will be addressed.
Recently, researchers examining the possibility of a genetic connection have discovered a gene presumed to be the cause of excitement seeking, novelty seeking, exploratory or risk behaviour (Okuyama, 2000; Persson, 2000). The ‘D4DR’ gene was discovered in experiments investigating connections between alcoholism (Bau, 1999) and drug abuse (Ebstein, 1997). The long allele (an allele is an alternative form of a gene and one member of a pair) that is located at a exact position on a specific chromosome (Udry, 2000) has also been associated with individuals risk-seeking behaviours (Persson, 2000).

Today little research has included high-risk or extreme sports participation but some theorists have considered there to be a connection (Baker, 2004; Zuckerman, 2000).

Another biological model approach uses the developmental perspective to explain risk-taking, participially as it relates to the bio-psychosocial changes that occur during adolescents. Risk-taking is viewed as a way of coping with normal developmental tasks such as exploration and achieving autonomy (Millstein, 1995) and difficulties adolescents face in making decisions (Furby, 1992).

An individual's personality, genetic predispositions, and social environment are all thought to play a role in a person becoming a sensation seeker or risk taker (Zuckerman, 1994). Zuckerman (1979) indicated that he and others held the general perception that an individual is born with a desire for sensation seeking.

Other factors, including several psycho-physiological and sociological aspects, have been found to help determine whether an individual develops into a sensation-seeking adult (Schneider, 2007). A psycho-physiological example involves the stimulation and production of the neurotransmitter/hormone, dopamine. Dopamine acts as either an excitatory or inhibitory (Seeley, 2006) that can influence an individual’s euphoria of an experience while seeking novel activities (Weiss, 1987; Zuckerman, 1990). Zuckerman (1994) suggested that high sensation seekers may produce low levels of dopamine. Given that the release of dopamine helps facilitate a sense of satisfaction, high sensation seekers
may tend to pursue activities that stimulate dopamine production (Weiss, 1987, Zuckerman, 1994).

Evidence also suggest that sociological nurturance or non-nurturance by the family unit and/or society for risk taking behaviour could support or stifle a chemically predisposed risk taker at childhood (Zuckerman, 1994).

Literature also addressed the relationship between risk taking and sensation seeking, and it is noted that high sensation seekers are generally risk takers. Zuckerman (1994) defined risk as “the appraised likelihood of a negative outcome or behaviour” (Zuckerman, 1994. p. 124).

Research suggesting that high sensation seekers find that the sensations they experience are worth any potential risks, whereas low sensation seekers do not necessarily value or tolerate the feelings achieved through risky activities (Schneider, 2007). Additionally, low sensation seekers rarely consider high-risk activities as being worth the perceived risks.

Zuckerman (1994) affirmed that in addition to general motivational or emotional traits, risk taking choices depend on the motivational and emotional states of the individual at the time of the decision to participate in an activity (Schneider, 2007; Zuckerman, 1994). He reported that it was his belief that risk is necessary for sensation seeking to arise but that risk itself is not necessarily the fully intended goal of a sensation seeker. Choosing risk for the sake of risk is not the goal. Rather, while being attracted to activities that offer novel or intense experiences, sensation seekers are willing to accept the potential risks involved (Zuckerman, 1994).

Zuckerman (1994) also suggests that personality traits and chemical predispositions in sensation seekers allow high sensation seekers to take on situations and physical challenges that push their comfort zone and elevate their experience level. Sensation seeking personality construct consists of four dimensions: thrill and adventure-seeking, disinhibition, experience-seeking and boredom susceptibility (Zuckerman, 1994).
The more risk experiences sensation seeking individuals acquire, the more comfortable or at ease they feel with perceived risk (Schneider, 2007). What a high sensation seeker perceives as low risk, a low sensation seeker may consider the situation or event to be high risk or even dangerous. As Zuckerman notes, high sensation seekers accept higher risks to reach their goals (Zuckerman, 1994).

From a social psychology perspective, Helms (1984) described what he called ‘risky shift’ phenomena, which involves groups of individuals, in certain contexts, that are willing to take risks as a group that they would not take as individuals (Helms, 1984). As he described it:

*When a group verbalizes its decision concerning a risky situation, the group’s decision tends to be riskier than the individuals would have recommended privately. There are several factors that affect the upward shift in risk taking capacity. When an individual realizes that he or she is not riskier than the other members of the group, he or she will adjust his or her risk-taking attitude upward. Furthermore, group discussion allows the members to rehearse their arguments regarding the decision and familiarity when a hazard promotes a higher level of acceptable risk concerning the hazard or situation.*

(Helms, (1984), p. 23)

Thus, the influence of the collective whether peer pressure is involved or not, cannot be underestimated in examining risk.

Numerous studies have been conducted on examining sensation seeking and high risk sports (Donnelly, 2004; Schrader, 1999; Stranger, 1999). Risk and sensation seeking are common daily phenomena and every person experiences risk to some degree. A substantial amount of literature has concentrated on risk taking and sensation seeking in sport (Breivik, 1996; Levenson, 1990; Robinson, 1985; Rossi, 1993; Yates, 1992; Zuckerman, 1994). Cherpitel *et al* (1998) suggested that “sensation seeking behaviours have been found to be common among those engaging in such activities as mountaineering, deep sea diving, skiing and snowboarding, all of which may be
considered relatively high-risk activities for accidental injury” (Cherpitel, Meyers and Perrine, 1998, p 218).

The majority of the previous research regarding risk taking and sensation seeking within the sports environment has employed quantitative methods that rely on various questionnaires, personality profiles, and/or sensation seeking scales including Zuckerman's (1994) Sensation Seeking Scale. The Sensation Seeking Scale (SSS-V; Zuckerman, 1994) has been validated repeatedly by various studies in sport (Breivik, 1996; Levenson, 1990; Robinson, 1985; Rossi & Cereatti, 1993).

The construct is an old one, originally formulated by Wundt (1873), to explain the relationship between affective reactions and intensities of stimulation (Zuckerman, 1978). Along with sports such as downhill skiing, numerous other outdoor sports and activities have also been found to attract individuals who rate high in sensation-seeking and risk-taking. Breivik (1985) investigated personality, sensation seeking and risk taking in a Norwegian Everest expedition team. A number of psychological tests were administered, including the Sensation Seeking Scale Five (SSS-V). These particular Norwegian Everest climbers have proven to be some of the highest overall scorers on the SSS-V.

Rossi and Cereatti (1993) continued work on validating the Sensation Seeking Scale by examining mountain climbers, ski jumpers, cavers, and rock climbers as compared to physical education students and a control group. Zuckerman (1983) declared that for athletes, risk is not an attraction, rather, risk is reduced as much as possible by the athlete through his or her development of skills, planning, and concentration to compete with the highest control possible. Although spectators may regard some sports as very risky, athletes tend to try and minimize risk through skill and preparation. Outside of his scale-based work, however, Zuckerman (1994) further emphasized the need for research on perceptions of risk in sport in order to better understand this phenomenon.

Boga (1988) attempted to answer the question of why athletes partake in high risk sports. This was achieved through an interview process of 10 world class athletes in sports such
as hang gliding, cycling, rock climbing, and motorcycle racing. Boga’s results indicated that high-risk athletes were not fearless, but that had learned how to handle fear. The climbers he interviewed viewed fear as an acceptable and potentially useful emotion in helping keep them safe (Boga, 1988). A qualitative and quantitative examination of the phenomenon of risk in alpine sports may reveal concepts, belief systems and learned behaviours that parallel the risk perspectives outlined in the research reviewed for this study (e.g. Levenson, 1990; Zuckerman, 1994).

Adolescents seek to develop their own identity and values (Miller, 1989). For children and adolescents, given the freedom to experiment with certain aspects of their life may also entail taking some type of risk (Cherpitel Meyers and Perrine, 1998; Schneider, Butryn, Furst and Masucci, 2007). Research provides evidence that when anybody takes risks there are possibilities for negative consequences, including serious alpine injuries. However, research proposes that adolescent decision making may possibly differ from that of adults when it comes to engaging in high risk behaviours (Furby and Beyth-Marom, 1992; Reyna, 2006). In comparison to personality trait investigations or biological explanations of risk-taking and sensation seeking various literature has concentrates on the psychological and sociological aspects of risk in sport and the perceptions of risk in sport (Reyna, 2006).

According to Jessor (1983) risk-taking is considered to be a normal part of adolescent development, but it may also place a greater risk of injury (Jessor, 1983). The relationship between risky behaviour and injury has been evaluated in children as early as preschool. Pre-injury behaviour or risk behaviour was a significant predictor of injury liability. The relationship was also found in children aged between six and nine (Jessor, 1983).

Although the report Alcohol Consumption: Sensation Seeking and Ski Injury: A Case-Control Study, by Cherpitel, Meyers and Perrine (1998), provides information and speculations into the association between risk-taking behaviours and accidental injury. Alcohol consumption is known to be associated with both risk of accidental injury and
with sensation seeking. Sensation seeking has been found to be common among those engaging in such high risk activities as skiing and snowboarding (Connolly, 1981; Hymbaugh and Grant 1974 and; Kusyszyn et al., 1973).

The impact of peer influences on adolescent injury is another area that has limited research. Findings from related areas suggest that it may be a very important factor to consider. A relationship between peer involvement in problem behaviours and the onset of risky sexual behaviours in adolescents has been reported in one study (Metzler, 1994). Additionally, Horvath and Zuckerman (1993), while studying risky behaviour and risk appraisal in collage undergraduates, found that the best predictor of an individual’s risk behaviour was the rate of risky behaviours the individuals reported in his or her peer group (Horvath and Zuckerman, 1993).

The theoretical basis for the present study has been Zuckerman’s sensation seeking theory and ideas. Zuckerman’s (1994) definition provides an effective basis for a study with adolescent participants. Because sensation seeking within an alpine environment can involve the traits Zuckerman defined including the seeking of varied, novel, complex and intense situations and experiences, and willingness to take physical risk for such an experience. No study that the author is aware of examines the association of both sensations seeking and risk taking on accidental ski and snowboard injuries. A factor that has been contributed to increased rates of injury during adolescence is risk taking (Langran, 2004). Therefore, the purpose of this study was to qualitatively examine the risk-taking and sensation seeking characteristics in an adolescent cohort who participates in the alpine sports. A secondary purpose of this study was to explore the notion that participants who seek risk may sustain more alpine injuries.

2.10 Outcomes of the Literature Review

2.10.1 Findings

This literature review establishes that there is currently a gap in the alpine injury epidemiology literature between those injured and factors that cause the injury. To bridge
the gap between injury diagnosis and the demographics of the injured, including why and how the alpine injury was sustained, would help clarify and broaden the already existing alpine epidemiology data with the long term goal of reducing alpine injuries.

Currently substantial literature exists on certain intrinsic and extrinsic factors, including who is getting injured (age group), anatomical location of the injury and type of injury (e.g. fracture, dislocation sprain) that was sustained. Intrinsic (personal) risk factors are inherent characteristics of an individual that influence injury risk in alpine sports. Intrinsic characteristics include lower ability/less experiences (previous alpine sports experience and participation frequency in alpine sports), age (younger age groups have been found to be more at risk that older participants), gender and personality characteristics.

Extrinsic factors can also increase the risk of sustaining an alpine injury. Extrinsic risk factors include inappropriate training (e.g. too frequent or too intense), improper equipment such as binding adjustments, inappropriate clothing or protective gear, poor technique, terrain type, weather, snow conditions and visibility. Studies have also investigating the effect of activity type (i.e. skiing or snowboarding) and equipment ownership on injury risk but results are less consistent. Extrinsic risk factors accounted for in this project include terrain type, protective equipment usage and activity.

Little or no literature exists on what caused the alpine accident and whether social implications or protective equipment may have caused or prevented the injury retrospectively. Studies exist that examine the relationship between sensation seeking and drugs, criminality and motor vehicle accidents (Cherpitel, 1998; Petersen, 1993a), yet no studies that the author is aware of examines the association of both sensation seeking and risk-taking on ski and snowboard injuries with a selected adolescent population.

In Australia, there have been no children or adolescent Alpine injury epidemiology studies. This creates an opportunity to help rectify the problem through an investigation to determine injury demographics and attempt to establish if there is a pattern of risk-taking and sensation seeking behavioural characteristics among adolescents during alpine activities. In addition to studying participation injury rates, this study endeavours to
identify if adolescents’ perceptions of risk-taking and social factors may result in the occurrence of more injuries and severity. This is important to the Australian Tourism industry because with a focus on injury prevention and injury reduction people are more likely to participate in alpine sports. Maintaining and increasing participation rates will strengthen the alpine tourism industry financially.
CHAPTER THREE: RESEARCH METHODOLOGY AND METHODS

3.1 Introduction
In Chapter 2’s the literature review explored the historical development of winter alpine sports and its subsequent growth into a profitable adventure tourism market. The objective of that chapter was to place this research project within a framework of current and past understanding by reviewing relevant scientific, technical and informal work on alpine epidemiology and risk-taking.

In this chapter theoretical perspectives that have been used in previous injury prevention and the current ones used in this thesis are described. This is followed by a description of the research methodology employed in the research project. The theoretical perspective is a set of assumptions presumed to have explanatory adequacy in treating the generalisations that arise in this study. Methodology is, strictly speaking, the philosophy underlying the procedures and principles in a particular field of inquiry (Vygotsky, 1978).

The present chapter provides an outline of the epistemological issues, theoretical perspective and the research design governing this project. A description follows of how the research material was developed, gathered and analysed. Figure 3.1 illustrates a flow diagram that guide the structure of the chapter.
**Figure 3.1 Research Design**

<table>
<thead>
<tr>
<th>RESEARCH DESIGN</th>
<th>CURRENT RESEARCH PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontological View</td>
<td>• Knowledge exists and learnt as we engage in the real world</td>
</tr>
<tr>
<td>Epistemology</td>
<td>• Constructionism</td>
</tr>
<tr>
<td>Theoretical Perspective</td>
<td>• Interpretive Paradigm.</td>
</tr>
<tr>
<td>Methodology Basis</td>
<td>• Questionnaire Research - Primarily qualitative with supplementary quantitative. The development and perceived legitimacy of both qualitative and quantitative research has lead to this research employing the mixed method research design.</td>
</tr>
<tr>
<td>Methods</td>
<td>• Data Collection Tool - Questionnaire utilising a mixed-method design of both quantitative and qualitative style questions.</td>
</tr>
</tbody>
</table>

*Adapted from Ayres (2006), Influences on Career Development in Australian Tourism.*
3.2 Epistemological Issues

Epistemology or the theory of knowledge is the study of knowledge and justified belief (David, 1978). It is a branch of philosophy which is concerned with the nature and scope of knowledge (Wikipedia, 2009). Boufoy-Bastick (2005) who suggested that the term epistemology was first introduced into the English language by a Scottish philosopher, James Frederick Ferrier (1808-1864) (Boufoy-Bastick, 2005). The field of epistemology basis is “on analysing the nature of knowledge and how it relates to similar notions such as truth, belief and justification” (Wikipedia, 2009). Epistemology is also concerned with the creation or production of knowledge, as well as scepticism about different knowledge claims in particular areas of inquiry. Broadly epistemology is related to:

- What is knowledge?
- How is knowledge acquired?
- What do people know?

According to Plato (428/427 BC – 348/347 BC), knowledge is a division of which is both true and believed (Wikipedia, 2009). Figure 3.2 demonstrates Plato’s belief in what knowledge is as a subset of what is both true and believed.

*Figure 3.2 According to Plato, knowledge is a subset of that which is both true and believed.*

![Figure 3.2 Diagram showing knowledge as a subset of truths and beliefs](source; Wikipedia, 2009).

Crotty (1998) distinguished between different frameworks of research on the basis of their grounding in epistemology (Crotty, 1998). Epistemology provides the foundation for
research and on this is built the theoretical perspective of the research project. The methodology is then selected followed by the method of how the research project will be conducted. Each stage provides the basis for the next.

Accordingly (see Table 3.1), epistemology is the theory of knowledge underlying research, examples of philosophical positions include objectivism, constructionism, subjectivism and their variants (Crotty, 1998).

The theoretical perspective in a given philosophical position then provides a context for the research such examples include positivism, interpretivism, critical inquiry, feminism and also include sub-branches of these.

One’s research methodology, then, refers to the overall strategy for conducting the research project.

Finally, there is the type of method used, such as questionnaires, interviews, focus groups and case studies. Research projects are not limited to using only one research method and a number of methods can be utilised. Crotty deemed that epistemology and theoretical perspective are equivalent to Gadamer’s pre-understanding. The research potential for Crotty’s format is that it provides a systematic layout for the research to conceptualise and clarify the foundation of their research project. Using this format style as a guide, researchers can consciously deliberate underlying issues, ideas and concepts to piece together their project (Crotty, 1998).
### Table 3.1: A representative sample of several epistemological positions, theoretical stances, methodologies, and methods

<table>
<thead>
<tr>
<th>Epistemology</th>
<th>Theoretical Perspective</th>
<th>Methodology</th>
<th>Methods</th>
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<tbody>
<tr>
<td>Objectivism</td>
<td>Positivism (and post-positive)</td>
<td>Experimental research</td>
<td>Sampling</td>
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<td>Interpretivism:</td>
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<td></td>
<td>- Symbolic</td>
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<td>- Phenomenology</td>
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<td></td>
<td>- Hermeneutics</td>
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<tr>
<td>Constructionism</td>
<td>Survey research</td>
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<td>Measurement and scaling</td>
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<tr>
<td></td>
<td>Interpretivism:</td>
<td></td>
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<tr>
<td></td>
<td>- Symbolic</td>
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<td></td>
<td>- Phenomenology</td>
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<tr>
<td></td>
<td>- Hermeneutics</td>
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<tr>
<td>Subjectivism (and their variants)</td>
<td>Critical Inquiry</td>
<td>Ethnography</td>
<td>Questionnaire</td>
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<td></td>
<td>Feminism</td>
<td>Ground theory</td>
<td>Observation:</td>
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<td></td>
<td></td>
<td>- Participant</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- Non-participant</td>
</tr>
<tr>
<td>Postmodernism</td>
<td>Heuristic inquiry</td>
<td></td>
<td>Interview</td>
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<td></td>
<td>Action research</td>
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<td>Focus group</td>
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<td></td>
<td>Discourse analysis</td>
<td></td>
<td>Case study</td>
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<tr>
<td></td>
<td>Feminist standpoint research</td>
<td></td>
<td>Life history</td>
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<tr>
<td></td>
<td>Statistical analysis</td>
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<td>Narrative</td>
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<td></td>
<td>Data reduction</td>
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<td>Visual ethnographic methods</td>
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<tr>
<td></td>
<td>Theme identification</td>
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<td></td>
<td>Comparative analysis</td>
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<td></td>
<td>Cognitive mapping</td>
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<td></td>
<td>Interpretative methods</td>
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<td></td>
<td>Document analysis</td>
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<td></td>
<td>Content analysis</td>
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<td></td>
<td>Conversation analysis</td>
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</table>


Higgs (2001) took a similar stance to Crotty’s approach and the two are comparable. Higgs’s research approach can be distinguished by three core research paradigms (Table 3.2): empirico-analytical, interpretive and the critical paradigm. According to Higgs, a paradigm is composed of a set of beliefs, conventions, and assumptions that define what can be asked as meaningful questions, how these questions can be answered, and what
constitutes an adequate answer to any question (Higgs, 2001). It determines what counts as knowledge and how knowledge can be validly generated. Higgs’s approach is comparable to Crotty’s in that different aspects of the research build upon each other. Higgs considered that the paradigm and its corresponding philosophical stance was equivalent to Gadamer’s pre-understanding.

**Table 3.2 Higgs (2001) research approach paradigm**

<table>
<thead>
<tr>
<th>Research Paradigm</th>
<th>Philosophical Stance</th>
<th>Research Goals</th>
<th>Research Approaches</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirico-analytical</td>
<td>Positivism/objectivism (Knowledge and meaning exist objectively in the world independent of human concerns, and wait to be discovered.)</td>
<td>Measure, test hypotheses, predict and control, explain generalise, identify cause and effect.</td>
<td>Scientific approach, operationalism, observation</td>
<td>Experiment, survey, sample, randomized control trial</td>
</tr>
<tr>
<td>Interpretive paradigm</td>
<td>Idealism (Knowledge and meaning are constructed by people.)</td>
<td>Understand, interpret, seek, meaning, illuminate</td>
<td>Phenomenology, hermeneutics, narrative inquiry</td>
<td>Interview, participant and non-participant observation, case study, textual review.</td>
</tr>
<tr>
<td>Critical paradigm</td>
<td>Historical realism (Social practice and culture practice)</td>
<td>Improve, empower, liberate, raise consciousness</td>
<td>Action research, collaborative research, critical hermeneutics</td>
<td>Interview, focus groups.</td>
</tr>
</tbody>
</table>

Source: Research Paradigms (derived from Higgs, 2001)

Crotty’s epistemology and theoretical perspective are generally equivalent to Higgs’s paradigm and philosophical stance. For this research the author has chosen to follow Crotty’s approach, and has adopted a constructionist view of human knowledge where by knowledge is constructed rather than discovered.

The constructionist theory leads itself to this project because and the author’s appreciation for the 'constructivist theory' for which “Meanings are constructed by human beings as they engage with the world they are interpreting” (Crotty, 1998, p 43). Therefore, according to the constructionism, “We do not create meaning. We construct meaning” (Crotty, 1998, p 43 and 44). It is this aspect of constructing meaning and the fact that there are” no true or valid interactions” (Crotty, 1998, p 44).
3.3 **Theoretical Perspective**

A brief discussion of this study’s theoretical perspective or the philosophical stance lying behind the methodology provides a context for the process involved in the research and a basis for its logic and its criteria (Crotty, 1998). It has been reported that the prevailing paradigm of disease etiology in the past was a cause-single consequence relationship (Jenicek, 1995). However, changes have occurred in our modern thinking and technology that has enabled researchers to investigate webs of causation. Jenicek (1995) reported that:

*One of the greatest challenges in understanding disease and its epidemiological approach is our ability to define, measure and understand with equal rigor all of the above mentioned categories of factors (i.e., chemical, physical, biological and social). Traditionally, physicians are most comfortable following biological factors, sociologists in studying social factors, psychologist following stressful events and so on. Obviously the etiology of disease is not a disciplinary affair and as such must be approached with a maximum of interdisciplinary understanding.*  
(Jenicek, 1995, p 27)

Jenicek’s concept of the web of causation infers an ecological perspective to disease and injury epidemiology (Cadman, 1996a; Jenicek, 1995). Like social ecology, Jenicek connects the present ecological problems to deep-seated social problems.

Various theoretical paradigms underpin alpine epidemiology research. These paradigms are typically positivism and interpretive paradigm. The epistemological stance for this research is constructionism and a constructivist believes that to understand our world of meaning one must interpret it (Ayres, 2006; Schwandt, 1998). This approach reflects recognition that meaning is constructed. According to the interpretive paradigm, the meaning people attribute to things in the world around them is not only constructed but contingent (Ayres, 2006). This means that meaning constructed depends heavily on contextual features, that is, on the particular history, place, and culture that people bring to any act of meaning-making. Perfectly valid meanings can therefore vary from person to person and change within one person according to circumstances.
Interpretivism is based on a humanistic approach compared with other theoretical paradigms and provides a basis for a wide variety of qualitative research. The paradigm has primarily developed from the works of Geertz (1973) and Becker (1797). Geertz (1973) proposed that social science research studied meaning rather than behaviour, seek understanding rather than causal laws, and reject mechanistic explanations of natural science variety in favour of interpretive explanations. The assumptions of interpretive paradigm are different from other paradigms and listed are some key interpretivist assumptions and why the interpretive paradigm compasses this project’s parameters. They include:

- Multiple constructed interpretations of reality exist. We may all live in one universe but our experiences and interpretations of the universe can be different. Vygotsky (1978) argued that our “culture provides us with an interpretive repertoire, rooted in language that shapes the way in which we make out interpretations” (Vygotsky, 1978, p 78). It is the author’s belief that as Vygotsky (1978) statement there is always more than one way to interpret information and this statement is extremely important in relation to this research. Information obtained from qualitative questionnaires more than likely are going to be interpreted differently by a second individual who has a different understanding and or background.

- The investigator and research participant are both changed by the research process. The author believes there is no question of conducting research in a totally detached manner. It can be argued that this also occurs in much positivist research, even where attempts are made to minimise the effects of researchers on the research subjects, such as double blinding that occurs in drug trials. Although there can be some minimisation of the effects the researcher brings to a project the participants and researchers must be affected in some way. In this situation the researcher in particular will be changed by the research process and its results.
Description and understanding can be more useful and interesting than attempts to establish cause and affect relationships (Kuhn and Greenfield, 1996). In this project a large amount of data will be collected. Due to the nature of the data and limited previous research in the area it may not be possible to establish a cause and affect relationships rather a description and understanding of the data.

Inquiry is always ‘value-bound’ (Kuhn and Greenfield, 1996). This reflects Kuhn and Greenfield’s (1996) notion of paradigms and their suggestion that there can be no neutral interpretations (Kuhn and Greenfield, 1996). All findings are strongly affected by the values, theories and prejudgments that researchers bring to the research process. It is the authors understanding and interpretations which will alimentally affect the findings. The authors’ values, theories and past experiences will all affect the research process. The aim of this thesis is to improve our understanding of the phenomenon of adolescents’ alpine snowsports injuries, by exploring the interpretations of participant’s demographics, injury patterns and risk-taking.

The limitations of the interpretive paradigm as reported by (Shankman, 1984) are that this theoretical perspective lacks predictability, replicability, verifiability, and law-generating capacity (Ayres, 2006). Interpretive paradigm seeks to explain the stability of behaviour from the individual's viewpoint and therefore is appropriate to use in the alpine injury context as the researchers using this paradigm is trying to observe the on-going processes to better understand individual behaviour/injury.

3.4 **Methodology**
Methodology is the philosophy underlying the procedure of data collection. There are three main research methodologies and these are

- Qualitative Methods
Examples include; Ethnography, Case Study, Grounded Theory, Autobiography, Participatory Action Research and Phenomenology (each grounded in a specific discipline and philosophical assumptions)

- Quantitative Methods
  - Examples include; Survey methods and Experiments

- Mixed Methods
  - Example includes both qualitative and quantitative methods.

A quantitative approach is one in which the investigator primarily uses post-positivist claims for developing knowledge (i.e. cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories) (Creswell, 2003), as opposed to qualitative researchers who study things in their natural settings, attempting to make sense of or interpret phenomenon in terms of the meanings people bring to them (Denzin, 2000).

A qualitative approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives (i.e. the multiple meanings of individual experiences, meanings socially and historically constructed, with an intent of developing a theory or pattern) or advocacy/participatory perspectives (i.e. political, issue-oriented, collaborative or change oriented) or both (Creswell, 2003).

In this thesis the methodology utilised is a mixed method approach. This approach is still a relatively new method in the social science realm (Creswell, 2003; Weaver, 2000). The key advantage of this approach is that it allows the researcher to consider the research problem or phenomenon from more than one perspective. It is suggested that it is a means to maximise the strengths and minimise the weakness of each set of methods employed.

Mixed method design is a design in which mixing of quantitative and qualitative approaches occurs in all stages of the study (formulation of research questions, data collection procedures and research method, and interpretation of the results to make final inferences) and or across stages of the study (e.g. qualitative questions, quantitative data).
Support for the use of mixed methods is divided and according to the fundamental principles of this approach. The researcher should use a mixture or combination of methods that has “complementary strengths and non-overlapping weakness” (Jack, 2006, p 349).

Mixed method researchers advocate that there are two complementary methods of the research rather than competing or separate approaches (Ayres, 2006; Finn, 2000). Figure 3.3 illustrates the quantitative and qualitative research methodologies that were utilised in the current thesis.

![Figure 3.3 Mixed methods model were quantitative and qualitative approaches are mixed across two stages of the research](http://www.southalabama.edu/coe/bset/johnson/lectures/lec14.htm)

The mixed-method design was chosen for two reasons: the regression-discontinuity because of its strong internal validity; and because it can parallel other non-equivalent designs in terms of validity threats.
The mixed-method approach attempts to be reflexive and more critical of the evaluation practice and, ideally, more useful and accountable to broader audiences. For example, this mixed-method approach will enable the author to explore different injuries participants have sustained using open-ended questions (qualitative data collection), and then is able to quantify the results by counting the number of times each type of injury (response) occurred (quantitative data analysis).

3.4 Methods

Questionnaire-based research techniques were used to collect both quantitative and qualitative data. This research project is divided into two components, the pilot study that was conducted in the winter season of 2006, and was followed with a revised research study that was completed in the 2007 winter season. All comments regarding the research methods build upon earlier research examined in the literature review. On completion of an extensive literature review, eight resources were utilized to assist in the creation of the questions used in both the pilot and revised study design. At the time six of the seven, excluding Zuckerman’s, were unpublished works that the author obtained through industry contacts. The resources used were:

(i) Snowsport Injury – 2006 Questionnaire, (Dickson, 2008a)
(ii) Skier/boarder Attitudes 2006, (Dickson, 2008a)
(iii) Scottish Ski and Snowboard Injury 2005 Database Study (Langran, 2007a)
(iv) Killington Clinical Data Form 2005, (Greenwald, 2008)
(v) Snowboarding Safety in Scotland 2005 Questionnaire, (Langran, 2007a)
(vi) Safety in the Snow –2006 Study, (Dickson, 2008a)
(vii) Sensation Seeking (Zuckerman, 1979, 1984).

The original questionnaire used in the pilot study was comprised of 28 separate questions covering 10 categories. After the pilot study was completed, two more questions were added to the sensation seeking table to strengthen validity. The eight categories that the questionnaire covered included:
1. Demographics
2. Previous alpine sports experience and participation frequency in alpine sports
3. Protective equipment usage, preferences and breakage
4. Perceived injuries and participants’ perception on the most common anatomical injury location in their chosen snowsport
5. Risk-taking and sensation seeking characteristics
6. Hydration and food intake
7. Event level participated in
8. Previous alpine injuries sustained.

Each of the eight areas were gathered for specific reasons and Table 3.3 illustrates why each of the eight areas were chosen.

Table 3.3 Justification for Eight Areas of Questionnaire

<table>
<thead>
<tr>
<th>Topic</th>
<th>Justification for inclusion in questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>To compare with previous research to ascertain if subjects had similar demographics</td>
</tr>
<tr>
<td>Previous alpine sports experience and participation frequency in alpine sports</td>
<td>Experience levels and participation rates have been previously found to relate to snowsport injuries but limited research had been conducted comparing this to children and adolescents</td>
</tr>
<tr>
<td>Protective equipment usage, preferences and breakage</td>
<td>To quantify protective usage among Australian adolescents to compare internationally. Preferences in terms of styles of protective equipment were collected to help manufacturers when designing equipment for target groups. Breakage was collected because author has known individuals to break up to five helmets per season and wanted to analyse this on a larger scale.</td>
</tr>
<tr>
<td>Perceived injuries and participants’ perception on the most common anatomical injury location in their chosen snowsport</td>
<td>No research that the author could find has previously asked adolescents how many injuries they thought were sustained while participating in snow sports. The researcher wanted to determine if those participating in the sport thought it had high or low injury frequencies.</td>
</tr>
<tr>
<td>Risk-taking and sensation seeking characteristics</td>
<td>Limited information was found for this topic and based on research conducted in other areas it was deemed a very suitable area to investigate. The theoretical basis for the risk-taking section was Zuckerman’s sensation seeking theory (Zuckerman, et al. 1978). Zuckerman defined sensation seeking as a willingness to take physical and social risk for the sake of varied, novel and complex sensations. The researcher believes that the risk associated with skiing and snowboarding is relevant to Zuckerman’s theory as explained in the literature review.</td>
</tr>
<tr>
<td>Hydration and food intake</td>
<td>The author failed to find information comparing hydration and food intake with</td>
</tr>
</tbody>
</table>
alpine injuries and believed it was a significant area that needed further investigation as other outdoor sports and overall daily performance has been found to correlate to energy levels, hydration and food intake.

<table>
<thead>
<tr>
<th>Level of participation</th>
<th>The researcher hypothesized that those who were better at their chosen alpine spots (i.e. those that made it through to state) would have higher risk-taking characteristics based on literature and personal experiences.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous alpine injuries sustained</td>
<td>It has been statistically proven (Langran, 2007a) that there is a correlation between previous alpine injuries and the chance of a participant re-injuring themselves.</td>
</tr>
</tbody>
</table>

The questionnaire was initially validated by testing the reliability of the data collected from the pilot study, then by running a focus group. The risk-taking questions were statically analysed and after the completion of reliability testing the researcher consulted three industry professionals. In consultation with the industry professionals and a statistician it was recommended that two more risk-taking questions be added.

The pilot study and revised study used the same set of questions in the questionnaire, although the pilot study questionnaire was divided into two separate questionnaires undertaken at the beginning and end of the winter season.

Questions were based on if
- data obtained through the questionnaire was reliable;
- the distribution method was appropriate; and
- the questionnaire was understandable by the target population and if the result of the questionnaire was reliable.

The pilot study was conducted in the New South Wales Alps in the 2006 winter season. The study was divided into two categories a pre-season and post-season questionnaire with individuals participating in both. This two part approach was aimed to pair each individual’s subject questionnaires together. Each questionnaire was anonymous but had a coding system so the pre and post season questionnaires could be matched together.

The pre season questionnaire addressed demographics, what snow sports the individuals participated in, previous alpine experiences including coaching and lessons, how many
years have they had competed in Interschools, previous snow sport injuries, protective equipment and risk-taking behaviours at the snow.

The post-season questionnaire addressed days skied and snowboarded over the season, sustained snow sport injuries, if a injury was sustained how and why, race placing in their chosen events, the participant’s hydration over each skiing day and protective equipment usage, and failure.

The pre and post-season questionnaires were distributed by postal service to 493 participations covering 52 schools in early June and late September 2006 respectively. After each mail out, follow up letters were distributed to each school followed by a courtesy reminder phone call. This postal method was found to be an inadequate way of distribution since the questionnaires had a very low return rate of 13.9% (Sample selection will be addressed in Chapter 3.5). After analysing the results, minor changes were made to the questionnaire’s structure and the two additional risk-taking questions were added.

To establish if these changes were appropriate and the questionnaire remained reliable a discussion group session of year six primary school children was conducted. The discussion group included 32 children at the lower age average of the target group. Permission was granted from the principal and class teacher before the questionnaires were distributed. The children were asked to carefully read through the questionnaire and if there were any parts they did not understand to write their concerns on a separate piece of paper. When children in the group had completed reading the questionnaire 15 minutes was spent discussing questions they had regarding the questionnaire. The group determined that the questionnaire was easy to understand for the target age population. The results of the pilot study were published in Skiing Trauma and Safety (See Appendix, Chapter 6) (Cooper, 2008).

The pilot study proved to be a valuable tool giving an insight into how to correctly word questionnaires, categorise injuries, and ask risk-taking and sensation seeking questions.
3.5 **Sample design and selection**

Sample design entails the selection of a technique to choose the survey population. In a bid to obtain a representative sample of the adolescent population participating in alpine sports all avenues were exhausted.

A major concern of this research project was to collect a representative adolescent population sample. The aim of the research was to obtain a general perspective by surveying a selected adolescent group. At the time the research was being developed it was very difficult to conduct research within a New South Wales ski resort. This was due to resort management not allowing research to be undertaken. Therefore the researcher needed to find a sample group that was reachable and known to participate in alpine sports. The participants for both the pilot study and main research project were gathered from Southern New South Wales and Australian Capital Territory year six primary school and secondary school children involved in Interschool Snowsports racing programs. This geographical area had 36 secondary schools involved, both private and public schools, with over 600 snow sport participants. Alpine Interschools children were selected as a target group because they have a governing body that has demographic details and could be accessed without being in a ski resort premises.

The Interschools Snowsports Championships are a series of competitions in seven disciplines including: Alpine - skiers are timed on a modified giant slalom course; Skiercross- skiers are timed on a slope-style course; Freestyle Moguls - skiers are scored on a bumps/jumps course; Snowboard Giant Slalom - snowboarders are timed on a modified giant slalom course; Snowboard Cross - snowboarders are timed on a slope-style course; Cross Country Freestyle - raced with skate or classic cross country skis style with a group start and Cross Country Relay - three person relay team event (Snow Sports Development Foundation, 2006).

Ski cross is a relatively new type of skiing competition and is based on the same principles as Boarder Cross. A group of four skiers start simultaneously and attempt to reach the end of the course first. The course comprises of naturally occurring terrain and artificial features like jumps, rollers, and banks (Wikipedia, 2008b). The first two
individuals to cross the finish line will advance to the next round. At the end, the final determine 1st to 4th place (Wikipedia, 2008b).

The emphasis is on fun and participation in the initial regional championship and competitors from all ability levels are encouraged to enter. As the competitions move into the State and the National events, the level of competition and the degree of difficulty increases (Snow Sports Development Foundation, 2006).

Interschools is a team-based competition for students attending the same school, although individuals can enter when insufficient competitors are not available to form a team (except for the Cross Country Relay which is a team only event). Teams and individuals compete in their school divisions which are subdivided into five divisions: Division 1, school Years 11 & 12; Division 2, Years 9 & 10; Division 3, Years 7 & 8; Division 4, Years 5 & 6; and Division 5, Year 4 and below.

Competitors can compete up a division to make a team. However, a primary school competitor cannot race in a secondary division. Females can compete in a male team (Snow Sports Development Foundation, 2006). The top three teams and individuals are awarded in each event, except the Cross Country Relay where only the teams are recognised. The top five teams and top 10 individuals from an event are considered for an invitation to the next competition round (Snow Sports Development Foundation, 2006).

Literature states there are three main methods of collecting data such that the information collected can be used to represent conclusions about the target ‘universe or total research population’. These are:

1. Collection of data from all enterprises. In this case this would mean all Interschool participants. This would be a costly and lengthy procedure due the 1459 Southern New South Wales and Australian Capital Territory Interschool participants.

2. Collection of data from a sample of participants that have been selected from the total research population. This sample is intended to be representative of the total
target population. This type of sample design is referred to as a *purposive* (or sometimes *judgmental*) sample. To be able to draw inferences regarding the total target population using this method, a number of assumptions have to be made about the representativeness of the data collected and of the reporting units. (Business Tendency Survey Handbook - Statistics Directorate, 2003).

3. Data collection from a random sample of participants. In this case no assumptions about representativeness are needed in estimating totals or averages for the total research population and, in addition, there are well known techniques for determining the precision of these estimates (Pallant, 2004).

Collection of data for the pilot study used a random sample. This design failed to yield a large enough sample size due to poor return numbers. In an effort to increase the sample size purposive data sample collection was used in the research project. It was determined that the required sample size was 305, with a confidence interval and confidence level of 95% and five respectfully.

Due to the limited response in the pilot study the researcher utilised personal contacts for distribution of questionnaires. This involved seeking out individuals that were known to have involvements or contacts within the Interschools organisation. At the time of the project the author was working part time as a ski instructor and ski sales consultant in Jindabyne which is situated at the base of the New South Wales alpine area. The company that the author worked for is one of the main cross country and alpine equipment hire shops for the Interschools participants. The author also volunteered to help during two Interschools competitions to expand personal contacts with school team manager. The following four data collection methods were used:

1. Questionnaires were given out with Interschool hires and asked if it be returned with the equipment.
2. Over the lead up to Interschools many of the participating schools rang to enquire about lessons and equipment hire. The author would enquire if the school could
participate in the questionnaire and if the response was positive information packages with consent forms and parent information forms were posted to the relevant teacher.

3. During the interschool races the researcher would travel to the accommodation lodges that the school had book into. If consent was gained from the relevant teachers/guardians questionnaires would be distributed after the evening meal and the author would collect the questionnaires when finished.

4. The author drove to local schools and spoke directly with Interschool Team manager. All Snowy Mountain local school were able to participate and the teacher distributed and collected participant’s questionnaires.

The total number of questionnaires distributed using the four above mentioned techniques was 420.

3.6 Ethical Considerations

The project was conducted with a conscious attention to all ethical principles at each stage of the research project. The research received approval by the Committee for Ethics in Human Research (CEHR) at the University of Canberra. The foremost ethical considerations of this research was voluntary participation of minors with parental or guardian informed consent, confidentiality of data gathered and participant’s anonymity. After ethics approval from the university, consent for the research project was sought from the following six levels:
1. *Department of Education (NSW & ACT).* Application to conduct research was submitted June 24th 2006 to the New South Wales Department of Education and Training, and the Australian Capital Territory Department of Education and Training. Each organisation consented to the proposed research.

2. *Individual school principals* (see Appendix, Chapter 6.1). A letter explaining the research project was posted to all schools involved requesting if they did not want their school to be involved with the research project they should contact the researcher so packages would not be sent.

3. *Australian Capital Territory and Southern New South Wales Interschools Organiser* (see Appendix, Chapter 6.4). A meeting was held in Jindabyne NSW to discuss the proposed research with the Interschools Zone Organiser. Consent was given for the research project, a list of schools participating in Interschools and number of participants was given to the researcher. A letter of support was written by the Interschools Organiser to accompany each letter to school team managers.

4. *Individual School’s Interschools Team manager* (see Appendix, Chapter 6.2). Letters addressed to Interschools Team Managers were mailed to each school participating in Interschools or personal contact was made with the team manager.

5. *Parental or guardian* (see Appendix, Chapter 6.3). Participants’ parents or guardians were given detailed information on the research project in either a letter or verbally by researcher. Informed consent had to be given from the minor’s parent or guardian before they could participate in the research. Parents were supplied with an information sheet explaining the purpose of the project and what would be required of their child. Parents were given a consent form which laid out in detail what they were agreeing to.

6. *Individual child.* If consent was obtained from all levels above, participants were informed of what was required of them to participate in the research. It was made
clear that they should not discuss their answers with other children and that every answer that they gave was anonymous. Participants were given instruction on the first page of the questionnaire clearly stating that they were not to write their name on the questionnaire, so the anonymity of the participant was assured and they are informed that they were not required to complete the survey if they did not wish too.

Confidentiality was another important principle of the research. All gathered data was kept in a secure cabinet. As the participants’ names were not recorded it was hoped that they were free to record all details and opinions without fear of being later identified in any way that may be to their disadvantage.

3.7 Data analysis

All data collected was transcribed by the researcher to maintain confidentiality and consistency of results. Data was entered into Microsoft Excel spreadsheet then transferred to Statistical Package for the Social Sciences (SPSS version 16.0) for statistical analysis. Statistical analysis was conducted for both quantitative and qualitative data. The majority of qualitative data was reduced into numeric data for the purposes of analysis. Simple statistical analysis, cross tabulations, reliability analysis, analysis of variance (ANOVA) and correlations were conducted.

A cross tabulation “displays the joint distribution of two or more variables” (Pallant, 2005, p 214). An exact Chi-square test was conducted using Monte Carlo procedure to test the statistical significance of the cross tabulation. Pallant (2005) reported that this procedure removes some of the concerns relating to too many expected cells, and the small number in one or more of the cells in each table. The Chi-square test for independence were used to determine if two variables are related (Pallant, 2005).

Reliability analysis is used to “determine the consistency of a set of measurements or measuring instruments and does not imply validity” (Pallant, 2005, p 95). This can either be if the measurements of the same instrument give (test-retest) or are likely to give the
same measurement, or in the case of more subjective instruments, whether two independent assessors give similar scores (inter-rater reliability) (Pallant, 2004).

Reliability may be estimated through a variety of methods that are split into two types: single-administration and multiple-administration. Both of these methods have been used in data analyses for the present research. Multiple-administration methods “require that two assessments are administered. In the test-retest method, reliability is estimated as the Pearson product-moment correlation coefficient between two administrations of the same measure (Pallant, 2004; The Free Dictionary, 2007).

In the “alternate forms method reliability is estimated by the Pearson product-moment correlation coefficient of two different forms of a measure, usually administered together” (The Free Dictionary, 2007 online). Single-administration methods include split-half and internal consistency. The split-half method treats the two halves of a measure as alternate forms. This halves the reliability estimate and is then stepped up to the full test length using the Spearman-Brown prediction formula. The most common internal consistency measure is Cronbach’s alpha, which is usually interpreted as the mean of all possible split-half coefficients (Pallant, 2004).

This project statistically employed analysis of variance (ANOVA). ANOVA is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables. The analysis of variance technique was developed by the statistician and geneticist R.A. Fisher in the 1920s and 1930s, and is sometimes referred to as Fisher's ANOVA or Fisher's analysis of variance. In practice, there are several types of ANOVA depending on the number of variables and what needs to be applied.

Data was analysed comparing proportions of injured and uninjured adolescents on demographic characteristics (gender and age), skiing/snowboarding ability and experience, and risk-taking and sensation seeking. The two groups are also compared with race placing, hydration levels and food intake. The study excluded sledding and
tobogganing as a mechanism for injury. Although, tobogganing and sledding are very popular in the selected sample group they are generally unregulated.

Not all accidents in alpine sports, as well as other areas of one’s life can be associated to being related to risk-taking behaviour. Like driving a car, alpine sports injuries can occur from the innocent bystander phenomena (Shealy, 1974), where the victim was passively standing still and was run into by another individual. In alpine sports, there are categories of injuries that typically occur at low speeds and are associated more with awkwardness and inexperience rather than risk-taking. In order to try and correct for this problem, data from a separate analysis included injuries resulting from high speed incidents was completed. Presumably in these cases the individuals were skiing at their outer limits of control and one could infer a degree of risk-taking on the part of the participant. Thereby the effect of non-risk-taking based accidents will be identified and diminished.

3.8 Conclusion
Information provided in this chapter explains how the researcher was able to ensure that data collection and analysis was underpinned by a reliable and valid justified research design which was thorough and rigorous. The thesis was governed by a constructionist approach to knowledge and the theoretical perspective used was interpretive paradigm. In line with these approaches, a mixture of both qualitative and quantitative methodologies involving the use of the researcher’s school snowsport connections and school organisations for the distribution of questionnaires was adopted.

In support of this research approach it should again be stated that the aim of this thesis was to obtain only a snapshot, a ‘still’ of the ‘moving picture’ of adolescent epidemiology snowsport analysis and the influences of risk-taking and sensation seeking on injury over one Australian winter season. Care should be taken in adopting or transferring the findings of this particular thesis to other countries and age brackets as individual personality characteristics and alpine attitudes may differ depending upon upbringing and geographical location in relation to the snow.
There are some restrictions to the research paradigm. Alpine participants as a whole are better educated, younger and more athletically inclined than the Australian or international population at large. This must also be taken into account when generalising from this population to others.
CHAPTER FOUR: RESULTS

This chapter presents the results of the research project and subsequent data analysis. The preceding chapters have directed the reader towards a clear understanding of the issues, the methodology, research questions and the particular methods employed in obtaining reliable and replicable data. The author required a sample size (return rate) of 305 to obtain a confidence interval and confidence level of 95% and five respectively. There were 345 questionnaires returned and analysed, which represents a return rate of 82.1%. The results, data analyses and discussion have been divided into nine categories. The following is a list of the categories that will be addressed individually in this chapter:

1. Demographics
2. Previous alpine sports experience and participation frequency in alpine sports
3. Protective equipment usage, preferences and breakage
4. Perceived injuries and participants’ perception on the most common anatomical injury location in their chosen snowsport
5. Risk-taking and sensation seeking characteristics
6. Hydration and food intake
7. Level of participation
8. Previous alpine injuries sustained
9. The relationship between injuries sustained and the previous eight categories.

A preliminary analysis of all the data was performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity (Pallant, 2004).
4.1 Demographics

An important first step in understanding the cause of and distribution of injuries in alpine sports is to better understand the population at risk and how they are participating. The researcher believes that the data collected was a good representation of the total Interschool participants based on a comparison of Interschools entries and questionnaire results as it represented approximately 30% of the total Southern Interschool participants. There were 420 questionnaires distributed with a return rate of 82.1%. Interschool entries recorded for the 2007 racing season indicated that 45.0% of participants were female, 55.0% male. In the representative sample group collected from the questionnaire, 46.1% were female and 53.9% male.

There were 345 school children from private and public schools across New South Wales and the Australian Capital Territory that participated in the research questionnaire. There were 186 males (53.9%) and 159 females (46.1%). Participants ranged in age from seven to 18 years (see Table 4.1). Four participants (two male and two females) were removed from the data analysis because their age was greater than three standard deviations away from the mean. The removal of outliers is in order to try and achieve a normal distribution, which is the most commonly observed probability distribution (Kummailil, and Katie, date unknown). In the simplest of cases, this is achieved by computing the mean and the standard deviation using all the data points and rejecting any that are over three standard deviations away from the mean (Kummailil, Unknown). After the removal of the four youngest participants, data was analysed from 341 individuals aged 10 to 18 ($M = 14.29, SD = 1.622$) (Table 4.1). All participants were involved in the Alpine Interschools racing program, with 23 individuals (6.7%) training with their schools racing teams without participating in the 2007 racing session. Approximately three quarters of participants were 15 years and under, with 8.8% 16 years and over.
Table 4.1 Distribution of age frequency amongst participants

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>11</td>
<td>16</td>
<td>4.7</td>
<td>5.0</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>8.8</td>
<td>13.8</td>
</tr>
<tr>
<td>13</td>
<td>63</td>
<td>18.5</td>
<td>32.3</td>
</tr>
<tr>
<td>14</td>
<td><strong>75</strong></td>
<td><strong>22.0</strong></td>
<td><strong>54.3</strong></td>
</tr>
<tr>
<td>15</td>
<td>69</td>
<td>20.2</td>
<td>74.5</td>
</tr>
<tr>
<td>16</td>
<td>57</td>
<td>16.7</td>
<td>91.2</td>
</tr>
<tr>
<td>17</td>
<td>28</td>
<td>8.2</td>
<td>99.4</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>0.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>341</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

As previously reported the New South Wales and Australian Capital Territory, Alpine Interschools divisions are categorised into five racing divisions.

The participants’ racing division was recorded (Table 4.2) with over half (57.5%) of participants competing in division two, 18.8%, 38.7%, 31.7% and 10.9% were in divisions one, two, three and four respectively. The spread of divisions and sport types collected from the questionnaire followed a very similar trend, but the research project excluded division five because their age was outside the projects human ethics approval.
Table 4.2 Division breakdown

<table>
<thead>
<tr>
<th>Age Division (School Years)</th>
<th>Interschools recorded entries breakdown as a %</th>
<th>Research projects’ numbers as a %</th>
</tr>
</thead>
<tbody>
<tr>
<td>One (11 &amp; 12)</td>
<td>22%</td>
<td>18.8%</td>
</tr>
<tr>
<td>Two (9 &amp; 10)</td>
<td>28%</td>
<td>38.7%</td>
</tr>
<tr>
<td>Three (7 &amp; 8)</td>
<td>18%</td>
<td>31.7%</td>
</tr>
<tr>
<td>Four (5 &amp; 6)</td>
<td>17%</td>
<td>10.9%</td>
</tr>
<tr>
<td>Five (4 &amp; under)</td>
<td>15%</td>
<td>Not included</td>
</tr>
</tbody>
</table>

Comparisons between entries and data collected from the questionnaire were also made for age divisions and snow sport types. The following two tables compare Interschool 2007 entries percentages with the 2007 research projects displayed as percentages.

Table 4.3 Alpine Sports Equipment Types

<table>
<thead>
<tr>
<th>Event</th>
<th>Interschools Entries 2007</th>
<th>Research projects’ numbers as a % in 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine G.S</td>
<td>33%</td>
<td>25.1%</td>
</tr>
<tr>
<td>Snowboard G.S</td>
<td>11%</td>
<td>13.7%</td>
</tr>
<tr>
<td>Boarder Cross</td>
<td>11%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Skiers Cross</td>
<td>29%</td>
<td>23.2%</td>
</tr>
<tr>
<td>Moguls</td>
<td>9%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Cross Country</td>
<td>7%</td>
<td>16.3%</td>
</tr>
</tbody>
</table>

Figure 4.1 displays a comparison of distributions between the interschool entries and the studies alpine sports selection sample.
Postcodes were collected to gain an understanding of the distribution of the participants’ permanent residence. There were 70 different postcodes recorded and the most frequent (with 10 or more participants residing in the area) are recorded in Table 4.4. The table also shows the number of injuries per postal location with the mean number of injuries per participant from that location. There is a difference in the average number of injuries per person from different locations, Spit Junction and Mosman in Inner Sydney had higher averages than the other locations.
Table 4.4 Postcode and Locations of the most frequent permanent residence

<table>
<thead>
<tr>
<th>Postcode</th>
<th>Location/s</th>
<th>Region</th>
<th>Number of participants from location</th>
<th>Percentage of total (n=342)</th>
<th>Number of injuries per location and average number of injuries per participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>2627</td>
<td>Crackenback, East Jindabyne, Kalkite, Jindabyne, Grosses Plain, Hill Top, Snowy Mountains NSW</td>
<td>Snowy Mountains NSW</td>
<td>91</td>
<td>26.6% (n=37)</td>
<td>0.4</td>
</tr>
<tr>
<td>2088</td>
<td>Spit Junction, Mosman, Inner Sydney NSW</td>
<td>Inner Sydney NSW</td>
<td>25</td>
<td>7.3% (n=25)</td>
<td>1</td>
</tr>
<tr>
<td>2628</td>
<td>Nimmo, Dalgety, Beloka, Numbla Vale, Berridale, Eucumbene, Snowy Mountains NSW</td>
<td>Snowy Mountains NSW</td>
<td>16</td>
<td>4.7% (n=3)</td>
<td>0.2</td>
</tr>
<tr>
<td>2023</td>
<td>Bellevue Hill, Inner Sydney NSW</td>
<td>Inner Sydney NSW</td>
<td>10</td>
<td>2.9% (n=6)</td>
<td>0.6</td>
</tr>
<tr>
<td>2090</td>
<td>Cremorne, Inner Sydney NSW</td>
<td>Inner Sydney NSW</td>
<td>10</td>
<td>2.9% (n=4)</td>
<td>0.4</td>
</tr>
<tr>
<td>2603</td>
<td>Manuka Red Hill Griffith Forrest</td>
<td>ACT</td>
<td>10</td>
<td>2.9% (n=5)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Further examination of the postcodes reveals that one third of participants resided in New South Wales Snowy Mountains (n = 107), half of the participants (n =171) came from inner Sydney and the remaining (n = 64) selection of participants came from Canberra and other locations.

Participants were asked what snowsports they were competing and training in for the 2007 winter racing season. Answers could include more than one snow sport, as it is typical for individuals to participate in a number of different events (Table 4.5).
Table 4.5 displays the number of participants competing in the different events offered by Interschools. Approximately one quarter (25.4%) of the events competed in were for snowboarding events (boarder cross and snowboard G.S), more than half (58.3%) participated in downhill skiing events (alpine G.S, moguls and skier cross) and the remaining 16.3% participated in cross country events.

There were 77 participants who only competed in one event with the remaining competing in two or more events. There were 22 participants training with their school teams in three different disciplines without competing. Of those, 15 were training for skiing, seven training for snowboarding events and one individual training in cross-country.

Included in the demographics section of the questionnaire was a question related to the participants’ dominant hand. This data was collected because it has been reported in
numerous snowboarding literature that an individual’s dominant hand may have a relationship with snowboarding injuries involving the upper extremities, predominately wrist and or hand injuries (Bladin et al, 2004). Over half of the participants were right-hand dominant (65.1%), left-hand dominant accounted for a little over a quarter of the participants (n = 93, 27.3%) and ambidextrous accounted for the remaining 7.6%. The relationship of their dominate hand and injury will be discussed later in section six.

4.2 Previous experience and participation in alpine sports
Participants were asked seven questions in relation their previous experiences in alpine sports including:
1. How many seasons have they skied/snowboarded (including this season)?
2. Who did they ski the most with?
3. How much skiing/snowboarding have you done in total (number of days estimated)?
4. Have they ever had professional lessons in their preferred sport and if yes, how many professional lessons have they had?
5. How many years have they been competing in Interschool (including this year)?
6. What events do they participate in for Interschools?
7. Have they every tried any other of these snow sports?

The data from the Interschools questionnaire relating to previous experiences was collected using seven separate questions investigating the number of seasons and the amount of time individuals spent skiing or snowboarding. The number of seasons an individual had participated in alpine sports and raced with Interschools was recorded. A season could include a winter in the southern or northern hemisphere, with some participants skiing/snowboarding in both in a year (counted as two seasons).

The number of seasons ranged from one (2007 being the first season the individual had participated in alpine sports) to 22. It appears that 22 is a large number for participants under the age 18 and one would expect that these individuals have participated regularly in the Northern Hemisphere. The average number of seasons skied/snowboarded was 7.6 with a standard deviation of 4.0. The number of years participants had competed in
Interschool racing ranged from one year to 11 years, with an average of 3.3 years (standard deviation of 2.3).

Although the number of seasons a participant had skied or snowboarded is relevant, probably more critical is the number of days the individual has participated in alpine sports. For example, an individual could have skied one day a year for nine seasons (total of nine days skiing) compared with another individual who has only skied two seasons but skied for six weeks each season (total of 84 days). With this in mind, participants were asked to estimate the number of days that they had participated in alpine sports; the style of answer allowed participants to choose one of six answers: less than six days, seven to 13 days, 14 to 27 days, 28 to 40 days and more than eight weeks (Figure 5.2). Almost 70% (n = 237) of participants reported that they have skied or snowboarded for more than eight weeks (56 days or more). There were 3.8% (n = 13) and 3.2% (n = 11) participants who reported to have skied less than six and 13 days respectively.

*Figure 4.2 Estimated number of days participating in snowsports.*
An estimation of the total number days skied/snowboarded for participants was undertaken. This was achieved by multiplying the minimum participation days reported (i.e. 1 (n = 13), 7 (n = 11), 14 (n = 31), 28 (n = 26), 41 (n = 23), and 56 (n = 237)), with the number of participants in each group. For the 341 participants the minimum days skied/snowboarded was 15,467. The maximum number of days cannot be calculated as accurately because of the open ended answer option of more than eight weeks. But to provide evidence of how the injuries per 1,000 skier/boarder days can vary the estimated maximum number of days ski/snowboarded was calculated to be 23,294 (6 (n = 13), 14 (n = 11), 28 (n = 31), 41 (n = 26), 56 (n = 23), and 84 (n = 237)). Both numbers (15,467 and 23,294) will be used later to make estimated injuries per 1,000 skier/boarder days.

Participants were asked who they skied or snowboarded with the majority of the time. The majority of the participants reported to have skied or snowboarded mostly with their friends (47.1%, n = 161), followed by their family (39.9%, n = 136). Other results included skiing or snowboarding with a team (9.1%, n = 31), alone (1.2%, n = 4), school (0.9%, n = 3), instructor (0.3%, n = 1) and unexplained other (1.5%, n = 5).

Participants were asked if they had ever had professional lessons and 309 (90.6%) individuals reported that they had received professional lessons from a qualified instructor and the remaining 32 reported to have not had a professional lesson (9.4%). Of those who had professional lessons, they were asked if they had received one to five lessons (n=58, 17.0%), six to 10 (n=38, 11.1%), or more than 10 (n=214, 62.8%). Therefore it is evident that the majority of individuals who had professional lessons had received more than 10.

### 4.3 Protective equipment usage, preferences and breakage

Participants were asked the following three questions in relation to protective equipment usage:

1. If they wore a helmet while participating in alpine activities and if so how frequently they wore it and if not why not.
2. Other forms of protective equipment they utilised.

3. Snowboarders were asked preferences related to wrist guard styles.

There were 21 participants who only competed or trained in cross-country skiing and these individuals were removed from the helmet analysis because it is generally accepted that this type of protective equipment is not necessary for cross country and the Interschools snowsports rules do not state it is compulsory. Of 320 participants who competed or trained in events other than cross-country only four (1.25%) reported that they do not wear a helmet while skiing or snowboarding. Therefore an overwhelming majority of participants (98.8% (n=316)) reported to wear a helmet at some stage in their alpine sports participation. The majority (84.4%) reported that they used a helmet all the time while participating in alpine sports, approximately 5.0% reported only wearing their helmet while racing, 2.1% while racing and training and the remaining, 5.6% reported that they sometimes where their helmet and 2.6% indicated that they never wear a helmet.

The 43 participants (12.6%) who reported that they did not wear a helmet all the time whilst participating in alpine sports were asked why they did not do so. Answers included, in order of frequency: do not see the need (n = 13, 30.2%); do not like the look (n = 10, 23.3%); combination of the first and second reason (n = 7, 16.3%); uncomfortable to wear (n= 5, 11.6%); other unexplained reasons (n= 4, 9.3%); cannot get a hold of one when needed (n= 2, 4.6%); and too expensive (n = 1 2.3%).

Seven other forms of protective equipment were recorded as being used by 82 (24.1%) participants. The most popular protective equipment second to helmets was wrist guards/protector. There were 53 individuals who reported using wrist guards in downhill skiing, snowboarding, and cross-county. It was unknown why participants would have been wearing wrist guards in a cross-country race. This is not a typical occurrence. The number of individuals using wrist guards was 39 and 14 for snowboarding and skiing respectively.

There were 17 reported using a back protector in downhill skiing and snowboarding. There were 19 participants who reported using crash pants and eight used knee braces.
Other forms of protective equipment reported by single individuals included pole guards, shin pads and chin guards.

Snowboarders were asked what their preferences were in relation to wearing wrist guards. Manufacturers currently design wrist guards that fit inside individual’s gloves or over the top (outside) of the glove. There were 130 participants who answered this question and 88.8 % (n=115) preferred the guard to be on the inside of the glove.

Equipment failure was also recorded, with 125 pieces of equipment being reported to have broken or failed. There was no distinction made between an item breaking or failing it was considered the same thing for the purpose of this study. The pieces of equipment that were reported to fail the most were helmets (82), wrist guards (11), stocks (12) and bindings (7). Table 4.6 outlines the findings for equipment failure.

**Table 4.6 Equipment Breakage**

<table>
<thead>
<tr>
<th>Number of Reported Equipment Failures</th>
<th>Reported Occurrences</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helmet</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>Back Brace</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Wrist Guard</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Stock</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Binding</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ski</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Back Brace</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Snowboard</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Goggles</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

**Participant’s with equipment failure risk taking scores will be compared later in this chapter.**
4.4 Perceived injury rates and perception on the most common injury for their chosen snowsport

Participants were asked to assume 1,000 people were participating in their preferred snowsport on the slopes in one day. They were then asked to estimate how many people they thought would injure themselves in that one day. This style of reporting on the frequency of injuries is typically expressed as injuries per 1,000 skier/snowboarder days. Three individuals did not answer this question. Of those that did answer 31.4% (n = 106) believed that there were more likely to be 20 injuries per 1,000 skier/snowboarder days, which represents a significantly higher proportion than actually occurs. Table 4.7 displays participants’ perceived injury rates per 1,000 skiers/snowboarders days. There were 79 individuals (23.4%) that estimated the correct number of injuries per 1,000 skiers/snowboarders days that is generally reported in alpine epidemiology literature.

Table 4.7 Participant’s estimation of the number of injuries sustained per thousand skier/boarder days cross tabulated with their experience level in number of participation days

<table>
<thead>
<tr>
<th>Experience level</th>
<th>Estimation of how many people injured per 1,000 skier/boarder days</th>
<th>Total</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than 1</td>
<td>1-5</td>
<td>6-10</td>
</tr>
<tr>
<td>Under 6 days</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>7-13 days</td>
<td>0</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>14-27 days</td>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>28-40 days</td>
<td>1</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>41 days -8 weeks</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>More than 8 weeks</td>
<td>7</td>
<td>52</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>79</td>
<td>50</td>
</tr>
<tr>
<td>Total %</td>
<td>2.6%</td>
<td>23.4%</td>
<td>14.8%</td>
</tr>
</tbody>
</table>

Table 4.7 provides evidence that the majority of those who were more experienced estimated that there would be more injuries per 1,000 skier/boarder days than there
Table 4.8 displays participants’ perceived injury rates per 1,000 skiers/snowboarders days in each of their chosen (first) snowsports.

Table 4.8 Participant’s estimation of the number of injuries sustained per thousand skier/boarder days

<table>
<thead>
<tr>
<th>Sport</th>
<th>Less than 1</th>
<th>1-5</th>
<th>6-10</th>
<th>11-15</th>
<th>16-20</th>
<th>More than 20</th>
<th>Total</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine Skiing</td>
<td>6</td>
<td>48</td>
<td>28</td>
<td>38</td>
<td>25</td>
<td>75</td>
<td>220</td>
<td>65.1%</td>
</tr>
<tr>
<td>Snowboarding</td>
<td>0</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>8</td>
<td>29</td>
<td>87</td>
<td>25.7%</td>
</tr>
<tr>
<td>Cross-Country</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>25</td>
<td>7.4%</td>
</tr>
<tr>
<td>Moguls or SX</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1.8%</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>79</td>
<td>50</td>
<td>58</td>
<td>36</td>
<td>106</td>
<td>338</td>
<td></td>
</tr>
<tr>
<td>Total %</td>
<td>2.6%</td>
<td>23.4%</td>
<td>14.8%</td>
<td>17.2%</td>
<td>10.6%</td>
<td>31.4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Participants were asked to indicate what they believed was the most common area of the body injured for their chosen snowsport. They were asked to only choose one anatomical area. Figure 4.3 displays the results. For alpine skiing knee injuries were believed the most injured area, for snowboarding wrists and cross-country, skier cross and moguls knee injuries predicted to be the most frequently injured anatomical location.
Figure 4.3. Perception of injuries according to anatomical location expressed as a percentage

4.5 Risk-taking and sensation seeking characteristics

Risk taking and sensation seeking were measured using 18 questions presented in two tables. Questions were related to how often participants partook in risky activities or events. The participants could choose an answer from a five point likert scale. In the first table the scales were labelled: I don’t do this (1), very risky (2), fairly risky (3), slight risk (4) and I do this but there is no risk (5). In the second table the scales were labelled: never (1), rarely (2), sometimes (3), often (4), and always (5).
Participants’ scores were calculated by obtaining their mean score from the results of the 18 questions. The score was then called the risk-taking characteristics score. The highest risk-taking characteristics score was five and the lowest was one. Three individuals failed to answer the risk taking scores and were omitted from the analysis. A reliability analysis was carried out to determine if the participants’ results of risk taking were consistent over the 18 questions. Cronbach’s alpha demonstrated a reliability of 0.777. Values above 0.7 are considered acceptable; however values above 0.8 are preferable (Pallant, 2004). Figure 4.4 represents the spread of participants’ risk-taking characteristic scale. For the 338 participants the normal distribution is illustrated as a bell curve. The mean risk-taking characteristics score was 3.05 (SD = 0.499).

**Figure 4.4 Risk-taking Characteristics Scale**
Risk-taking scores were analysed against those participants who had equipment failure. There was a small significant correlation between equipment failure and risk taking ($r = 0.19$, $p=0.01$) (two-tailed).

An independent-sample t-test was conducted to compare the risk-taking characteristic total score between males and females. There was no significant difference in score for males ($M = 3.07$, $SD = 0.51$) and females ($M = 3.02$, $SD = 0.49$); $t (336) = 0.89$, $p = 0.37$ (two-tailed). The magnitude of the differences in mean score was less than 0.05.

Two person correlations were carried out to test the relationship between risk-taking scores and (1) first chosen snow sport, (2) age.

There was no relationship between participants first snowsport and risk-taking scores; $r = -0.048$, $n = 338$. However, there was a significant relationship between age and risk-taking characteristics using Spearman’s rho. There was a strong positive relationship between the two variables $rho = 0.334$, $n = 338$, $p = 0.01$ (two-tailed). This indicated that the older a participant was the more likely they were to have a higher risk-taking score. Figure 4.5 illustrates that as age increases so does their perception of risk-taking. The diagonal line indicates that there is a linear relationship between the two variables.
4.6 Hydration and food intake

Participants were asked five questions relating to the amount of food and water they consumed over the period of a day while participating in alpine sports. It is believed and reported through literature that there may be a relationship between dehydration, low energy levels and injury.

The five questions included:
1. Do they use a camel pack or carry a drink bottle while free skiing/snowboarding?
2. When they are skiing/snowboarding how often do they stop for a drink?
3. How many cups of water do they think they should drink a day while skiing/snowboarding?
4. How many cups of water do you drink at day while skiing/snowboarding?
5. When you are skiing/snowboarding how often do you stop for a snack or meal?

A more recent addition to alpine equipment is a ‘camel pack’ which is a portable drink bottle in the form of a backpack that can hold between one and four litres. The researcher believed that these may be becoming more prevalent and wanted to quantify their usage so that this data can then be used for comparison in future research. Results from the question asking if participants wore a camel pack while participating in snowsports indicated that 22.9% (n = 78) of participants used camel packs, with one individual failing to answer this question.

Two questions were asked regarding how often participants stopped to drink and eat each day while skiing or snowboarding. There were four different answers to choose from: every hour, every two hours, once a day or never. Six participants failed to answer this question and were removed from analysis. Figure 4.9 illustrates the number of participants that stopped to eat and drink during the day. Fewer than half the participants (n = 149, 44.5%) reported stopping once a day for a drink, 133 (39.7%) reported stopping every hour to drink, 35 (10.4%) every hour and 18 (5.4%) not at all during the day. Similar results were found in relation to the frequency participants stopped to eat (n = 334). In order of frequency; once a day (n = 193, 57.8%), ever two hours (n = 123, 36.8%), every hour (n = 15, 4.5%) and never (n = 3, 0.9%).

Participants were asked to estimate how many cups of water they consumed during the day skiing or snowboarding and how many they thought they should be drinking (n = 333). In all cases participants reported that they drank less than the amount that they believed they should be drinking. Overall 51 participants reported drinking one litre or less, 140 reported drinking between one and two litres per day, 120 participants to reported drink between two and three litres, with the remaining 21 participants reported to drink more than three litres per day. Figure 4.6 demonstrates how much participants...
reported to drink per day (blue) and how much they thought they should be drinking per day (red) whilst participating in alpine sports. The mean number of drinks participants reported to drink was 4.11, whilst the mean that they thought they should be drinking was 7.5 cups per day.

**Figure 4.6 Frequency of stopping to eat and rehydrate**

Participants were asked how often they stopped for a snack or something to eat. Seven participants failed to answer this question. Approximately 58.0% of the participants reported to only stopping once a day for something to eat, 36.5% reported that they stopped every two hours, approximately 5.5% reported they stopped every hour and less than one percent reported that they never stopped to eat something during the day while skiing or snowboarding.
4.7  Level of Participation and Event Level

Event level information was collected for regional, state and the Australian championships. Participants were asked to complete a table providing information at what levels they had completed as an individual. The highest event level that each participated competed in was recorded. To begin with all participants compete at zone level, and then could progress through the different levels if they gained a place, typically the first five competitors moved onto the next division. There were 161 participants that reported that they had only ever competed in zone level, while 175 participants had competed in regional Interschools, accounting for just over half the participants (51.2%), with 130 individuals going on to compete at a state level (38.1%) and 77 (25.5%) of these individuals competed in the Australian championships.

Figure 4.7  Level participants competed in
4.8 Previous Injuries

The data from the 2007 Interschools questionnaire provided important evidence that supports the research questions outlined in the introduction of the thesis. Of the 341 participants, 90 suffered self reported injuries prior to the 2007 winter season that needed medical treatment. Females had a previous injury rate of 27.3% (n=43), while the injury rate for males was 25.5% (n=57). An injury was defined as an incident requiring medical treatment. Table 4.9 displays the distribution of injured mean for the 90 participates.

Table 4.9 Previous Injuries prior to the 2007 winter season

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>6</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Knee</td>
<td>17</td>
<td>14</td>
<td>31</td>
</tr>
<tr>
<td>Shin</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Fracture Wrist</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Hip</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Thumb</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Shoulder</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Hand</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lower Leg</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Back</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Broken Collar bone</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ankle</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Hamstring and toe</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cracked Ribs</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Stitches (unknown where)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Shoulder Reconstruction</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Knee, Hip and Wrist</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Elbow Dislocation</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Knee and Neck</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Knee and Back</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fractured Tail Bone</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Compression Fracture to Skull</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fractured Arm</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>47</td>
<td>43</td>
<td>90</td>
</tr>
</tbody>
</table>

Males had a slightly higher frequency of injuries than females, but there was no significant differences between the two groups (p<0.05). Approximately one in four participants had sustained a previous alpine injury.
After examination of previous injuries sustained, alpine injuries were analysed (see Table 4.10. The data on adolescent injuries allowed an examination of the patterns of injury generalised by different demographics or injury anatomical locations. There were 68 males who sustained an injury and 47 females. Of those injuries there were a total of 208 injuries.

**Table 4.10 Alpine Injuries**

<table>
<thead>
<tr>
<th>Number of injuries</th>
<th>Males injured</th>
<th>Females injured</th>
<th>Total Number of Injuries</th>
<th>Total Number of Injuries%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46</td>
<td>28</td>
<td>74</td>
<td>35.6%</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>10</td>
<td>44</td>
<td>21.2%</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>6</td>
<td>27</td>
<td>12.9%</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>2</td>
<td>20</td>
<td>9.6%</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1</td>
<td>15</td>
<td>7.2%</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>3.4%</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>10</td>
<td>4.8%</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>1</td>
<td>11</td>
<td>5.3%</td>
</tr>
<tr>
<td><strong>Total Injuries</strong></td>
<td><strong>68</strong></td>
<td><strong>47</strong></td>
<td><strong>208</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.11 displays the number of injuries by body region, in descending order of frequency and then anatomical location injury/type. Three participants reported suffering two injuries of different anatomical location therefore there is a total of 211 from 208 incidents. In some cases the participant described the nature of the injury (example: fractured wrist) while other participants only gave the area injured (example: hand). When the nature of the injury was known it was recorded as the participant had described. When the nature of the injury was not given the anatomical area injured was only recorded. The upper body suffered the most injuries at 53.6% (n = 113), while the mid section, including breathing difficulties, accounted for 10.4% (n = 22). The lower body accounted for the remaining 36 % (n = 76) of injuries.
Table 4.11  Anatomical injury distribution and frequency

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Anatomical Location</th>
<th>Frequency</th>
<th>Subtotal percent</th>
<th>Total percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Body</strong></td>
<td>Head</td>
<td>18</td>
<td>15.9</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>Neck</td>
<td>7</td>
<td>6.2</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Knocked unconscious</td>
<td>3</td>
<td>2.7</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Fracture check bone</td>
<td>2</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Face laceration</td>
<td>2</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Upper Extremity</strong></td>
<td>Fractured wrist</td>
<td>31</td>
<td>27.4</td>
<td>14.7</td>
</tr>
<tr>
<td></td>
<td>Shoulder dislocation</td>
<td>21</td>
<td>18.6</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Fractured humerus</td>
<td>10</td>
<td>8.9</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>Thumb injury</td>
<td>10</td>
<td>8.9</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>Elbow fracture or dislocation</td>
<td>5</td>
<td>4.4</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>Hand injury</td>
<td>3</td>
<td>2.7</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Fractured collar bone</td>
<td>1</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Middle Body</strong></td>
<td>Back</td>
<td>14</td>
<td>63.6</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>Fractured ribs</td>
<td>4</td>
<td>18.2</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>Breathing difficulties</td>
<td>4</td>
<td>18.2</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Lower Body</strong></td>
<td>Fractured pelvis</td>
<td>2</td>
<td>2.6</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Fractured tail bone</td>
<td>1</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Hip</td>
<td>1</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Lower Extremity</strong></td>
<td>Knee injury</td>
<td>45</td>
<td>59.2</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td>Lower leg</td>
<td>9</td>
<td>11.8</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Thigh muscle strain</td>
<td>9</td>
<td>11.8</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Ankle / Foot</td>
<td>6</td>
<td>7.9</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>Heal</td>
<td>2</td>
<td>2.6</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Fractured femur</td>
<td>1</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>211</td>
<td></td>
</tr>
</tbody>
</table>

The most common area injured was the knee, accounting for approximately 21.3% of all injuries, followed by fractured wrist, which made up 14.7% of injuries. The third most
common area injured was the head (including two fractured cheek bones, and two face lacerations), with 22 injuries that accounted for 10.4% of all injuries.

There were gender differences in the anatomical areas injured. Males sustained more head and face injuries, had a greater frequency of fractured wrists and untypically had a significantly higher proportion of knee injuries than females (66.7%) (p<0.05). Females sustained more shoulder dislocations (52.4%) and fractured humorous (arm) than males with a significantly higher frequency of thigh muscle injuries (88.9%) than males (p<0.05) (see Figure 4.8). Females sustained 100.0% of breathing difficulties. Males had a slightly higher frequency of injuries than females, but there was no significant differences between the two (p<0.05). There was an average of 0.61 injuries per person or broken down my gender males had an average 0.63 injuries and females an average of 0.57.

*Figure 4.8  Gender and Nature of Anatomical Areas injured*
Of the 208 accidents causing injury, 195 cases were reported on in more detail by the participant completing the table. Of these, 65.1% were injured while alpine skiing (n = 127), 27.7% while snowboarding (n = 54), 1.0% while cross-country skiing (n = 2) and the remaining 6.2% through other forms of alpine sports (n = 12). Figure 4.9 displays the area injured broken down by snow sport activities. The majority (63.6%, n = 124) of the injuries occurred while free-skiing/snowboarding while 17.9% (n = 35) and 18.5% (n = 36) occurred while racing and training respectively.

**Figure 4.9 Anatomical Injury Locations of different Snow Sport Types**

Table 4.12, Figures 4.10 and 4.11 display the number of injuries for alpine skiing and snowboarding. Alpine skiing knees (53.7%) were the most common anatomical site injured and wrist for snowboarding (60.9%).
Table 4.12 Anatomical injury location for Alpine Skiing and Snowboarding.

<table>
<thead>
<tr>
<th>Anatomical Location</th>
<th>Alpine Skiing injuries (n)</th>
<th>Alpine Skiing injuries (%)</th>
<th>Snowboarding injuries (n)</th>
<th>Snowboarding injuries (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>4</td>
<td>1.9</td>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>Face</td>
<td>3</td>
<td>1.4</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Neck</td>
<td>5</td>
<td>2.3</td>
<td>3</td>
<td>3.4</td>
</tr>
<tr>
<td>Back</td>
<td>11</td>
<td>5.1</td>
<td>4</td>
<td>4.6</td>
</tr>
<tr>
<td>Shoulder</td>
<td>12</td>
<td>5.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Elbow</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wrist</td>
<td>33</td>
<td>15.4</td>
<td>53</td>
<td>60.9</td>
</tr>
<tr>
<td>Hand</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thumb</td>
<td>7</td>
<td>3.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Finger</td>
<td>5</td>
<td>2.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thigh</td>
<td>4</td>
<td>1.9</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Knee</td>
<td>115</td>
<td>53.7</td>
<td>11</td>
<td>12.6</td>
</tr>
<tr>
<td>Ankle</td>
<td>3</td>
<td>1.4</td>
<td>3</td>
<td>3.4</td>
</tr>
<tr>
<td>Foot</td>
<td>2</td>
<td>0.9</td>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>Bottom</td>
<td>2</td>
<td>0.9</td>
<td>4</td>
<td>4.6</td>
</tr>
<tr>
<td>Hip</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arm</td>
<td>3</td>
<td>1.4</td>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>Leg</td>
<td>2</td>
<td>0.9</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>214</td>
<td>100</td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>
Figure 4.10 Alpine Skiing Anatomical Injury Locations
Participants were asked to record whom they were with when their injury occurred. About 40.0% (n = 78) of respondents indicating that injuries were sustained while skiing/snowboarding with friends, 26.2% (n = 51) occurred while with a coach or professional trainer, 21.5% (n = 42) with family, 11.8% (n = 23) when alone and the remaining 0.5% (n = 1) was recorded as other.
Table 4.13  Social context when participant injured

<table>
<thead>
<tr>
<th>Social context when injured</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skiing/boarding with friends</td>
<td>78</td>
<td>40.0%</td>
</tr>
<tr>
<td>Skiing/boarding coach</td>
<td>51</td>
<td>26.2%</td>
</tr>
<tr>
<td>Skiing/boarding family</td>
<td>42</td>
<td>21.5%</td>
</tr>
<tr>
<td>Skiing/boarding alone</td>
<td>23</td>
<td>11.8%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>0.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>195</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

When comparing who participants skied or snowboarded most with and if they had ever sustained an alpine injury there was a significant differences using Pearson Correlation at 0.05 (2-tailed), \( r = -0.112 \) \( (n = 340) \). The participants who skied with their family were significantly less likely to sustain an alpine injury than others. This correlation is significant at the 0.05 level (2-tailed).

Figure 4.12 Who participants were skiing/snowboarding with and if any injury occurred as a percentage
A cross tabulation of injury activity and social setting showed that 90.7% of injuries while skiing with friends were obtained when free skiing. Table 4.14 demonstrates the results of the cross tabulation.

**Table 4.14  A cross tabulation between social setting when participant was injured**

<table>
<thead>
<tr>
<th></th>
<th>Racing n=35</th>
<th>Training n=36</th>
<th>Free Skiing n=124</th>
<th>Total N=195</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alone</td>
<td>46.6%</td>
<td>53.4%</td>
<td>93.0%</td>
<td>23</td>
</tr>
<tr>
<td>With Friends</td>
<td>7.0%</td>
<td>2.3%</td>
<td>90.7%</td>
<td>78</td>
</tr>
<tr>
<td>With Family</td>
<td>8.4%</td>
<td>11.5%</td>
<td>80.1%</td>
<td>42</td>
</tr>
<tr>
<td>Training/Coach</td>
<td>19.3%</td>
<td>45.2%</td>
<td>35.5%</td>
<td>51</td>
</tr>
</tbody>
</table>

To obtain an understanding of the range of severity of injuries and who treated the injury, injured participants were asked who treated them. They could write more than one treating party, as frequently the ski patrol may pick up an injured participant and if the injury required further medical assistance the injured person would then be taken to the doctor at the resort. Following this if the injury is severe they may be flown or taken by ambulance to a bigger hospital.

The ski patrol treated the most number of injured participants (31.4%), followed by a doctor in a medical centre rather than a hospital. The ski patrol treated 43.1% of the first service, while a doctor not in a hospital treated 42.9% of the second service and physiotherapist treated 36.6% of the third treating services (see Table 4.15). These results are expected as the ski patrol commonly is the first to the injured. They then provide immediate care and transport the victim to the resort doctor, who treats the injury and typically if a musculoskeletal injury refers the victim to commence physiotherapy.
Table 4.15 Frequency of the injuries reported to have received treatment and treating service

<table>
<thead>
<tr>
<th>Services that treated injured participant</th>
<th>First treating service</th>
<th>Percent of first treating service</th>
<th>Second treating service</th>
<th>Percent of second treating service</th>
<th>Third treating service</th>
<th>Percent of third treating service</th>
<th>TOTAL</th>
<th>Percent of Services that treated participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ski Patrol</td>
<td>84</td>
<td>43.1%</td>
<td>13</td>
<td>13.3%</td>
<td>8</td>
<td>19.5%</td>
<td>105</td>
<td>31.4%</td>
</tr>
<tr>
<td>Friends/Family</td>
<td>32</td>
<td>16.4%</td>
<td>7</td>
<td>7.1%</td>
<td>0</td>
<td>0</td>
<td>39</td>
<td>11.7%</td>
</tr>
<tr>
<td>Doctor (not in Hospital)</td>
<td>29</td>
<td>14.9%</td>
<td>42</td>
<td>42.9%</td>
<td>7</td>
<td>17.1%</td>
<td>78</td>
<td>23.4%</td>
</tr>
<tr>
<td>Hospital</td>
<td>17</td>
<td>8.7%</td>
<td>10</td>
<td>10.2%</td>
<td>5</td>
<td>12.2%</td>
<td>32</td>
<td>9.6%</td>
</tr>
<tr>
<td>Physiotherapist</td>
<td>17</td>
<td>8.7%</td>
<td>15</td>
<td>15.3%</td>
<td>15</td>
<td>36.6%</td>
<td>47</td>
<td>14.1%</td>
</tr>
<tr>
<td>Treated Yourself</td>
<td>14</td>
<td>7.2%</td>
<td>1</td>
<td>1.0%</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>4.5%</td>
</tr>
<tr>
<td>Ambulance</td>
<td>2</td>
<td>1.0%</td>
<td>10</td>
<td>10.2%</td>
<td>6</td>
<td>14.6%</td>
<td>18</td>
<td>5.4%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>98</td>
<td>41</td>
<td></td>
<td></td>
<td></td>
<td>334</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.16 displays who treated the injured participant, broken down into skiing, snowboarding and other. This table may be used to obtain a perception of the severity of injuries sustained by skiers and snowboarders. At least 31.4% of skiing injuries were treated by a medical centre doctor or in hospital. Snowboarders had 28.0% of the injuries sustained treated by a doctor (not in a hospital) and 25.0% by ski patrol. When looking at the three activities separately Ski patrol treated 35.4% of all ski injuries, 25.0% of snowboarding and 26.9% of all other activates.
Table 4.16 Frequency of the injuries reported to have received treatment and treating service by snowsport

<table>
<thead>
<tr>
<th>Services that treated injured participant</th>
<th>Skiing Percent services that treated skiing</th>
<th>Snowboarding Percent services that treated snowboarding</th>
<th>Other Percent services that treated other</th>
<th>TOTAL</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ski Patrol</td>
<td>76</td>
<td>22</td>
<td>7</td>
<td>105</td>
<td>31.4</td>
</tr>
<tr>
<td>Friends/Family</td>
<td>22</td>
<td>12</td>
<td>5</td>
<td>39</td>
<td>11.7</td>
</tr>
<tr>
<td>Doctor (not in Hospital)</td>
<td>51</td>
<td>22</td>
<td>5</td>
<td>78</td>
<td>23.4</td>
</tr>
<tr>
<td>Hospital</td>
<td>17</td>
<td>13</td>
<td>2</td>
<td>32</td>
<td>9.6</td>
</tr>
<tr>
<td>Physiotherapist</td>
<td>35</td>
<td>11</td>
<td>1</td>
<td>47</td>
<td>14.1</td>
</tr>
<tr>
<td>Treated Yourself</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>15</td>
<td>4.5</td>
</tr>
<tr>
<td>Ambulance</td>
<td>11</td>
<td>4</td>
<td>3</td>
<td>18</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>220</td>
<td>88</td>
<td>26</td>
<td>334</td>
<td>100</td>
</tr>
<tr>
<td><strong>Percent (%)</strong></td>
<td>65.8</td>
<td>26.3</td>
<td>7.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Participants were asked to estimate what speed they were travelling when the accident occurred that caused their injury. The researcher is not assuming that speed caused the accident but research has shown it can be a significant risk factor for injury. Speed at the time of the accident was self reported. More than half (n = 101, 51.8%) were travelling fast, over a quarter (n = 53, 27.2) were travelling moderately fast, and the remaining quarter were travelling slowly (n = 13, 6.7%), very slow (n = 6, 3.1%) or not moving (n = 7, 3.6%), and 15 participants (7.7%) reported that the speed they were travelling was not specific to their injury.
The terrain area where participants injured themselves was recorded. Ski resorts typically give slopes a terrain difficulty rating which is signed with a colour that is internationally recognised. Terrain parks are generally classified as black or double black. Participants recorded the terrain type where they were injured and 17 individuals recorded other. Other terrain types such as:

- Cross-country trail
- Tube Town (inflated rings that participants sit in to travel down slope)
- Tree run
- Chair lift and line
- Snow mobile
- Walking across a bridge
The two most common terrain types where an injury occurred was in black terrain (n = 59, 30.3%) and terrain parks (n = 54, 27.7%). Blue terrain accounted for 19% of injuries (n = 37) followed by other (n = 17, 8.7%), green (n = 9, 4.6%), half pipe (n = 7, 3.6%), race course (n = 7, 3.6%) and moguls course (n = 5, 2.6%).

In some published literature the terrain park and half pipe are analysed as one area. If this was the case the combined percentage of the two would be 31.3% making it the area were the most injuries occurred.

By undertaking a crosstabulation analysis showed that on each of the terrain types excluding the race and moguls courses, the majority of injuries occurred while ‘free skiing/boarding’. Injuries on the races courses were mainly obtained while racing (60.0%), all of the moguls course injuries occurred while the victims were training (Table 4.15).
Table 4.17 Cross tabulation between frequency of the injuries in different terrain and activity setting

<table>
<thead>
<tr>
<th>Terrain Type</th>
<th>Activity expressed as a Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Racing (n=35)</td>
</tr>
<tr>
<td>Green run</td>
<td>0</td>
</tr>
<tr>
<td>Blue run</td>
<td>16.0</td>
</tr>
<tr>
<td>Black run</td>
<td>17.2</td>
</tr>
<tr>
<td>Terrain Park</td>
<td>6.7</td>
</tr>
<tr>
<td>Half Pipe</td>
<td>40.0</td>
</tr>
<tr>
<td>Other</td>
<td>33.3</td>
</tr>
<tr>
<td>Race Course</td>
<td>60.0</td>
</tr>
<tr>
<td>Moguls Course</td>
<td></td>
</tr>
</tbody>
</table>

The cause of the accident was described by participants and included caught an edge (n = 50, 25.6%), jumping (n = 42, 21.5%), somebody ran into them (n = 31, 15.9%), not specific to accident (n = 25, 12.8%), do not know (n = 20, 10.3%), lost control (n = 15, 7.7%) and they ran into somebody/something (n= 12, 6.2%).

Participants were asked if they were wearing a helmet and wrist guards at the time of their accident. Of the 195 participants, 182 were wearing their helmet (94.3%) and 15 individuals (11.3%) were not wearing wrist guards. There were 31 participants who sustained a fractured wrist. Analysis was completed to compare those who were and were not wearing wrist guards at the time of injury. There were 25 snowboarding participants (86.2%) who were not wearing wrist guards and sustained a wrist fracture, while only four that had wrist guards on sustained a fractured wrist (13.8%), while three participants failed to report if there were wearing wrist guards or not. Therefore 86% of participants who sustained a fractured wrist were not wearing wrist guards at the time of injury.
4.9 The Relationship between sustained injuries and the eight key categories

This section of the results determines whether there is any relationship between sustaining an alpine injury and the following eight categories:

I. Demographics
II. Protective equipment usage, preferences and breakage
III. Perceived injury rates and perception on the most common injury for their chosen snowsport
IV. Risk-taking and sensation seeking characteristics
V. Hydration and food intake
VI. Event level
VII. Previous injuries sustained

Demographics

Age - 13 to 16 year olds sustained the most number of injuries, although they were the largest group of participants. Figure 4.15 and Table 4.16 illustrate that in this study the 14 year olds age bracket sustained the majority of the alpine injuries (i.e. greater injury frequency distribution) than the younger children and older adolescents. The blue curve in figure 4.15 represents the distribution of participants that have not sustained an alpine injury while the green curve displays the age distribution of those that have sustained one or more alpine injury.
Figure 4.15 Distribution of injured verse non injured participants by age

Table 4.18 Age and Frequency of Injured

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of Injures for each age group</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>4.3</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>6.0</td>
</tr>
<tr>
<td>13</td>
<td>17</td>
<td>14.7</td>
</tr>
<tr>
<td>14</td>
<td>28</td>
<td>24.1</td>
</tr>
<tr>
<td>15</td>
<td>25</td>
<td>21.6</td>
</tr>
<tr>
<td>16</td>
<td>22</td>
<td>19.0</td>
</tr>
<tr>
<td>17</td>
<td>11</td>
<td>9.5</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>116</td>
<td></td>
</tr>
</tbody>
</table>
The relationship between age and whether an alpine injury was sustained was investigated using the Pearson product-moment correlation coefficient. There was no correlation between the two variables, $r = 0.065$ and $n= 116$.

**Gender** – The relationship between gender and if an individual had sustained an alpine injury was examined using Pearson product-moment correlation coefficient. There was no correlation between the two variables, $r = -0.069$ and $n=340$. An independent-sample t-test was conducted to determine if there was a significance difference in the mean scores of number of injuries sustained for male and females. There was no significant difference in scores for males ($M = 2.18, SD = 1.11$) and females ($M = 2.39, SD = 0.95$); $t (339) = -1.85$, $p = 0.065$ (two-tailed). The magnitude of the differences in the means (Mean differences $= -0.209, 95\% CI: -0.431$ to $0.013$) was small ($\eta^2 = 0.001$).

**Postcode** - Using Spearman’s rho there was a significant correlation between where an individual permanently resided and if they sustained an alpine injury. The level of significances was $-0.147$ at 0.01 level (2-tailed). Therefore where somebody resides has an effect on if they have sustained an alpine injury but the exposure to potential injury is subsequently higher if one lives and participates in snow event more often. The research suggests, as one would expect, those that live in postcodes closer to the alpine region (2627 and 2624) will participate more and may have a higher exposure rate.

**Snowsport** - A one-way between-group analysis of variance was conducted to explore the impact of the type of snowsport with the number of alpine injuries sustained. Alpine sports were divided into four groups according to participant’s preferred (first reported) snowsport (alpine skiing, snowboarding, cross-country and moguls/skier-cross). There was a statistically significant difference at the $p< 0.05$ level in the number of injuries and their chosen snowsport: $F (3,336) = 2.92$, $p = 0.034$. Despite reaching statistical significance the actual difference in mean scores between groups was quite small. The effect size, calculated using $\eta^2$, was 0.025. Post-hoc comparisons using Tukey HSD test indicate that the mean score for alpine skiing ($M = 0.68, SD = 1.39$) was not significantly different from snowboarding ($M = 0.53, SD = 0.822$), cross-country ($M =$
0.08, SD = 0.272) or moguls/skier-cross (M = 1.5, SD = 2.811). There was no significant differences between any of the four variables but cross-country and moguls/skier-cross almost reached significances at p = 0.06. Figure 4.16 displays the mean values and differences.

*Figure 4.16 Mean numbers of Injuries of Participants first chosen snowsport*

*Dominant hand* — Of the 31 wrist fractures, five participants were left-handed, 19 right-handed and seven ambidextrous. The researcher failed to ask participants if their wrist fracture was to their left or right hand. Because this data was missing a correlation between wrist injuries and snowboard stance, and dominant hand could not be undertaken.
Previous Alpine Sport Experience and who they participated with – there were six questions that the researcher analysed in relation to previous alpine experiences and sustaining a snowsport injury. These included:

1. The number of seasons a participant had skied or snowboarded;
2. Who they skied/snowboarded with the most;
3. How much skiing/snowboarding done in total;
4. Professional lessons and how many;
5. Years competed in Interschool; and
6. If they had tried other types of snow sports.

How many seasons skied/snowboarder - There was a significant correlation using the Pearson product-moment correlation coefficient test between how many seasons a participant had skied or snowboarded with if they had ever sustained an alpine injury. The level of significance at the 0.05 level (2-tailed) \( r = 0.135 \) (n=339, missing two participants). You could also write this as: there was a weak positive correlation between the two variables (\( r = .135, n=339, p<.05 \)). Once again this is related to exposure, as you would expect when one participates more they will have a higher rate of injury.

Participant’s social situation while skiing or snowboarded at time of injury - The relationship between who participants skied/snowboarded with the majority of the time was examined using the Pearson product-moment correlation coefficient test. There was no correlation between the two variables, \( r = 0.032, \) and \( n = 338. \)
How many days in total that participant has skied and or snowboarded - How many days participants skied and snowboarded was investigated in relation to if a participant had sustained an alpine injury and the number of injuries they had sustained. There were no statistical relationship found using Person product-moment correlation coefficient between participation amount ($r = 0.101, n = 340$) and ($r = 0.055, n = 338$) for if an injury was sustained and the number of injuries respectively. The relationship between the two was a weak positive but did not reach significance.

Professional Lessons Yes or No - There was no correlation between if a participant had received professional lessons and if they sustained an alpine injury ($r = 0.023, n = 341$). There was also no correlation between the number of lessons a participant had and if they sustained an alpine injury ($r = 0.055, n = 341$). In this situation it was found that lessons were not related to injury. This is contradictory to the majority of the research into this topic.

Years competed in Interschools - The years a participant had competed in Interschools and if they had ever sustained an alpine injury was investigated. There was a significant positive correlation between the two variables using Pearson product-moment correlation coefficient at the 0.01 level (two-tailed) ($r = 0.191, n = 341$). Therefore the longer the participant had competed in Interschools the more likely they were to have sustained an alpine injury. This is similar to postcode and how many seasons a participant have skied/snowboarder it is related to exposure to potential injury. These results are presented in Figure 4.17.
Previous injuries that may affect the participation ability to participate in snowsports - The relationship between any previous injuries sustained before the 2007 winter season (i.e. other sporting or non sporting injuries) sustained before the 2007 alpine season and if the participant had sustained an alpine injury during the 2007 was examined using the Pearson correlation coefficient. There was a small correlation between the two variables ($r = 0.24$, $n = 341$). The correlation was significant at the 0.01 level (two-tailed). Figure 4.18 illustrates the relationship between the variables. In blue are participants who have never sustained an injury, while the red columns represent participants who had sustained an alpine injury.
**Figure 4.18 Comparison of previous injury prior to 2007 and alpine injuries.**

**Risk-taking and sensation seeking characteristics** – The Spearmen’s correlation between risk taking characteristics scale and number of injuries indicates that there is a significant relationship (r = 0.202, p = 0.01) (two-tailed) between injuries and risk taking. The higher individual scores in risk taking and sensation seeking, the more likely he or she was to have sustained an injury. Figure 4.19 represents all participants and some points on the graph may represent more than one participant’s results.
Figure 4.19  Risk taking versus the number of injuries sustained.

Hydration and food intake – there was no significant correlations between sustaining an alpine injury and the amount of water and food consumed over the day while participating in alpine sports.
CHAPTER FIVE: DISCUSSION

The objective of this thesis was to collect and analyse adolescent epidemiological data, and to identify if behavioural and psychological characteristics such as risk-taking and sensation seeking were related to higher incidents of injuries sustained in the targeted adolescent population. It is believed that risk-taking and its associated psychological characteristics could be a possible explanation for the higher incidence rate of snowsport injuries in children and adolescents. The reason for evaluating epidemiological data is that certain factors and characteristics may become evident which can then be used in the identification of those populations at risk of an alpine sports injury. Such information can be of value to individuals involved in the prevention of accidents that lead to injury, such as equipment designers and manufacturers, and in stimulating awareness of the potential problems for those at risk.

The thesis had three main objectives:

- Firstly, to gather adolescent alpine epidemiology data to determine if the targeted group had similar injury trends to reported scientific literature;
- Secondly, to collect risk-taking and sensation seeking characteristic data; and
- Thirdly, to compare the collected alpine epidemiology information and risk taking data with participants demographics, previous experience, hydration and food intake and level of participation to identify any relevant patterns.

The objectives were met by obtaining demographical information, injury and risk-taking data from a pilot study and subsequent questionnaire developed by the author. This project advances the current body of knowledge regarding adolescent alpine injuries, risk-taking and sensation seeking. It has built upon previous research and literature and has the capacity to fuel further study in the presented areas. The description of adolescent alpine injuries formulated in this thesis reinforces what has previously been published whilst also contributing to a new area: adolescent alpine risk-taking. The overall sports-specific injury epidemiology and anatomical injury percentages are comparable to other research. Additional analyses in this study in relation to protective equipment usage, appears to be
some of the first data gathered in Australia. Attitudes towards protective equipment in Australian adolescents and therefore cannot be compared with previous literature.

In Australia both downhill skiing and snowboarding are popular winter sports practiced by a heterogeneous and growing group of participants. Alpine injury statistics are extremely difficult to ascertain, both because of incomplete reporting (many minor injuries are treated by family physicians often large distances from ski resorts) and because of the approximate calculations of ‘skier-days’ based upon the ticket sales (Sacco et al, 1998). The current research strived to collaborate all data collection and analyses in the most reliable and replicable manner possible. This chapter relates the present findings to those of previous research and published literature, where applicable. Additionally it details and discusses the limitations of the project and provides suggestions for injury prevention and recommendations for future work or interventions in the area of adolescent and children alpine injury prevention.

5.1 Incidence of Injuries

The incidence of injury in alpine sports is largely a function of the injury definition and the nature of the study. In this study injuries were defined as those needing medical treatment, self-described by the participant.

The prevalence and nature of the participant’s injuries were analysed with just over one third (n = 116) of the 341 participants reported to have sustained an alpine injury. Out of those participants injured there were 208 injuries reported. The frequency range of injuries reported was between one and 11. Six participants reported to have sustained five or more injuries. The total number of injuries sustained appears to be high but comparable to other literature of a similar target population (Hagel, 1999).

The minimum number of alpine participation days reported for the 341 participants was 15,467, calculated to approximately 13.48 injured participants per 1,000 skier/boarder days (please refer to section 4.2 to review how these numbers were obtained). This injury rate per 1,000 skier/boarder days is the highest injury frequency because calculations were
taken for the minimum number of days participated, with the more days participated the lower the injury rate becomes. An approximation of the maximum days skied/snowboarded was calculated to be 23,294, which equates to 4.98 injured participants per 1,000 skier/boarder days.

When reviewing the incidence of injuries combined for skiers and snowboarders to obtain an indication of total alpine injuries under the age of 18, MacNab found there to be 4.8 injuries per 1,000 visits for those aged seven to 12 years of age and 4.4 injuries per 1,000 visits for those aged 13 to 17 years of age (MacNab, 2002). Machold’s retrospective cohort study based on medically reported injuries for snowboarders found 15 injuries per 1,000 snowboarder days (Machold, 2000), which is higher than that found in the present study. There is a large difference between the research presented in adolescent and children’s literature on skiing and snowboarding injury rates per 1,000 skier/boarder days. No real comparisons can be made between the data collected in previous literature given the large discrepancy in what the real injury rate per 1,000 skier days equals. The results indicate that there was between 5 and 14 injuries per 1,000 skier/boarder days for participants aged 10 to 18 years of age.

5.2 Injury Characteristics
Depending on the injury definition, plus other characteristics of the research project and the participants, large differences in the profile of injuries can occur (Hagel, 2005a). Injury characteristics and anatomical location of the injury differs largely depending upon the particular alpine sport. In this study as previously reported, the alpine sports breakdown was 58.5%, 25.4% and 16.3% for alpine skiers, snowboarders and cross-country skiers respectively. Skiers were over represented in the injured group (this is taking into consideration the higher participant numbers) with a higher proportion of injuries. Approximately 65.1% of those injured were skiers, snowboarders accounted for 27.7% of injuries and the remainders were cross-country participants. Each snow sport will be presented with a breakdown of lower extremity injuries, upper extremity injuries and head and spinal injuries.
**Skiing**

*Skiing - Lower Extremity Injuries*

With the higher frequency of skiers injuring themselves it is understandable why there are a high proportion of knee injuries. The lower extremity receives a lot of concentration in alpine research especially skiing. While there is a large variation between different studies, almost all recognise the lower extremity as the most frequently injured body region for skiers with proportions ranging from 22% (Skokan, 2003) to 72% (Hagel, 2005a). Hagel (2005) reported that the majority of injuries that occur in child and adolescent skiers involve the lower extremity. In this project 60.3% of skier injuries sustained were to the lower extremity. In relation to the lower extremity the knee accounted for 94.3%, the ankle 2.5%, and the foot and leg each accounted for 1.6% of all lower leg extremity injuries. Previous literature and these results consistently demonstrate that knee and lower leg injuries is the most common to occur in skiers (Giddings, 1993; Hagel, 2005a; Heir, 2002). Knee and other lower extremity injuries are often due to torsion (twisting) mechanism of skiing placed on the lower leg.

Knee dislocations, knee sprains and tibia fractures are the most alpine injuries admitted to hospital (Ashby and Cassell, 2007). In this study knee injuries accounted for 53.7% of skiing injuries compared with 12.6% of snowboarding injuries. Although not applicable to this research project’s design it has been previously reported in alpine epidemiology studies (Ashby and Cassell, 2007; Greenwald, 1997, 2003; Hagel, 2005a) that knee injuries can be underestimated as a substantial proportion of sports participants with knee and ankle sprains presented to sports medical clinics and physiotherapists by passing surveillance database collection sites at resort medical centres.

*Skiing - Head and Spinal Injuries*

Depending upon injury definition, age and gender distribution of the group, head injuries in alpine skiing accounts for between 5.0% (Ekeland, 1993) and 51.5% in skiers (Shorter, 1996). The neck and spinal injuries have been reported to account for between 2.9% and 7.7% (Hagel, 2003; Shorter, 1996; Skokan, 2003). This high variability of head and neck injuries may be related to data collection methods, injury definition, and anatomical grouping. Results from this project indicated that the total percent of head,
face, neck and back injuries accounted for approximately 10.0% of the total injuries skiers sustained. Head injuries skiers sustained accounted for 1.9%, facial injuries accounted for an additional 1.0%, back 5.1%, and the neck injuries accounted for 2.3% of all ski injuries.

The lower frequency of head and neck injuries in comparison to the literature may be an indication of the effectiveness of helmets with a high proportion being used. This project data is consistent with the link between injury severity and head injuries (Hagel, 2003). Cadman and MacNab (1996) stated that not all head and neck injuries presented to medical centres are severe. Only occasionally does spinal injury occur, and the high prevalence of individuals seeking medical treatment as a result of head, back, or neck injuries appears to be more of a precautionary measure rather than an actual occurrence of a significant injury.

Skiing - Upper Extremity Injuries
As with the case of head and spinal injuries, the injury definition and injury grouped characteristics result in a significantly large range of reported upper extremity injuries. The upper extremity received 29% of all injuries sustained by skiers. Of these injuries 15% were to the wrist, which was not an expected result. Typically shoulders and thumbs are the most common upper extremity injury incurred by skiers (Koehle, 2002). This high proportion of wrist injuries has not been reported previously in literature. Literature reports that upper extremity injuries generally account for 14% to 22% of all injuries in skiers (Hagel, 2005a). Skokan et al reported that upper extremity injuries are not normally part of the spectrum of severe injuries in skiers. It was reported that upper extremity injuries accounted for 8.0% of all ski injuries in those under 18 admitted to a level one paediatric trauma centre (Skokan, 2003).

Snowboarding
Snowboarding - Upper Extremity Injuries
Snowboarders have a higher incidence of severe injuries to the upper extremities than skiers do (National Institute of Economic and Industry Research, 2006). Whereas the lower extremity represents the largest problem for children and adolescents skiers, the
opposite holds true for snowboarders who injure the upper extremity at a significantly higher frequency. Upper extremity injuries represented approximately 63.0% of snowboarder injuries in this study. As expected, wrist injuries accounted for 60.9% of all snowboarding injuries and the forearm 2.3%. While 96% of all upper extremity injuries were to the wrist, the remaining 4% were to the forearm.

Other upper extremity injuries sustained by snowboarders reported in the literature included shoulder dislocation, elbow fracture or dislocation and fractured collar bone (technically not upper extremity). The majority of literature on children and adolescent snowboarders indicate that the upper extremity, specifically the wrist and forearm are the most frequently injuries due to the impact mechanism.

Skokan reported that approximately 5% of admissions to a paediatric trauma centre involved injuries to the upper extremity reflecting their importance in terms of frequency, but not necessarily severity (Hagel, 2005a; Skokan, 2003). There is substantial documented evidence of the high incidences of wrist fractures among snowboarders. This is particularly a problem in children and adolescents where the fractures are near to the growth plate which may lead to deformity of the wrist. It has been recommended that snowboarders should wear wrist guards. Studies indicate that wrist guards should be built into gloves (Langran, 2007a). Other recommendations suggested children should not snowboard until they are seven years of age (Ashby and Cassell, 2007). (Protective equipment usage will be discussed later in this chapter.)

Snowboarding - Head and Spinal Injuries

Head, neck, face and back injuries accounted for approximately 12% of all snowboarding injuries, which is 2% higher than the results from this project skier group. The head accounted for 2.3%, face 1.1%, neck 3.4% and back 4.6%. As was the case for skiers these results are lower than previously reported in literature and may be because of the higher usage of helmets. Literature reports the percent of significant head and neck injuries for snowboarders to be approximately 8.0% of those injured under 19 years of age based upon admission to emergency department records (Drkulec, 2001) and 50% in those aged seven to 12 years based on ski patrol reports (Cadman and MacNab, 1996).
Snowboarding - Lower Extremity Injuries

Lower extremity injuries while snowboarding do not occur at the same frequency as skiers. Results from this project show that approximately 25% of all injuries incurred by adolescent snowboarders were to the lower extremity. The breakdown of lower extremity injuries included knee (12.6%), bottom (4.6%), ankle (3.4%), thigh (1.1%) and leg (1.1%). This is consistent with precise literature published where 16% to 24% of snowboarder injuries were to the lower extremity (Hagel, 2005a).

Cross-Country Skiing

Cross-country skiing has relatively fewer injuries compared with alpine skiing and snowboarding, but falls can cause various injuries, and overuse conditions may develop from technique errors or overtraining. Cross-country skiing and racing is thought to cause fewer acute injuries than downhill skiing (Renstrom, 1989).

In the current research 25 participants were injured while cross-country skiing training and none while racing. However, the sport's ‘true’ injury incidence is difficult to establish because when training recreational cross country skiers ski do not always ski within a resort and therefore if injured may not necessarily seek immediate medical assistance at a resort medical centre, although when competing in cross-county races are held within the ski resort.

In this project cross-country injuries accounted for 7.9% of the total injuries. Smith and associates (Smith, Matheson, and Meeuwisse, 1996) reviewed existing cross-country injury statistics and estimated that there were 0.49 to 5.63 injuries occurring per 1,000 cross-country skier days. The researcher could not find specific injury rates for children cross-county racing injuries to compare against. Boyle and colleagues (Boyle, Johnson, Pope, et.al, 1985) reported that the majority of acute cross-county injuries occur on downhill runs. Lightweight fibreglass and graphite skis became available in the mid-1970s, and additional improvements in trail grooming and equipment technology have allowed speeds on some downhill cross country terrain to approach 80 kilometres per hour (Smith, 1996). This increases the chance of a fall potentially leading to injury while racing or training.


**Cross-Country Skiing - Lower Extremity**
The lower extremity is at greatest risk for injury in cross-country skiing and has been reported in literature to affect between one quarter (Accident Research Centre Monash University, 2006) and just over half of cross-country skiing injuries (Smith, 1996). Likewise, in the current research lower extremity injuries accounted for 52.1% (n = 13) of all cross-country injuries. In this study the knee accounted for 44.2% (n= 11) of the cross-country injuries and the ankle accounted for 8.2% (n= 2). No significant conclusions could be made in relation to cross county lower extremity results.

**Cross-Country Skiing - Upper Extremity**
Literature reports that the upper extremity accounts for about one third of traumatic cross-country skiing injuries (Accident Research Centre Monash University, 2006). In this project they accounted for 36.0%. Injuries to the upper extremity included the wrist (32.1%) and the thumb (3.9%). Previous literature has reported the thumb to be the most common upper extremity injury due to incorrect poling. Proper poling necessitates passing the hand through the loop of the pole strap and then grasping both the strap and pole in the palm. If the skier falls, the pole may lever the thumb into abduction and extension, thereby stressing the ulna collateral ligament (Accident Research Centre Monash University, 2006).

**Cross-Country Skiing - Head and Spinal Injuries**
In this study 12% of the cross-country injuries were to the neck (n = 2) and back (n=1). The limited number of injuries do not allow for statistical correlations. Literature reports that approximately 10% of injuries in cross-country skiing involve the head, neck, and trunk (Smith, 1996). Such injuries can include ‘compression fractures’ of the body of the lumbar vertebrae or fracture of the coccyx resulting from falls (Smith, 1996). Facial lacerations and corneal lacerations can occur from contact with vegetation near trails (Smith, 1996).

**Cross-Country Skiing - Overuse injuries**
Various overuse injuries not related to a single traumatic incident can occur with cross-country skiing while training and racing. Although this project did not report any overuse
injuries, it is important to recognise that some injuries sustained could possibly have been overuse injuries. Overuse injuries most often result from training errors or errors in technique (Smith, 1996). According to Morris (1999), the muscle movements involved in cross-country skiing is complex.

5.3  *Alpine Injuries Sustained at Competition compared with Practice*
In this project the majority of injuries sustained occurred during recreational participation (63.3%). A smaller proportion of adolescents were injured during competition or training, with less than 17.9% of injuries sustained while racing and 18.5% occurred while training. Literature provides similar evidence that the majority of injuries occur during recreational participation in skiing (66.7%) and snowboarding (74.7%) (Hagel, 1999). Only a small proportion of skiers and snowboarders were reported to be injured during training or competition. However, this may simply reflect the greater number of hours individuals participated in recreational based skiing rather than racing.

5.4  *Injury Severity*
Few studies have been conducted on the issue of injury severity in children and young adolescents. Those that have been conducted indicate that injury severity can be measured by injury severity scales, length of hospital stay and the associated financial and personal costs. The results indicated that there were 334 services that treated the 208 injured participants. Of this a doctor not in a hospital treated 78 participants (23.4% of all injuries), 32 (9.6%) participants were treated in hospital and 18 (5.4%) were transported to a hospital via ambulances. This indicates that approximately 128 (38.3%) of the treatment services used could indicate a serious injury.

Head injury is one of the leading causes of alpine sport fatalities and serious injury (Sacco, et al, 1998; Sulheim, Holme, Ekeland and Barh, 2006). It was found that 22 participants (approximately 10% of all injuries) suffered a head injury. Previous all-aged studies reported that hospitalisation from head injuries ranged from 3% to 23% of
hospital treated alpine injuries (Ashby and Cassell, 2007). Hagel reported that some studies determined that snowboarders are more at risk of head injury than skiers (Hagel, 2005c) based on snowboarders stance and method of descending down the slope. Common scenarios for head injuries in alpine sports include losing control and crashing into trees, lift towers and other obstacles such as snow makers; collisions with/being hit by the lift or T-bar, other skiers and snowboarders; more typically novice snowboarders losing control and falling backwards hitting the occipital region of the head; and more advanced snowboarders and new emerging skiers who crash land during the performances of a jump or other obstacles such as a box or a rail in terrain park (Cooper, 2006). In this project the half-pipe and terrain park incurred the highest number of injuries for terrain type.

5.5 Injury Risk Factors
Hagel (2005) conducted a critical review of the research literature on children and adolescents skiing and snowboarding injuries. This review established that the majority of alpine published studies were descriptive case series without exposure estimation. Studies of this type can identify possible risk factor as they do not include a comparison group of non-injured participates. Hagel concluded that evidence from 13 studies included in his review (case series with exposure estimations, prospective cohort, and case controlled studies) provided support for intrinsic and extrinsic risk factors. This project investigated both intrinsic and extrinsic risk factors in alpine sports and how they related to injury. Intrinsic factors studied included; alpine ability and experience, professional lessons, age gender and personality characteristic such as the desire to take risks and hydration and food intake. Extrinsic factors examined included terrain type and protective equipment usage.

Intrinsic Risk Factors
Ability and Alpine Experiences
Alpine literature has continued to report that beginner and intermediate level alpine sports participants have a higher risk of injury than experienced participants in skiing and snowboarding. In this research project participant self reported how many days in total
and seasons they had participated in alpine sports. Results indicated that those who had participated in fewer seasons had a significantly higher rate of injury. The injury rate for novice skiers has been reported to be as high as nine or 10 times higher than that of advanced level participants. In this project it is difficult to discern whether the risk of injury is increased due to a lack of experience or a lack of skill. As reported early it appears that experience teaches participants how to avoid situations where the injury risk is high.

Previous Injury

Australian snowboarding research examining the effect of past injury on subsequent injury risk found that those with a past injury were 1.35 times more likely to sustain a subsequent snowboarding injury compared with those reporting no prior sport injury (Machold, 2000). Similarly this project found a significant relationship between past injuries and alpine injuries. There were 90 participants with self reported injuries prior to the 2007 and results showed that there was a significant correlation between those that has sustained a previous injury and those that had sustain alpine injuries. There are a number of possible explanations that have been presented in literature as to why those that have previously suffered an injury are subsequently more likely to reinjure themselves. Three different explanations that could explain the higher injury rates for those that had sustained prior injuries in this study are:

1. Participants who have previously sustained an injury have not received adequate care for the injury or have not allowed sufficient time for the healing and rehabilitation (Hagel, 2005a);

2. Skiers and snowboarders who are better educated in slope safety and ethnicity, physically fitter and more athletically inclined than others may have a reduce injury rate compared with the total selected population; and

3. Those who have previously sustained an injury may be more likely to demonstrate higher risk-and sensation seeking characteristics than none injured participants.
Professional Lessons

The research on the relationship between professional alpine lessons and injury is currently equivocal in scientific literature. Various researchers advocate that there is an increased risk for participants who have not had formal lessons while others suggest that there is no relationship between formal training and injury risk.

In this study over 90% of the participants had received professional lessons from a qualified instructor. Common sense would imply that formal learning is a good initiative for a novice, allowing them to acquire and develop a degree of skill. The results from this project show no correlation between a participant receiving professional lessons and if they did or did not sustain an alpine injury, although there was an extremely high percentage of participants that had received a professional lesson. There is also a counter argument that those who gain skills rapidly though professional lessons can become overconfident and therefore attempt to descend difficult slopes that increase the risk of injury.

Goulet, Réginer, Grimard, Valois, and Villeneuve (1999) found after adjusting for skill level, proper binding adjustment and equipment ownership there was no noted relationship between formal training and injury risk. Hagel (2005) suggested that this lack of differences could subsequently be due to methodological limitations. Similarly this project found no correlation between a participant who had received professional lessons and if they sustained an alpine injury. However, Goulet advocates that by far the more important factor may be skill level and that ‘formal ski lessons … be viewed as one among several tools… to raise the level of skill of the young skier’ (Goulet, 1999, pp 696). A further explanation is that participants taking lessons may be more likely to report their injuries as they are being supervised by an instructor, as has been found in other investigations (Requa, 1977), which would bias the association toward finding no effect, assuming lessons are protective.

Contrary to Goulet and Machold’s research MacNab, Cadman and Greenlaw (1998) indicates that not having taken professional lessons is a risk factor for injury (MacNab, Cadman and Greenlaw 1998). Their investigations suggest that the injured group was
less likely to identify the ‘blue square’ (beginner slopes) as indicating run difficulty compared with an uninjured participants. However, low response rates and other methodological limitations make the results of this investigation less compelling than the work of Machold et al. (2000) and Goulet et al. (1999). These conflicting results between literature and the presented thesis indicate the need for further research into the nature and extent of ski and snowboard lessons and the implications on risk-taking and injury.

Age
Compared with older alpine participants those aged 12 to 17 are significantly more likely to be injured (Lipskie, 2000). In this project those aged 13 to 16 were more likely to have sustained an alpine injury and had more alpine injuries (i.e. greater injury frequency distribution) than the other age groups. According to Cadman (1996) injury among the youth population is not evenly distributed (Cadman, 1996) and in this project 13 years olds sustained 18.5% of injuries, 14 years olds 22.1% of injuries, 15 year olds 20% and 16 year old 16.8%, although there was no significant differences in the number of injuries sustained and age. The 14 year old children had the majority of the injuries which was a similar result as Cadman (1996) study therefore the results are consistent with previous research.

The importance of replicable incidence rates of injury cannot be overstated. Injury frequency in alpine sports is largely governed by the total number of participants on the slopes. Here we see in the age frequency distribution of injured participants, more 14 year olds were injured than any other age group in the study, although it is not statistically significant because there were a greater number of 14 year old participants than any other age group.

Gender
Gender differences in alpine epidemiology data is apparent in adult participants and has been documented in research through the United Stated of American, Canada, Europe, New Zealand and Australia. Typically adult males generally garner the label of higher risk-takers and sustain more injuries, but in children and adolescent alpine literature this does not bear true. In this thesis gender distribution among injuries participants (10 to 18
years) is 57.4% male and 42.6% female and the difference is not statistically significant and therefore comparable to other children and adolescent research. Why there is not a difference in this gender population is currently unknown, it could be because females research results reflect an actual increase in injury rates for females or merely a greater likelihood of reporting. Perhaps it is also related to different psychological characteristics and maturity of the adolescent females compared with adult females.

*Personality characteristics such as the desire to take risks*

The researcher hypothesized that individuals who score higher in risk-taking and sensation-seeking scales would have sustained a higher number of injuries over the winter season and the results supported this. It was identified that adolescents with high risk-taking and sensation-seeking characteristics sustained significantly more injuries than those who scored lower in these scales.

Although there have been independent efforts to assess the prevalence of adolescent injury and the factors contributing to risk taking in adolescence, few investigations that the author is aware of have assessed the relationship between adolescent risk-taking behaviours and adolescent injury. One study examined the relationship between risky behaviour and injury in young children. The study of preschool children found pre-injury behaviour or risky behaviour was a significant predictor of the likelihood of injury (Spelts, Gonzales and Sulzbacher, 1990). Similarly Potts, Martinez and Denman found a relationship between risk taking and injury in a sample of school-age children between the ages of six and nine (Potts, Martinez and Dedmon, 1995). Although this was not the current study’s target age bracket, it provides evidence from the literature that there is a relationship between behaviour and injury which may carry through to skiing/snowboarding behaviours.

The impact of peer influence on adolescent injury is another area that is yet to be examined closely in alpine epidemiology. Almost three-quarters (74%) of all injuries sustained in this selected group occurred while they were skiing with their friends. Although this does not take exposure into consideration (e.g. do they spend most of their time skiing with friends?), it provides evidence that the target population may take more
risks while skiing/snowboarding with friends than in comparison to family. Findings from literature related to injury and risk taking within an adolescent context suggest that peer influence of risk taking behaviours and injuries may be an important area that needs to be considered (Jelalian, Spirto and Rasile, 1997), and results from this project provides support allowing for a more in depth evaluation in future research.

Equipment failure and risk taking characteristics were also found to have a significant relationship. Those had equipment failure and the more equipment that failed on the individual the higher the individual scores in risk taking and sensation seeking, thus more likely he or she was to have sustained an injury.

*Hydration and Food Intake*

Results indicated that there was no statistical difference between those that ate and hydrated frequently in relation to the frequency of injury. Previously the author has alluded to the importance of hydration in adequate energy to participate in sports. This area needs more investigations before conclusions can be made.

*Extrinsic Risk Factors*

*Terrain Type*

It is evident that more injuries occur on runs that had a great difficulty (steeper gradient). The majority of injuries occurred on black terrain (30.3%) and terrain parks combined with half pipes (31.3%). The majority of terrain parks within the Australian alpine resorts are classified as black terrain, unless situated on a beginner slope. Few studies have examined the effects of the introduction of terrain parks and pipes in injury rates and trends in the adolescent population.

As previously discussed Cooper (2006) investigated fall direction in snowboarding in the winter season of 2004-2005. It was identified that there were dramatically different falling mechanics and arrest strategies for each ability level and terrain type. Results concluded that in terrain parks approximately one in four runs resulted in a fall and one in three runs in a half pipe (Cooper, 2006).
The more likelihood of a fall increases the participants’ chance of injury. No clear conclusions can be made from this data as information was not collected on the percentage of time participants spent in each terrain area. The data provides evidence and relevant information into the type of terrain where injuries most frequently occur.

*Protective equipment usage, preferences and breakage*

Alpine personal protective equipment refers to protective clothing and equipment that is designed to protect the athlete’s body from environmental conditions and injury. The most common protective equipment used by participants for this study was helmets and wrist guards. Helmets have been proven effective in reducing the incidence of minor concussion during low velocity collisions and wrist guards which are designed to reduce the incidence of wrists fractures.

In the current research 98.6% of participants reported that they wear helmets and of that 86.6% all the time. It is mandatory for participants competing in the downhill events at Interschool competitions to wear a certified helmet. MacNab (2002) provided encouraging evidence from three investigations that helmets are effective in the prevention of less severe head injuries (MacNab, 2002). In the first investigation of the helmet issue MacNab and colleagues noted that injured subjects were 81% more likely to have never used a helmet. In the two subsequent case-control studies, the authors found that failure to use a helmet increased the risk of a head injury by 1.8 fold. The authors moreover reported no associated increase in the risk of a cervical spine injury with helmet use.

It is difficult to ascertain in this project if helmet usage had an impact on the reduction of head injuries as they accounted for approximately 10% of all injuries. The author did not obtain enough information in regards to the types of heads injuries sustained to draw conclusions on the effectiveness of helmets reducing head injuries. Machold *et al.* (2000) found no head injuries in the cohort of 196 snowboarders using a helmet, but 17 in the 2,366 not using one. The small number of injured individuals and subsequent lack of control for possible confounding factors make the results of these studies encouraging, but far from conclusive.
The results indicate that the use of helmets and other protective devices has substantially increased in Australia and may be higher than in other parts of the world where it has been reported that 20% to 24% of all participants in recreational alpine sports use helmets (Hagel, *et al.* 2005). Protective equipment and attitudes among participants appear to be very positive with an increasing percentage of young children and adolescents choosing to use protective equipment in Australian ski resorts.

Wrist injuries are common among snowboarders (Bladin *et al.*, 2004; Greenwald, 1997, 1998, 2003; Langran, 2004; Oberthaler, 1995; Shealy, 1996; Young, 1999). Literature has studied the rationale behind the previous knowledge that snowboarders have a higher rate of wrist injuries and incorporated this with the use of preventative protectors. Some studies support the use of certain wrist protectors or guards (Langran, 2004) while other studies emphasize the fact that wrist protectors may transfer the injury further up the arm (Greenwald, 1998). Results within this research project may help clarify contradictions within the literature because 86.0% of participants who sustained a fractured wrist were not wearing wrist guards. Therefore only 14.0% of those who sustained a wrist fracture were wearing wrist guards.

These results are similar to a prospective, randomized, clinical study conducted by Rønning, Rønning, Gerner, and Engebretsen (2001), with 5,029 snowboarder participants. The participants were randomized into two groups with 2,515 people in the braced and 2,514 in the control group. An injury was classified as a fracture or a sprain with the loss of range of motion and pain in at least three day duration. Eight (21.6%) injuries occurred in the braced group while 29 (78.4%) occurred in the control (Rønning, 2001).

Major barriers for participants to wear helmets, wrist guards and other protective equipment are very similar. In this project and Langran (2007b) the perceptions amongst non-wearers report that protective equipment is uncomfortable, ineffective, fear of injury from wrist guard or injury higher in arm, ‘do not see the need’, cost, ‘uncool’ appearances and unavailability (Langran, 2007b). In this study helmets were worn by the majority of the participants, fewer participants used wrist guards and other forms of
protection. The two most common reason in this project for not wearing a helmet including not liking the look and not seeing the need.

**Activity**

There is evidence from this project and literature to suggest the type of alpine sport can influence the risk of injury. Literature furthermore reports that the severity of injury may be greater in young snowboarders compared with young skiers (Skokan, 2003). Nevertheless, others advise greater injury severity in young skiers (Shorter, 1996). In this project results indicated that there was a statistically significant difference in the number of injuries and the participants chosen snowsport. Results indicated there was no difference in injury frequency between downhill skiing and snowboarding, but cross country skiers sustained significantly more injuries than the downhill alpine sports which appears abnormal to other literature.

Skokan (2003) reported in a case-series investigation allowing for comparisons of the risk of severe injury in snowboarding compared with skiing in children under 18 requiring hospitalisation for winter sports injuries (Skokan, 2003). In this study snowboarders represented a quarter of the sample group and 26.3% of the injuries population. Unlike Hagel (2005), no statistically significant data implied that snowboarders were two or more times more likely to have an injury (Hagel, 2005a).

Similarly in Hagel (2005), snowboarders were estimated to have an almost five-fold increase in the likelihood of being admitted to the paediatric Intensive Care Unit (Hagel, 2005a). These results implied that snowboarders may have sustained more severe injuries. The evidence indicates a greater injury severity in snowboarders compared with skiers if you look at the results of who treated the injured participant, with 4.5% of snowboarding injuries requiring an ambulance, while 0.5% of skiers required Ambulance transportation. Similarly, 14.8% of snowboarders were treated in hospital and 7.7% of skiers were treated in hospital. Possible explanations for the difference may relate to the focus on aerial manoeuvres characteristic of snowboarding. Many young adolescent male snowboarders also skateboard which may increases their confidence and willingness to take risks and perform big manoeuvres.
5.6 Considerations and limitations

It is acknowledged that this study was subject to inherent weakness and limitations that must be taken into account when interpreting the results presented. Firstly, the participants may not be representative of the general adolescent alpine population in Australia. The study was targeted at adolescents who race and excluded younger primary school children due to ethical considerations. This evidently excluded a large proportion of young Interschool competitors. Similarly, 18% of all questionnaires were not returned and it is likely that those who did return their questionnaire represented a slightly different sub-population of individuals interested in the topic or teachers had a greater influence.

Not all accidents in alpine sports as in other area of endeavour are related to risk-taking and sensation seeking behaviours. As in other areas of life, in alpine sports there is the innocent bystander phenomenon, where the victim was passively standing still and was run into by another person. In alpine sports, this category of injuries typically occurs at low speeds including in or near lift lines and is associated more with awkwardness and inexperience than with risk-taking. This type of injury has also been known to occur at high speeds where the bystander is situated in a location with poor visibility to those descending down the ski slope.

Selection Bias and Other Numerator Issues

Selection bias is introduced by differences between those who are included in a study and those who are not studied (Last, 1995). This project was limited to adolescents who participated in Interschools, and schools targeted by the author, therefore the source of the data could be criticized as a weakness.

5.7 Conclusion

Young alpine participants have a significantly greater risk of injury than adults as previously stated by Hagel, (2005a). Children and adolescents risk of injury is influenced by their behaviour and both their social and physical environment. Participating in alpine sports can offer exhilarating feelings and experiences but can also can incur an injury.
These injuries can have significant personal cost (loss of mobility, school work affected and loss of quality of life) and social cost (hospital treatment and rehabilitation). The research goal was to investigate children and adolescents alpine epidemiology, racing injury rates and determine if risk-taking characteristics influence the likelihood of injury. Significant results were found that indicated children and adolescents who scored higher in risk-taking and sensation seeking scores were more likely to have sustained an alpine injury it also intended to evaluate the effects of the combined psychological characteristics of risk-taking and sensation seeking on alpine injuries sustained in a targeted adolescent population. This was important due to the increasing number of Interschools participants and the growing number of ski based excursions to the snowfields, injury trend may have changed. This study provided information needed to develop injury control and prevention programs for an adolescent population.

The current data does not suggest that there has been an increase in the number of injuries in Interschools snowsport races. The results showed that only 17.9% of the total injuries occurred while participating in racing events. The results indicated injury patterns for the different alpine sports where in skiers the knee was the most common injury site and fractured wrist for snowboarders.

This study demonstrates that there are a variety of variables that influence the types and frequency of injuries. There are also a number of intrinsic and extrinsic risk factors that influences the chance of sustaining an injury. The literature review also provided information that demonstrated alpine injuries while participating in snowsport vary by age, gender and equipment type.

Research into risk-taking activities in the general community suggests that children and adolescents increase their risk-taking activities while with their friends. This fact may also hold true when participating in alpine sports. There is no literature available to support this area of research therefore it may should be an area for future investigations. The author believes the social factor is a crucial influence in injury prevention. Children and adolescents are possibly more likely to engage in higher risk skiing and snowboarding activities while together as opposed to with their parents. This style of
risk-taking is socially acceptable however interventions are needed to educate young participants and their parents how to reduce the risk of injury and death by adopting safe alpine strategies.

This study provides valuable information for the development of a preventive program aimed at young alpine sports participants. The age specific rates of injury along with the identification of higher risk-takers allow for specific intervention and prevention initiatives. Future adolescent educational programs aimed at minimising injuries and improving injury awareness strategies will need to take these issues into account. The identification of factors that defines adolescent high risk-takers will help sport educators in targeting these groups for injury prevention programs. Subsequently, the next challenge will be to develop educational based programs in a format that is suitable and appropriate to such individuals. Future studies could target children who scored higher in risk-taking questionnaires to participate in alpine awareness and injury prevention courses. Future children and adolescent educational programs aimed at minimising injuries and improving injury awareness strategies will need to take risk perception issues into account.

Suggestions for Future Research

The author’s perception into alpine injuries is that prevention in far better the cure. Today there are extensive high quality investigations focusing on the demographics of injured participants. We now know who is more likely to get injured and that participants who demonstrate higher risk-taking characteristics have a greater likelihood of injuring themselves.

Literature available tends to be case-series research. These types of investigations fail to provide information and diminutive data regarding protective factors and risks involved. Hagel (2005) suggested similar feelings and stated control groups identifying the prevalence of the risk or protective factor in the source population that produced the injured cases is required to identify these relationships (Hagel, 2005a). Future research needs to focus on case-control research because if these studies adhere to rigorous principles valid results are obtained.
In this particular group risk-taking characteristics had a statistical relationship to injury. The higher a participant scored in risk-taking the greater chance there was that they sustained an alpine injury. Future studies could target children who scored higher in risk-taking questionnaires to participate in alpine awareness and injury prevention courses. Future children and adolescent educational programs aimed at minimising injuries and improving injury awareness strategies will need to take risk perception issues into account. The identification of factors that define adolescent high risk-takers will help sports educators to target these groups for injury prevention programs. Subsequently the next challenge will be to develop education based programs in a format that is suitable and appropriate to such individuals.

Based on the results from this project and literature presented, a number of recommendations for further research are outlined:

1. Additional investigation needs to investigate and clarify how much risk-taking characteristics influence the participant’s chance of injury. Results indicated that the higher the participants scored in risk taking, the greater chance there was that they sustained an alpine injury. Future studies could target children who scored higher in risk-taking questionnaires to participate in alpine awareness and injury prevention courses to determine if the awareness decreases the frequency of injury.

2. Research should be conducted to create and test the effectiveness of children and adolescent educational programs aimed at minimising injuries and improving injury awareness strategies that will need to take risk perception issues into account. Further projects need to be completed to examine the influence of professional lessons on injury risk. Hagel (2005) reported that engaging in an activity without having any background knowledge is inherently dangerous. Nevertheless, the content of instructional programs should be investigated further for skiers and snowboarders (Hagel, 2005a). Zuckerman (1994) also believed that as some people become more confident through gained experience at a given task for example skiing, they may eventually push their limits and seek novel
sensations. This limit pushing may be an explanation for a higher rate of injury and research needs to examine the effects of professional lessons and skill development.

3. More extensive research needs to be conducted to determine the relationship between dehydration and inadequate food intake on injury.

4. The effectiveness of helmets in alpine sports still causes a considerable amount of argument amongst leading researchers. Future efforts need to clarify the effect of helmet use on head and neck injury risk, additionally if helmet use changes behaviour of participant due to a false sense of security.

5. The design of helmets and the effect of music ports inside should be studied to ensure they don’t increase the chance of injury by influencing the user’s ability to hear.

6. Researchers should closely monitor the frequency of head, neck and spinal injuries paying particular notice to terrain parks and half pipes. The author speculates that the popularisation of terrain parks including half pipes and jumps are partly responsible for the head, neck and spinal injury trends. The greater use of terrain parks by snowboarders in the past few years may also be partly responsible for the evidence suggesting greater injury severity in this group compared with skiers.

7. Further study into the cause of these trends in terrain parks and ways to reduce head and spine injuries in child and adolescent skiers and snowboarders is needed. Particular United States resorts are placing super pipes in terrain parks as a method of reducing pipe injuries. Investigations need to study the specific equipment and terrain parks to determine if their design can minimise the risk of injury.
CHAPTER SIX: APPENDIX
6.1 Letter to school principal
Dear School Principal

I am currently undertaking a postgraduate research degree specialising in Alpine sports injuries at the University of Canberra. A major part of my thesis involves collecting information regarding risk-taking and Alpine injuries among Interschool children. It would be helpful if your school’s Alpine Interschools team could participate in the two part questionnaire. The questionnaires have been approved by the University of Canberra Committee for Ethics in Human Research and the NSW and ACT Department of Education and Training. The questionnaires are about the children’s involvement with Alpine winter sports. The information given will be used to further the knowledge of Alpine injuries.

This research aims to analyse the pattern of risk-taking and sensation seeking behavioural characteristics among adolescents during Alpine activities, and their perceptions of risk-taking and to identify the social factors which effect occurrences of injuries and severity. The rationale behind the study incorporates the benefits of knowing injury higher risk-taking groups and how they relate to injury. This information can be used to the design and implement more appropriate Interschool training and injury prevention programs.

The research involves a pre-season questionnaire addressing previous snow sport injuries and risk-taking behaviours at the snow, followed by a post-season questionnaire addressing sustained snow sport injuries over the current season and race placing in their chosen events. All information gathered is anonymous and confidential.

For additional information regarding this research I can be contacted via email on nadine.cooper@student.canberra.edu.au or my supervisor Dr. Tracey Dickson on 02 62012465 or email her at: tracey.dickson@canberra.edu.au

Thanking you

Nadine Cooper
6.2  Letter to Interschools Team Manager
Dear Interschools Coach

I am currently undertaking a postgraduate research degree specialising in Alpine sports injuries at the University of Canberra. A major part of my thesis involves collecting information regarding risk-taking and Alpine injuries among Interschools children. It would be helpful if your school’s Alpine Interschools team could participate in the questionnaire. The questionnaires has been approved by the University of Canberra Committee for Ethics in Human Research and the NSW and ACT Department of Education and Training. The questionnaires are about children’s involvement with Alpine winter sports. The information given will be used to further the knowledge of Alpine injuries.

This research aims to analyse the pattern of risk-taking and sensation seeking behavioural characteristics among adolescents during Alpine activities. Their perception of risk-taking and to identify the social factors which effect occurrences of injuries and severity. The rationale behind the study incorporates the benefits of knowing higher risk-taking groups and how they relate to injury. This information can be used to assist in the design and implementation of more appropriate Interschools training and injury prevention programs.

For additional information regarding this research I can be contacted via email on nadine.cooper@student.canberra.edu.au or my supervisor Dr. Tracey Dickson on 02 62012465 or email her at: tracey.dickson@canberra.edu.au

Thanking you

Nadine Cooper
6.3 Instructions letter for Interschools Team Manager
Dear Interschools Team Manager

Thank you for your participation in this research. Following is a list of instructions to help make the process easier for you.

1. First could you please hand out the permission notes to be completed by a parent/guardian for the two part questionnaire. Part A should be completed pre-season (approximately 10-15 minutes) and Part B after the season (approximately 5 minutes).
2. Collect completed permission notes. When the parent/guardian has given their consent the child is then able to participate.
3. When you are ready to administer the questionnaire have the child/children sit apart to maintain confidentiality.
4. Before the child/children start the questionnaire please read them these instructions:

   This questionnaire is about your involvement with Alpine winter sports. The information you give will be used to further the knowledge into Alpine injuries.

   Please DO NOT write your name on this questionnaire. It is important that you complete the coding system on the 2nd page before you begin.

   The answers you give will be kept in private. No one will know what you write. Please try to answer the questions correctly. Make sure you read and answer every question. If you don’t feel comfortable with answering the questionnaire you may stop.

5. When all the children have completed their questionnaires, have them place them in an individual small sealed envelope then place them all in the larger envelope we have supplied. I will collect it, within 15 days of the initial delivery.

Thank you very much for your help.

Regards.

Nadine Cooper
MA Research Student
Tourism Program, University of Canberra
Ph: 0404965886
Email: nadine.cooper@student.canberra.edu.au
6.4  Letter of Introduction
Dear Interschools School Coordinator / Team Manager,

This is a letter of introduction and recommendation on behalf of the NSW Interschools and ACT Interschools Snowsports.

Nadine Cooper (no relation – just a lucky surname) is currently undertaking postgraduate studies under the supervision of Dr Tracey Dickson from the University of Canberra. Dr Dickson is the Australian National Secretary for the International Society for Skiing Safety. Nadine Cooper’s project involves the examination of children’s risk-taking and sensation-seeking behaviours with respect to snowsports. She is investigating the possibility of a correlation between snowsports injuries and risk-taking.

Part of this research involves collecting statistical information, and she has consulted with us to gain our agreement for this to occur. From an Interschools point of view this is an important and interesting project, and we give Nadine our full support, as the results have the potential to benefit our collective organisations.

Shortly, a package will arrive at your school either via mail or direct from Nadine, and we would ask that you may both distribute and collect the student surveys from those who have been involved in our events.

Thanking you.

Regards,

Steve Cooper
NSW Interschools Snowsports
29th May, 2006.
6.5 School Permission Note
Dear Parent/Guardian

I am currently undertaking a postgraduate research degree specialising in Alpine sports injuries at the University of Canberra. A major part of my thesis involves collecting information regarding risk-taking and Alpine injuries among Interschool children. It would be helpful if your child could participate in the two part questionnaire. The questionnaires have been approved by the University of Canberra Committee for Ethics in Human Research. The questionnaires are about their involvement with Alpine winter sports. The information given will be used to further the knowledge of Alpine injuries.

This research aims to analyse the pattern of risk-taking and sensation seeking behavioural characteristics among adolescents during Alpine activities, and their perceptions of risk-taking and to identify the social factors which effect occurrences of injuries and severity. The rationale behind the study incorporates the benefits of knowing injury higher risk-taking groups and how they relate to injury. This information can be used to the design and implement more appropriate Interschool training and injury prevention programs.

The research involves a pre-season questionnaire addressing previous snow sport injuries and risk-taking behaviours at the snow, followed by a post-season questionnaire addressing sustained snow sport injuries over the current season and race placing in their chosen events. All information gathered is anonymous and confidential.

In order for your child to be involved we ask that you complete the permission slip below and return to the team manager, who will than administer the questionnaire. I do not require your child's name therefore the questionnaire will be anonymous and confidential. There will be a coding system to match part A and B of the questionnaire together involving the first four letters of their first name followed by the day and month they were born.

For additional information regarding this research I can be contacted via email on nadine.cooper@student.canberra.edu.au or my supervisor Dr. Tracey Dickson on 02 62012465 or email her at: tracey.dickson@canberra.edu.au

Thanking you.
Nadine Cooper

-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

I give permission for my son/daughter to complete both questionnaires.

Signed_____________________ (Parent/Guardian)

Date ______________________
6.6 *Pilot Part A Questionnaire*, distributed in prior to the 2006 winter season.
Interschool Racing Team
Questionnaire
Part A

Interschools 2006
Interschool Alpine Racing Team Questionnaire. Part A.

This questionnaire is about your involvement with Alpine winter sports. The information you give as will be used to further the knowledge into Alpine injuries. This is part A of the questionnaire, you will do part B at the end of the season.

DO NOT write your name on this questionnaire. Below there is a coding system which is required to match questionnaires A and B together at the end of the season. The answers you give will be kept in private and none of your friends or teachers will know what you write. You can choose not to answer some or all the questions.

Thank you very much for your help.

Write the first four letters of your name, followed by the day then the month you were born in. Example Katherine Henderson born on the 26th of January therefore her code would be Kath2601

________________

Demographics

1. **Age** (in years) __________
2. **Gender** Male ☐ Female ☐
3. **Postcode** of where you live __________
4. **Division** __________
5. **In which Snowsports are you competing in?**
   a. Alpine Skiing ☐
   b. Snowboarding ☐
   c. Cross-county ☐
   d. Other ________________
6. Dominant hand?
   a. Left  
   b. Right  
   c. Ambidextrous

Previous Experiences in Alpine sports.
7. How many seasons have you skied/snowboarded? (including this season)? ____________

8. How much ski/snowboarding have you done in total?
   a. Under 6 days  
   b. 7-13 days  
   c. 14-27 days  
   d. 28 days  
   e. Up to 8 weeks  
   f. More than 8 weeks

9. Have you ever had professional lessons in your preferred sport?
   Yes  
   No
   If yes, how many professional lessons did you have?
   a. 1-5 lessons  
   b. 6-10 lessons  
   c. More than 10

10. How many years have you been competing in Interschool? (including this year) ____________

11. What events do you participate in? (please tick)
    a. Snowboard G.S.  
    b. Boarder X  
    c. Alpine G.S  
    d. Moguls  
    e. X- Country  
    f. Skier X

12. Have you every tried any other of these snow sports?
   192
a. Alpine Skiing  □  b. Snowboarding  □  
  c. Telemarking  □  d. Cross-country skiing  □

**Previous Inquires in Alpine Sports.**

13. **Do you have any previous injuries that affect your snowsports participation?** eg. A knee injury

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

14. **Have you injured yourself in any Alpine sport prior to this season?**
   Yes  □  No  □

How many times? ________________

(If yes please complete the table writing the letter in each box)

<table>
<thead>
<tr>
<th>Were you?</th>
<th>E.g.</th>
<th>1(^{st}) Injury</th>
<th>2(^{nd}) Injury</th>
<th>3(^{rd}) Injury</th>
<th>4(^{th}) Injury</th>
<th>5(^{th}) Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Alpine Skiing</td>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Snowboarding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. X-Country skiing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| What were you doing at the time of injury? | a.   |                   |                   |                   |                   |                   |
|                                           | a.   |                   |                   |                   |                   |                   |
|                                           | b.   |                   |                   |                   |                   |                   |
|                                           | c.   |                   |                   |                   |                   |                   |

| When each injury occurred, were you? | c.   |                   |                   |                   |                   |                   |
|                                       | c.   |                   |                   |                   |                   |                   |
|                                       | a.   |                   |                   |                   |                   |                   |
|                                       | b.   |                   |                   |                   |                   |                   |
|                                       | c.   |                   |                   |                   |                   |                   |

| Were you treated by? | a.   | Treat yourself   |                   |                   |                   |                   |
|                      | b.   | Friend/family helped |                   |                   |                   |                   |
c. Ski Patrol
d. Doctor (not in hospital)
e. Physiotherapist
f. Ambulance
g. Hospital

<table>
<thead>
<tr>
<th>What areas did you injure that needed medical assistance?</th>
<th>E.g.</th>
<th>1\textsuperscript{st} Injury</th>
<th>2\textsuperscript{nd} Injury</th>
<th>3\textsuperscript{rd} Injury</th>
<th>4\textsuperscript{th} Injury</th>
<th>5\textsuperscript{th} Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please state where</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Did you have a helmet on? Yes or No

Did you have wrist guards on? Yes or No

Speed at time of accident?
\begin{itemize}
  \item a. Not moving
  \item b. Very slow
  \item c. Slow
  \item d. Moderately fast
  \item e. Fast
  \item f. Very fast
  \item g. Not specific to injury event
\end{itemize}

Difficulty of trail at accident site?
\begin{itemize}
  \item a. Green
  \item b. Blue
  \item c. Black
  \item d. Terrain park
  \item e. Half pipe
  \item f. Other (please state)
\end{itemize}

What was the cause of the accident?
\begin{itemize}
  \item a. Ran into somebody or something
  \item b. Lost control
  \item c. Somebody ran into me
\end{itemize}
15. Assume there are 1000 people participating in your preferred snow sport on the slopes one day. How many people do you think would injure themselves that day?
   a. Less than 1  
   b. 1-5  
   c. 6-10  
   d. 11-15  
   e. 16-20  
   f. More than 20

16. What do you think is the most common area of the body to be injured in your preferred snowsport? (please circle)
   Head  Face  Neck  Back  Chest  Shoulder  Elbow  Wrist  Hand  Thumb  Finger  Thigh  Knee  Ankle  Foot  Bottom  Other (Please state where) ___________
Protective Equipment.

17. Do you wear a helmet? Yes □ No □

If you do wear a helmet, do you wear it?

a. All the time □ b. Only racing □

c. Racing and training □ d. Sometimes □

If you don’t wear a helmet all the time, why not?

a. Don’t see the need □ b. Can’t get hold of one □

c. Too expensive □ d. Don’t like the look □

e. Uncomfortable to wear □ f. Other ______________

g. Don’t believe they will protect against injury □

18. Do you wear any other form of protection?

a. Wrist guards □ b. Back protector □

c. Crash pants □ d. Other ______________

19. Snowboarders; if you had to choose, what kind of wrist guards would you prefer?

a. Guards inside gloves □ b. Guards outside gloves □
Risks in Alpine Sports.

20. How dangerous would you rate the following activities to be for you?

<table>
<thead>
<tr>
<th>(Tick the appropriate box)</th>
<th>I don’t do this</th>
<th>I do this but there is NO risk</th>
<th>Slight risk</th>
<th>Fairly risky</th>
<th>Very risky</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed on piste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performing jumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using a half-pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Using a T-bar or pommel lift</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Using a chair lift</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using a terrain park</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed off piste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21. How often do you do the following?

<table>
<thead>
<tr>
<th>(Tick the appropriate box)</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring the doorbell and run</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sneak into places without paying</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ride a bike without a helmet on</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sleep outside in the</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bush</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ski/ride very fast down a hill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graffiti on walls or tables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perform in front of a big audience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steal from others including your family</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
6.7 *Pilot Part B Questionnaire*, distributed in after to the 2006 winter season.
Interschool Alpine Racing Team Questionnaire
Part B

Interschools 2006

This questionnaire is about your involvement in Alpine winter sports. The information you give will be used to further the knowledge into Alpine injuries. This is part B of the questionnaire you will have done part A at the beginning of the season.

DO NOT write your name on this questionnaire. Below there is a coding system which is required to match questionnaires A and B together. The answers you give will be kept private. None of your friends or teachers will know what you write. Please try to answer the questions correctly. Make sure you read and answer every question. Thank you very much for your help.

Write the first four letters of your name, followed by the day then the month you were born in. Example Katherine Henderson born in the 26th of January would be Kath2601
Previous experiences with your Alpine winter sports.

1. How many days did you ski/snowboarded this season? ________________

2. Did you have any professional lessons this season? (please tick)  Yes  ☐  No  ☐
   If yes, how many professional lessons you have?
   a. 1-5 lessons ☐  b. 6 -10 lessons ☐  c. More than 10 ☐

Snowsports Injuries this season.

3. Did you injure yourself this season? (please tick)  Yes  ☐  No  ☐
   If yes how many times? ________________
   (If you answered yes above please complete the table writing the injury in each appropriate box)

<table>
<thead>
<tr>
<th>Were you?</th>
<th>1st Injury</th>
<th>2nd Injury</th>
<th>3rd Injury</th>
<th>4th Injury</th>
<th>5th Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Alpine Skiing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Snowboarding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Other (please state)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What were you doing at the time of injury?</th>
<th>1st Injury</th>
<th>2nd Injury</th>
<th>3rd Injury</th>
<th>4th Injury</th>
<th>5th Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Racing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Free skiing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>When each injury occurred, were you?</th>
<th>1st Injury</th>
<th>2nd Injury</th>
<th>3rd Injury</th>
<th>4th Injury</th>
<th>5th Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Alone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. With friends</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. With family</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Were you treated by?</th>
<th>1st Injury</th>
<th>2nd Injury</th>
<th>3rd Injury</th>
<th>4th Injury</th>
<th>5th Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Yourself</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Friend/family helped</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Ski Patrol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Doctor (not in hospital)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Physiotherapist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Ambulance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What parts of the body did you injure that needed medical assistance?</th>
<th>1st Injury</th>
<th>2nd Injury</th>
<th>3rd Injury</th>
<th>4th Injury</th>
<th>5th Injury</th>
</tr>
</thead>
</table>

Did you have a helmet on?  Yes or No

Did you have wrist guards on?  Yes or No

Speed at time of accident?
   a. Not moving |            |            |            |            |            |
   b. Very slow |            |            |            |            |            |
   c. Slow |            |            |            |            |            |
   d. Moderately fast |            |            |            |            |            |
   e. Fast |            |            |            |            |            |
   f. Very fast |            |            |            |            |            |
   g. Not specific to injury event |            |            |            |            |            |
Difficulty of trail at accident site?
  a. Green
  b. Blue
  c. Black
  d. Terrain park rail/ box
  e. Half pipe
  f. Other (please state)

What was the cause of the accident?
  a. Ran into somebody or something
  b. Lost control
  c. Somebody ran into me
  d. Jumping
  e. Lost control
  f. Caught an edge
  g. Don’t know.

Race Placing
4. Complete the table below filling in the events you competed in. Indicating the events you competed in as an individual ONLY.

<table>
<thead>
<tr>
<th>Event</th>
<th>Regional</th>
<th>State</th>
<th>Australian Championships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowboard G.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boarder X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpine G.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moguls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-Country</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skier Cross</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Please state)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equipment Failure or Breakage.
5. Did any of your protective equipment break this season? (e.g. helmets) (please tick)
   Yes ☐ No ☐
   If yes how many times did each piece break?
   Helmet __________
   Wrist Guards __________
   Back Brace __________
   Other equipment types and how many times (please write) _______________________

Hydration and Food Intake.
6. Do you use a camel pack while free skiing/snowboarding? Yes ☐ No ☐
7. When you are skiing/snowboarding how often do you stop for a drink?
   Every hour ☐ Every 2 hours ☐ Once a day ☐ Never ☐
8. How many cups of water do you think you should drink a day while skiing/snowboarding? _______ cups of water
9. When you are skiing/snowboarding how often do you stop for a snack or meal?
   Every hour ☐ Every 2 hours ☐ Once a day ☐ Never ☐
6.8 Questionnaire for actual study
Snowsport Participation Questionnaire

This questionnaire is about your involvement with alpine sports. The information you give will be used to further the knowledge into alpine injuries. The answers you give will be kept in private and none of your friends or teachers will know what you write. Thank you very much for your help and please DO NOT write your name on this questionnaire.

**Demographics**

1. **Age** (in years) ____________  
2. **Gender** (please tick).  
   Male □   Female □  

3. **Postcode** of where you live. _________  
4. **Interschools division** ___________  

5. **In which Snowsports are you competing in?** (please tick, can tick more than one)  
   a. Alpine Skiing □  
   b. Snowboarding □  
   c. Cross-county □  
   d. Other _________________  

6. **Dominant hand?**  
   a. Left □  
   b. Right □  
   c. Ambidextrous □  

**Previous Experiences in Alpine Sports.**

7. a. **How many seasons have you skied/snowboarded?** (including this season)? ____________  
   b. **Who do you ski the most with?**  
   a. Friends □  
   b. Family □  
   c. Team □  
   d. Other _________________  

8. **How much ski/snowboarding have you done in total?**  
   b. Under 6 days □  
   c. 7-13 days □  
   c. 14-27 days □  
   d. 28 to 40 days □  
   e. 41 days to 8 weeks □  
   f. More than 8 weeks □  

9. **Have you ever had professional lessons in your preferred sport?**  
   Yes □  
   No □  
   If yes, how many professional lessons did you have?  
   a. 1-5 lessons □  
   b. 6-10 lessons □  
   c. More than 10 □  

10. **How many years have you been competing in Interschool?** (including this year) _______________  

11. **What events do you participate in?** (please tick)  
   a. Snowboard G.S. □  
   b. Boarder X □  
   c. Alpine G.S □  
   d. Moguls □  
   e. X- Country □  
   f. Skier X □  

12. **Have you every tried any other of these snow sports?** (please tick)  
   a. Alpine Skiing □  
   b. Snowboarding □  
   c. Telemarking □  
   d. XC skiing □  

**Previous Inquires in Alpine Sports.**

13. **Do you have any previous injuries that affect your snowsports participation?** eg. A knee injury  
   ________________________________________________  
   ________________________________________________  

14. **Have you injured yourself in any alpine sports that needed treatment?**  
   Yes □  
   No □  
   How many times? _______________ (If yes please complete the table writing the letter in each box)  

<table>
<thead>
<tr>
<th>Were you?</th>
<th>E.g.</th>
<th>1st Injury</th>
<th>2nd Injury</th>
<th>3rd Injury</th>
<th>4th Injury</th>
<th>5th Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Alpine Skiing</td>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Snowboarding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. X-Country skiing</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>d. Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### What were you doing at the time of injury?
- a. Racing
- b. Training
- c. Free skiing

### When each injury occurred, were you?
- a. Alone
- b. With friends
- c. With family
- d. Training/Coach

### Were you treated by? (You can have more than one answer)
- a. Treat yourself
- b. Friend/family helped
- c. Ski Patrol
- d. Doctor (not in hospital)
- e. Physiotherapist
- f. Ambulance
- g. Hospital

### What areas did you injure that needed medical assistance?
- Knee

### Did you have a helmet on? Yes or No
- Yes

### Did you have wrist guards on? Yes or No
- No

### Speed at time of accident?
- a. Not moving
- b. Very slow
- c. Slow
- d. Moderately fast
- e. Fast
- f. Not specific to injury event

### Difficulty of trail at accident site?
- a. Green
- b. Blue
- c. Black
- d. Terrain park
- e. Half pipe
- f. Other (please state)

### What was the cause of the accident?
- a. Ran into somebody or something
- b. Lost control
- c. Somebody ran into me
- d. Jumping
- e. Caught an edge
- f. No specific accident event
- g. Don’t know.

15. Assume there are 1000 people participating in your preferred snow sport on the slopes one day. How many people do you think would injure themselves that day?
- a. Less than 1
- b. 1-5
- c. 6-10
- d. 11-15
- e. 16-20
- f. More than 20

16. What do you think is the most common area of the body to be injured in your preferred snowsport? (please circle ONLY ONE)
Protective Equipment.

17. **Do you wear a helmet?**
   Yes □  No □

   If you do wear a helmet, do you wear it?
   a. All the time □  b. Only racing □  c. Racing and training □  d. Sometimes □

   If you don’t wear a helmet all the time, why not?
   a. Don’t see the need □  b. Can’t get hold of one □  c. Too expensive □  d. Don’t like the look □
   e. Uncomfortable to wear □  f. Other ____________  g. Don’t believe they will protect against injury □

18. **Do you wear any other form of protection?**
   a. Wrist guards □  b. Back protector □  c. Crash pants □  d. Other ____________

19. **Snowboarders; if you had to choose, what kind of wrist guards would you prefer?**
   a. Guards inside gloves □  b. Guards outside gloves □

Risks in Alpine Sports.

20. **How dangerous would you rate the following activities to be for you?**

<table>
<thead>
<tr>
<th>(Tick the appropriate box)</th>
<th>I don’t do this</th>
<th>I do this but there is NO risk</th>
<th>Slight risk</th>
<th>Fairly risky</th>
<th>Very risky</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed on piste (hill)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performing jumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using a half-pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using a T-bar or pommel lift</td>
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<tr>
<td>Using a chair lift</td>
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<td></td>
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</tr>
<tr>
<td>Using a terrain park</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed off piste (hill)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21. **How often do you do the following?**

<table>
<thead>
<tr>
<th>(Tick the appropriate box)</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
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</thead>
<tbody>
<tr>
<td>Ring the doorbell and run</td>
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<tr>
<td>Sneak into places without paying</td>
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</tr>
<tr>
<td>Ride a bike without a helmet on</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep outside in the bush</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ski/ride very fast down a hill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graffiti/write on walls or tables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skip classes at school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perform in front of a big audience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Steal from others including your family
Smoke or drink alcohol
How often do you think you take risk

Race Placing
22. Complete the table below filling in the events and placing you competed in ONLY as an individual.

<table>
<thead>
<tr>
<th>Event</th>
<th>Regional</th>
<th>State</th>
<th>Australian Championships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowboard G.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boarder X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpine G.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moguls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-Country</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skier Cross</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Please state)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equipment Failure or Breakage.
23. Did any of your protective equipment break this season?(e.g. helmets)
   Yes □ No □
   If yes how many times did each piece break?
   Helmet __________
   Wrist Guards __________
   Back Brace __________
   Other equipment types and how many times (please write) _______________________

Hydration and Food Intake.
24. Do you use a camel pack or carry a drink bottle while free skiing/snowboarding? Yes □ No □

25. When you are skiing/snowboarding how often do you stop for a drink?
   a. Every hour □  b. Every 2 hours □  c. Once a day □  d. Never □

26. How many cups of water do you think you should drink a day while skiing/snowboarding? _______ cups of water

27. How many cups of water do you drink? __________

28. When you are skiing/snowboarding how often do you stop for a snack or meal?
   a. Every hour □  b. Every 2 hours □  c. Once a day □  d. Never □

Thank you for participating in this questionnaire.
6.9 Correlative Study into Injury Epidemiology, Use of Protective Equipment and Risk Taking Among Adolescent Participants in Alpine Snow Sports Report (Published Work)
Correlative Study into Injury Epidemiology, use of Protective Equipment and Risk-taking among Adolescent Participants in Alpine Snow Sport.

REFERENCE: Nadine Cooper*, University of Canberra.

Abstract: Risk taking and sensation seeking behaviors have been found to be common among those engaging in activities such as mountaineering, deep sea diving, skiing and snowboarding, all of which may be considered relatively high-risk activities for accidental injury. Risk-taking behavioural characteristics have been identified as a possible explanation for the higher incidences of snowsport injuries. The numbers of children and adolescents participating in snow sports continues to rise in Australia. In the southern states of NSW and ACT, school snowsports racing entries since 2001 have increased by 204%. A exploratory questionnaire was conducted during the 2006 winter season to investigate injury trends, sensation seeking and risk-taking in the adolescent snowsport participation population. Sixty-six participants completed a questionnaire. The participants’ ages ranged from 12-18 years old with the mean age of 14 years. Alpine skiing accounted for 68.2% of the participants, snowboarding 21.2% and 10.6% cross-country skiing. Of the 66 participants, 33 suffered injuries prior to the 2006 winter season, with 19 participants having sustained two or more injuries and one participant was injured 10 times. There were a total of 72 injuries amongst the 66 participants. Of those injured, 62% were injured while free skiing or snowboarding, 28% during training and 10% while racing. The majority (74%) of injuries were sustained while skiing with friends, 13% skiing with family and 13% skiing alone. From these results there appears to be a direct correlation between risk-taking behavior and snowsport injuries.

KEYWORDS: children, alpine, ski, snowsports, injury and risk-taking.

Introduction

Alpine winter sports attract a proportion of the population including many children and adolescents, who have been introduced to the sport through school sponsored ski programs, local community clubs and with their families [3]. With the rise of children and adolescents participating in snowsports, school alpine programs have substantially increased in size. One school based alpine program is the Australian alpine school racing organisation called Interschools Snowsports. Interschools Snowsports is a series of organised competitions for both primary (5-12 years old) and secondary (12-18) school children. The events are conducted over a number of days throughout the winter season. The six disciplines include: Alpine Giant Slalom, Cross Country, Skiercross, Moguls, Snowboard Giant Slalom and Boardercross.

In two geographical areas, Southern New South Wales and the Australian Capital Territory, Interschool entries since 2001 have increased by 204 %, from 465 entries in 2001 to 1485 entries in 2006. Therefore the occurrence of alpine injuries may have increased substantially, which is not only a problem for the participating groups, but also represents a potential public health issue. As the numbers of children and adolescents participating in snow sports continues to rise
in Australia, it is important to have up to date research to help create snow safe programs to reduce injuries.

While recreational activities and sports are important for children’s healthy development and have a health-promoting benefit, it can also have a detrimental effect on their health in the form of injuries and accidents [6]. The international literature in alpine skiing and snowboarding overwhelmingly suggests an injury incidence rate of between 2 and 3.5 per 1000 skier visits [1,2]. Epidemiology studies advocate that children are over-represented in the Alpine injury data [14,21,23]. Canadian literature reports children to have an injury rate 1.86 times higher than the total population [7]. Whilst research from Austria reports school children participating in school snowboarding programs to have up to 15 injuries per 1000 snowboarder days and 10.6 injuries per 1000 snowboarder days requiring medical care [14].

Risk-taking and sensation-seeking behavioural characteristics have been identified as a possible explanation for the higher incidences of snowsport injuries [12,13]. These two personality characteristics have been linked together as a probable cause of accidental injuries. Little is known about risk-taking and sensation seeking in the adolescent population in relation to alpine winter sports injuries. With the increasing number of Interschools participants and the growing number of school ski based excursions to the snowfields; the injury trend may have changed. This study aims to determine whether a pattern exists in the adolescent population with regards to alpine based injuries, and risk-taking and sensation seeking characteristics.

This research aims to analyze the nature of injury, pattern of risk-taking and sensation seeking behaviours among adolescents during alpine activities, and their perceptions of risk-taking. The benefits of identifying higher risk-taking groups and how they relate to injury can be then used to design and implement more appropriate Interschools training programs, school based excursions and injury prevention programs.

The objectives of this study were to (i) identify adolescents with high risk-taking and sensation seeking characteristics; (ii) evaluating the participants’ demographics in relation to their alpine injury data and risk-taking and sensation seeking characteristics; (iii) quantify protective equipment usage, and attitudes among participants. This was achieved by conducting a questionnaire based survey addressing previous snow sport injuries and risk-taking behaviors at the snow, injuries sustained at the snow over the current season and if an Interschools participant gained a placement in their chosen events.

The researcher hypothesizes that individuals who score higher in risk-taking and sensation seeking scales will have a higher number of inquires sustained over each winter season.

**Method**

An exploratory pilot questionnaire based study of Southern NSW and ACT Interschools Alpine Racing Teams were conducted during the 2006 Australian winter season. The purpose was to investigate epidemiology injury trends, sensation seeking and risk-taking in an adolescent population. A questionnaire was designed based on past research from Zuckerman (1996) [25], and Langran (2005) [13]. The questionnaire had forty-six questions and an additional table to complete if they had sustained an alpine sports injury. The questions were subdivided into six
areas including: demographics, previous alpine experience, previous injuries in alpine sports, protective equipment, risk perception and risk-taking and sensation seeking characteristics. Each question typically required the participant to tick the result that was best suited to his/her situation. For example:

**Do you wear a helmet?**

- Yes [ ]
- No [ ]

If you do wear a helmet, do you wear it?

- All the time [ ]
- Only racing [ ]
- Racing and training [ ]
- Sometimes [ ]

Risk-taking and sensation seeking questions comprised of two tables with a total of fourteen questions. These questions were ranked one to five, five being the highest level of risk-taking, than the twenty-two scores for each individual were combined. A mean was derived from the total and called risk-taking characteristic scale.

After University ethics approval the study was then dispatched to 52 schools in Southern NSW and ACT. The amount of questionnaires distributed to each school was determined by the number of participants the school had registered for the 2006 Interschools racing season. School participant numbers ranged from two to sixty-five.

Packages were distributed to schools via post and was marked *Attention Alpine Interschools Organiser*. Each package contained an introductory letter to the Interschools organiser from the researcher, a letter of introduction from Southern NSW Interschools Manager supporting the research and encouraging schools support, instructions regarding the questionnaire distribution/return and envelopes to be distributed to each participating child. The envelopes the participating student received contained: an information letter about the project the for parents/guardians, a permission note for each student to be signed and returned to the teacher, four page questionnaire and a postage paid self addressed envelope to return the questionnaire. A total of 493 were distributed and each school was sent two follow up reminder letters to encourage the return of the questionnaires.

**Results**

Sixty-six participants completed the questionnaire with a response rate of 13.4%, 68.2% were female and 31.8% were male. The participant’s ages ranged from 12-18 years old with the mean age of 14.9 years (SD=1.8). Alpine skiing accounted for 68.2% of the participants, snowboarding 21.2% and 10.6% cross-country.

Of the 66 participants 33 suffered self reported injuries prior to the 2006 winter season that needed medical treatment, with 19 participants having sustained two or more injuries and one participant was injured 10 times. An injury was defined as having to require medical treatment. There were a total of 72 alpine sports injuries amongst the 66 participants prior to the 2006 winter season. In the 72 injury cases: 62% were injured while free skiing or snowboarding, 28% during training and 10% while racing. The majority (74%) of injuries were sustained while skiing/snowboarding with friends, 13% skiing with family and 13% skiing alone. The lower
extremity suffered the slightly more injuries at 52%, while the upper body accounted for the remanding 48% of injuries (Table 1).

**TABLE 1. Anatomical Injury Location**

<table>
<thead>
<tr>
<th>Primary Injured Region of the Body</th>
<th>Accidents with Injury</th>
<th>% of All Accidents with Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, Neck and Concussion</td>
<td>17</td>
<td>23.6</td>
</tr>
<tr>
<td>Shoulder and Upper Arm</td>
<td>7</td>
<td>9.7</td>
</tr>
<tr>
<td>Wrist and Hand</td>
<td>3</td>
<td>4.2</td>
</tr>
<tr>
<td>Back</td>
<td>7</td>
<td>9.7</td>
</tr>
<tr>
<td>Ribs</td>
<td>4</td>
<td>5.6</td>
</tr>
<tr>
<td>Hips</td>
<td>3</td>
<td>4.2</td>
</tr>
<tr>
<td>Knee</td>
<td>26</td>
<td>36.1</td>
</tr>
<tr>
<td>Lower leg</td>
<td>3</td>
<td>4.2</td>
</tr>
<tr>
<td>Ankle</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>72</td>
<td></td>
</tr>
</tbody>
</table>

In the questionnaire, participants were asked if they wore a helmet or other protective equipment and if so when; and if they did not, why not. It was through that there may have been a correlation between: injury, risk-taking and protective equipment usage. A total of 65 participants (98.5%) owned and wore a helmet at some stage in the season and 50 (75.76%) wore their helmets all the time (FIG 1). The result for protective equipment usage for this population is independent of risk-taking behavior and injury since the greater majority wore helmets.

**FIG. 1- Helmet Usage amount participants**

Risk-taking and sensation seeking was measured using fourteen questions. Questions were related to how often they partake in risking activities or event. The participants could choose
from five different answers and each answer was given a value: never (1), rarely (2), sometimes (3), often (4) and always (5). Participant’s scores were calculated by obtaining their mean score from the results of the fourteen questions. The score was then called the risk-taking characteristics score. The highest risk taking characteristics score was 5 and the lowest is 1. A reliability analyses was carried out to determine if the participant’s results of risk-taking were consistent. Cropbach’s alpha demonstrated a reliability of 0.789.

The figure (FIG. 2) represents the spread of participant’s risk-taking characteristics scale. The two participants on the far right have been excluded from the results because their high risk-taking characteristic score were 3.8 and 4.2 standard deviations greater than the mean. They were therefore considered to be outliers and excluded from analysis.

FIG. 2- Risk-taking Characteristics *Note 2 participants on right hand side have been omitted from statistical analysis.

Spearmen’s correlation between risk-taking and sensation-seeking (r=0.392) indicates a significant relationship (p=0.001) between injuries and risk-taking. The higher an individual scores in risk-taking and sensation seeking the more likely he/she were to have sustained an injury (FIG. 3).
FIG. 3 Risk-taking vs. the number of injuries sustained. FIG 3, represents all participants and some points on the graph may represent more than one participant’s results.

Discussion

It is acknowledged that this exploratory study was subject to inherent weaknesses and limitations that must be taken into account when interpreting the results presented. Firstly, the participants may not be representative of the general adolescent alpine population in Australia. The study targeted adolescents and not primary school children due to ethical considerations. This evidently excluded a large proportion of Interschools competitors. More than 85% of all questionnaires were not returned and it is likely that those who did return their questionnaire represent a slightly different sub-population of individuals interested in the topic or teachers had a greater influence therefore the results must be interpreted with care. The ratio of males/females would also have an impact on the results. Because the current research does not include a control group of non skiers/snowboarders, no relevant data could be analyzed concerning the number of injuries per 1000 skier days and the risk-taking differences between groups.

The incidence of injury in alpine sports is largely a function of the injury definition and the nature of the study. In this study injuries were those needing medical treatment, self described by the participant. The rate and nature of the participant’s injuries were analysed and one in two participants had been medically treated for an alpine injury. This result appears to be extremely high, in comparison to other literature. When reviewing a combined incidence of injury for skiers and snowboarders under the age of 18 Macnab [15] found there to be 4.8 injuries per 1000 visits
for those aged 7 to 12 and 4.4 injuries per 1000 visits for those aged 13 to 17. Machold’s [14] retrospective cohort study based on medically reported injuries for snowboarders found 15 per 1000 snowboarder days. Therefore there is a large difference, Hagel’s [9] critical examination of adolescent and children’s literature on skiing and snowboarding reported that literature has found an combined incidence of injury in skiers and snowboarders under 18 to be any were between 2.95 per 1000 skiers day [5] to 9.1 per 1000 skier days [9].

Injury characteristics and anatomical location of the study differs largely depending upon the particular alpine sport. Seventy six percent of those injures were skiers, therefore it is understandable why there is a high proportion of knee injuries. The lower extremity receives a lot of concentration in alpine research. While there is a large variation between different studies, almost all recognize the lower extremity as the most frequently injuries body region for skiers with proportions ranging from 22% [19] to 72% [9]. This is consistent with the results from this research. With the high proportion of helmets being used it was unexpected to see such a high proportion of head, neck and concussion injuries. Hagel [10] found similar rates from ski patrol reports of those under 18. Females reported 23.7% of head, back or neck injuries while males reported 35.5%. Depending on the injury definition, age and gender of the group literature reports head injuries account for between 5% [8] and 51.5% [17]. This high variability of head and neck injuries maybe related to data collection method. Ekeland and colleges used a case control study design with a resort medical centre, while Shorter and colleges performed a case serious study with admission to a pediatric trauma centre. This data was consistent with the link between injury and severity and head injuries [10]. Cadman and Macnab [4] stated that not all head and neck injuries are sever and only occasionally does spinal injury occur, and the higher incident of head, back and neck injuries appear to be more a precautionary measures than the occurrence of significant injuries.

The use of helmets and other protective devices has substantially increased in Australia and may be higher in other parts of the world. Protective equipment and attitudes among participants appear to be very positive with an increasing percentage of young children and adolescents are choosing to use protective equipment in Australian ski resorts.

The researcher hypothesizes that individuals who score higher in risk-taking and sensation seeking scales would have a higher number of injuries sustained over each winter season and the results supported this. It was identified that adolescents with high risk-taking and sensation seeking characteristics sustained significantly more injuries than those who scored lower in these scales. Although there have been independent effort to assess the prevalence of adolescent injury and the factors contributing to risk taking in adolescence, few investigations that the author is aware of have assessed the relationship between adolescent risk-taking behaviours and adolescents injury. One study examined the relationship between risky behavior and injury in young children. The study of preschool children found pre-injury behaviour or risky behaviour was a significant predictor of injury liability [20]. Similarly, Potts, Martinez and Dedmon (1995) found a relationship between risk-taking and injury in a sample of school-age children between the ages of 6 and 9 [16]. Although this was not the current studies target age bracket it provides evidence that there is a relation between behaviour and injury which may carry through to skiing/snowboarding behaviours.

The impact of peer influence on adolescent injury is another area that is yet to be examined closely in alpine epidemiology. Seventy-four percent of all injuries sustained in this selected
Conclusion

The current data does not suggest that there has been an increase in the number of injuries in Interschools snowsport races. The results showed less than 2% of the total injuries occurred while participating in racing events. Although no statistical conclusions can be made because the frequency of how often participants skied with family or friends, the majority of injuries occurred when participants were skiing/snowboarding with their friends. Research into risk-taking activities in the general community suggests that children and adolescents increase their risk-taking activities while with their friends. This fact may also hold true when participating in alpine sports. There is no literature available to support this area of research therefore it may be an area for future investigations.

In this sample group knees were the anatomical area injured most frequently, with the number of skier participants this result is consistent with other literature. If there were a larger number of snowboard participants one would have expected more upper extremity injuries, especially wrist fractures.

In this particular group risk-taking characteristics had a statistical relationship to injury. The higher a participants scored in risk-taking the greater chance there was that they sustained an alpine injury. Future studies could target children who scored higher in risk-taking questionnaires to participate in alpine awareness and injury prevention courses. Future children and adolescent educational programs aimed at minimizing injuries and improving injury awareness strategies will need to take risk perception issues into account. The identification of factors that define adolescent high risk-takers will help sports educators to target these groups for injury prevention programs. Subsequently the next challenge will be to develop education based programs in a format that is suitable and appropriate to such individuals.
References:


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CHAPTER 7: REFERENCES


