1997

A specialised upper body exercise system for injury risk reduction in adolescent rugby league players

Peter Gordon Ritchie

University of Wollongong

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A SPECIALISED UPPER BODY EXERCISE SYSTEM
FOR INJURY RISK REDUCTION
IN ADOLESCENT RUGBY LEAGUE PLAYERS

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

DOCTORATE OF EDUCATION

from

UNIVERSITY OF WOLLONGONG

by

PETER GORDON RITCHIE, M.Ed.

FACULTY OF EDUCATION

1997
Declaration

This thesis is submitted in accordance with the regulations of the University of Wollongong in partial fulfilment of the requirements of the degree of Doctorate of Education. The work described in this thesis was carried out by myself and has not been submitted to any other university or institution.

Peter Ritchie
1997.
ABSTRACT


Rugby League is a sport which can develop capacities for exemplary physical fitness, skill and courage. However, the cost of injuries suffered whilst playing Rugby League is of major concern to the players, to their coaches, and to the greater community as a whole, both in terms of the medical expenses involved in treating the injuries and in the loss of productive time and capacity due to injuries. Player preparation is of utmost importance in reducing the risk of injury inherent in a body contact sport such as Rugby League.

This research involved the study of the implementation of a specialised exercise system aimed at reducing the risk of upper body injuries for adolescent Rugby League players (N = 156). Injuries to the shoulder and the neck regions were the specific injury sites targeted.

Descriptive statistics, two-sample pooled t-tests, and chi-square tests were employed to analyse normative upper body fitness test data collected at pretests and posttests. Injury incidence monitoring was undertaken by the club personnel involved and by the researcher. The researcher regularly attended training sessions and games in the capacity of skilled observer to monitor training procedures and injury incidence. Survey instruments were developed to obtain further data on dependent variables such as amount of training time devoted to the exercises and player opinions of the effectiveness of the prescribed preventive exercises.

The study found significant differences in the injury rates experienced by the subject population. The study also demonstrated results which indicated the exercise system influenced changes in fitness on a number of specific upper body fitness tests with implications for future injury risk reduction strategies.
The major finding for body contact sports was that high levels of specific shoulder endurance, as demonstrated by the Behind Neck Press Endurance low-weight barbell press-ups test, exposes the athlete to a significantly greater risk of very serious shoulder injury such as dislocation of the gleno-humeral joint. The experimental exercise system which targeted anterior as well as posterior overhead arm and shoulder strength development was shown to significantly decrease behind the neck shoulder endurance of this type, and therefore the program reduced the risk of very serious shoulder injury.

Accepted current practice discounts the importance of weight training exercises at angles behind the neck, and the researcher’s tendency to favour a “more balanced” resistance training development of the body musculature has been vindicated by the findings of this study. Many sports trainers, even at the elite professional level, employ weight training programs that emphasise power components using the Olympic Lift and Bench Press. These exercises concentrate on power development for anterior arm and shoulder actions and slight anterior overhead arm and shoulder actions. There is, however, a tendency to discount (and hence neglect) the importance of an all-round program that would of necessity include behind the neck shoulder power development exercise inclusions. The experimental exercise system indicated a need for conditioning programs with a component of behind the neck shoulder development because such a component is of particular importance in reducing upper body injury risk in those athletes identified as possessing high levels of behind the neck shoulder endurance. The exercise schedule developed is therefore a positive contribution to knowledge in the field of preventive sports medicine.

The study also incidenced a dangerous example of Rugby football code referees sometimes allowing hazardous game practices such as “screwing” or “collapsing” the scrum to go unpunished. Although the minor neck injuries attributed to such circumstances in the study did not require medical treatment, there were serious implications for players being placed at risk of possible catastrophic neck injuries and further steps should be taken by the respective administering bodies to ensure that this practice is completely eliminated.
ACKNOWLEDGEMENTS

The writer wishes to express appreciation and gratitude to his supervisors for their invaluable assistance throughout this work; Dr Paul Webb (Education) for his guiding hand and for being a source of on-going encouragement, Dr Ted Booth (Education) for his inspiring positive attitude, and Dr Graham Ward (Biomedical Sciences) for his expectations and his energising grasp of the subject matter. Further, in appreciation of fine academic support, I express my gratitude to Dr Ken Russell (Applied Statistics) for his statistical expertise.

Thanks must also go to Mario Solitro for his technical and construction knowhow over and above the call of duty in co-formulating the design and constructing the neck testing apparatus. Thanks to Richard Caladine for photography, and studio quality audio taping equipment. Gratitude to John Preston is expressed for editing skills.

The following people are thanked for their assistance, selflessness and openness in logistical support during the data gathering phases of what has proved to be an arduous but very rewarding experience: Tony Green, Nathan Walker, Robert Mooney, Nathan Giles, Ben Gallaty, Damien Patterson, Sarah Chipman, and Carlo Trimboli.

Special thanks to the football clubs for allowing the interruptions to their normal programs:

Penrith Panthers Rugby League Football Club personnel; Mal Gower, Gavin Perkins, Glenn Peterson, Sam Romano, Jim Jones, and their SG Ball players.

St George Rugby League Football Club personnel; Peter O'Sullivan, Andrew Collins, Ray Byrnes, Tony Barnes, Brian Smith, David Boyle, Max Ninis, and their SG Ball players.

Western Suburbs Rugby League Football Club personnel; Marshall Rogers, Glenn Beedle, Mick Reid, Ron Magnone, Mick Doyle, and their SG Ball players.
Cronulla Sharks Rugby League Football Club personnel; Michael Clinch, Paul “Bluey” Gilbert, Andy McDonald, Barry Russell, Peter Armstrong, and their SG Ball players.

Fairfield Patrician Brothers Rugby League Football Club personnel; Les Lees, Patrick Hafey, and their U/16 players.

Cronulla-Caringbah Black Cats Rugby League Football Club personnel; Kevin Taylor, Bill Newnham, Charley Bates, and their U/16 players.

Narellan Jets Rugby League Football Club personnel; Ray Hutton, Ashley Bourke, Pat Lord, and their U/16 players.

Campbelltown City Rugby League Football Club personnel; Kim Hailes, Mick Stewart, and their U/16 players.

I must not neglect to mention my gratitude to my Boorowa teaching experience and the people of Boorowa N.S.W. for rekindling my love for Rugby League football after a long hiatus of world wandering and wondering.

Finally, with all my heart, I wish to thank my family for their contribution to both my education and my courage to pursue my ongoing development.
# TABLE OF CONTENTS

ABSTRACT iii.
ACKNOWLEDGEMENTS v.
TABLE OF CONTENTS vii.
APPENDICES ix.
LIST OF TABLES x.
LIST OF FIGURES xv.

## CHAPTER 1. INTRODUCTION 1

1.1. Background 1
1.2. Purpose of the Study 4
1.3. Research Questions 5
1.4. Key Terms 7
1.5. Significance of the Study 9
1.6. Design 10
1.7. Limitations 11
1.8. Test Reliability 12
1.9. Validity 13

## CHAPTER 2. RELATED LITERATURE 18

2.1. Sports Injuries - Where they occur 18
2.2. Gender and Age 21
2.3. Injuries - Football Code Specific 22
2.4. Prevention of Injury to the Upper Body 32
2.5. Summary 44
## CHAPTER 3. METHOD

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Overview</td>
<td>47</td>
</tr>
<tr>
<td>3.2</td>
<td>The Subjects</td>
<td>51</td>
</tr>
<tr>
<td>3.3</td>
<td>Research Preparation and Procedures</td>
<td>52</td>
</tr>
<tr>
<td>3.4</td>
<td>The Experimental Treatment</td>
<td>53</td>
</tr>
<tr>
<td>3.5</td>
<td>Control Players</td>
<td>58</td>
</tr>
<tr>
<td>3.6</td>
<td>Fitness Tests and Data Gathering Procedures</td>
<td>58</td>
</tr>
<tr>
<td>3.7</td>
<td>Data Preparation and Analysis</td>
<td>68</td>
</tr>
</tbody>
</table>

## CHAPTER 4. RESULTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Overview</td>
<td>74</td>
</tr>
<tr>
<td>4.2</td>
<td>The Major Research Question</td>
<td>74</td>
</tr>
<tr>
<td>4.3</td>
<td>Related Research Questions</td>
<td>90</td>
</tr>
<tr>
<td>4.4</td>
<td>Overall Reception of the Study - Elite and Non-elite Levels</td>
<td>119</td>
</tr>
<tr>
<td>4.5</td>
<td>Summary of Results</td>
<td>121</td>
</tr>
</tbody>
</table>

## CHAPTER 5. DISCUSSION AND RECOMMENDATIONS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Discussion</td>
<td>128</td>
</tr>
<tr>
<td>5.2</td>
<td>Conclusions</td>
<td>142</td>
</tr>
<tr>
<td>5.3</td>
<td>Recommendations</td>
<td>144</td>
</tr>
</tbody>
</table>

Bibliography

viii
## APPENDICES

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPENDIX A</td>
<td>1987 Program - SPORTSAFE The Prevention of Neck and Head Injuries in Sport</td>
<td>155</td>
</tr>
<tr>
<td>APPENDIX B</td>
<td>The Experimental Treatment</td>
<td>161</td>
</tr>
<tr>
<td>APPENDIX C</td>
<td>The Test Instrument - Measuring Neck Fitness</td>
<td>164</td>
</tr>
<tr>
<td>APPENDIX D</td>
<td>Diagrams of At-risk Upper Body Articulations</td>
<td>168</td>
</tr>
<tr>
<td>APPENDIX E</td>
<td>Injury Data Gathering Forms -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medical History and Team Injury Reports</td>
<td>178</td>
</tr>
<tr>
<td>APPENDIX F</td>
<td>Player Survey Forms - Experimental and Control</td>
<td>182</td>
</tr>
<tr>
<td>APPENDIX G</td>
<td>Standard Format : Coach and Trainer Interview</td>
<td>189</td>
</tr>
<tr>
<td>APPENDIX H</td>
<td>Subject Participant Consent Forms -</td>
<td>191</td>
</tr>
<tr>
<td></td>
<td>Experimental Groups - Participant Consent Form</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>Parent/Guardian Consent Form</td>
<td>194</td>
</tr>
<tr>
<td></td>
<td>Neck Exercise Consent Form</td>
<td>196</td>
</tr>
<tr>
<td></td>
<td>Control Groups - Research Consent Form</td>
<td>198</td>
</tr>
<tr>
<td>APPENDIX I</td>
<td>Coach and Trainer Interview Reports</td>
<td>200</td>
</tr>
<tr>
<td>APPENDIX J</td>
<td>Pilot Study Summary of Results Leading to Fitness Testing Modifications</td>
<td>209</td>
</tr>
<tr>
<td>APPENDIX K</td>
<td>Data files for Tables and Figures - (Data stored on enclosed computer floppy disc)</td>
<td>211</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Severity Classification for Upper Body Injuries</td>
<td>15</td>
</tr>
<tr>
<td>2.</td>
<td>Upper Body Fitness Indicators As Tested</td>
<td>59</td>
</tr>
<tr>
<td>3.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Contingency Table - Elite Level - Shoulder Injury - Severity Classification: Very Serious</td>
<td>76</td>
</tr>
<tr>
<td>4.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Elite Level - Shoulder Injury Incidence - Severity Classifications Not Statistically Significant</td>
<td>77</td>
</tr>
<tr>
<td>5.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Elite Experimental Players - Benefit of Experimental Exercises in Increased Resistance to Upper Body Injuries - Cumulative Rating Scores</td>
<td>78</td>
</tr>
<tr>
<td>6.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Elite Experimental Players - Comparison of Total Time Performing Experimental Treatment Exercises In Minutes.</td>
<td>80</td>
</tr>
<tr>
<td>7.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Elite Level - Comparison of Total Game Time in Minutes - Experimental and Control Players</td>
<td>81</td>
</tr>
<tr>
<td>8.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Contingency Table - Non-elite Level - Neck Injury - Severity Classification : Able to play on</td>
<td>83</td>
</tr>
<tr>
<td>9.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Non-elite Level - Neck Injury Incidence - Severity Classification - Moderate - Not Statistically Significant</td>
<td>85</td>
</tr>
<tr>
<td>10.</td>
<td>RHH&lt;sub&gt;1&lt;/sub&gt;Injuries - Non-elite Experimental Players - Comparison of Total Time Performing Experimental Treatment Exercises In Minutes</td>
<td>87</td>
</tr>
</tbody>
</table>
LIST OF TABLES cont’d

11. RHH1Injuries - Non-Elite Level - Comparison of Total Game
    Time In Minutes - Experimental and Control Players 88

12. RHH2Fitness Increases - Elite and Non-elite Levels -
    Comparison of t-Test Results - Mean Scores Changes From
    Pretest To Post-test - Shoulder Flexibility - Prone Rod Lift 91

13. RHH2Fitness Increases - Elite level - Upper Body Fitness Test -
    Neck Flexibility - Head Rotation - Left + Right - Total Degrees -
    Experimental and Control Players 92

14. RHH2Fitness Increases - Elite Level Significant Mean Scores Changes -
    Upper Body Fitness Test - Shoulder Flexibility - Prone Rod Lift -
    Experimental and Control Players 94

15. RHH2Fitness Increases - Elite Level Significant Mean Scores Changes -
    Upper Body Fitness Test - Neck Flexibility - Flex and Extend -
    Total Degrees - Experimental and Control Players 95

16. RHH2Fitness Increases - Elite Level Significant Mean Scores Changes -
    Upper Body Fitness Test - Neck Flexibility - Lateral Flex - Left & Right -
    Total Degrees - Experimental and Control Players 96

17. RHH2Fitness Increases - Elite Level Significant Mean Scores Decreases -
    Upper Body Fitness Test - Behind Neck Press Endurance -
    Experimental and Control Players 97
LIST OF TABLES cont’d

18. RHH2Fitness Increases - Elite Level Significant Mean Scores Decreases - Upper Body Fitness Test - Shoulder Flexibility - Internal Rotation - Left & Right Arm - Total - Experimental and Control Players 98

19. RHH2Fitness Increases - Elite Level Mean Increase Scores That Were Not Significant - Experimental and Control Players 99

20. RHH2Fitness Increases - Non-elite Level - Mean Scores Increases - Upper Body Fitness Test - Behind Neck Press Strength - Experimental and Control Players 102

21. RHH2Fitness Increases - Non-elite Level - Mean Scores Decreases - Upper Body Fitness Test - Shoulder Flexibility - Internal Rotation - Left & Right Arm - Total - Experimental and Control Players 103

22. RHH2Fitness Increases - Non-elite Level - Mean Increase Scores That Were Not Significant - Experimental and Control Players 104

23. RHH2Fitness Increases - Non-elite Experimental Players - Benefit of Experimental Exercises in Increasing Upper Body Fitness - Cumulative Rating Scores 105

24. RHH3Shoulder Specific - Elite Level Comparison One - Behind Neck Press Endurance - Treatment and Control Players 107

25. RHH3Shoulder Specific - Elite Level Comparison One - Behind Neck Press Endurance - Very Serious Shoulder Injuries - Injured and Not Injured Players 108
LIST OF TABLES cont’d

26. RHH3Shoulder Specific - Elite Level Comparison One -
   Behind Neck Press Endurance - Very Serious Shoulder Injuries -
   Posttest Scores - Experimental and Control Players -
   Injured Player Scores Omitted 109

27. RHH3Shoulder Specific - Elite Level Comparison One -
   Behind Neck Press Endurance - Very Serious Shoulder Injuries -
   Increases Scores - Experimental and Control Players -
   Injured Player Scores Omitted 110

28. RHH3Shoulder Specific - Elite Level Comparison Two -
   Behind Neck Press Strength - Treatment and Control Players 111

29. RHH3Shoulder Specific - Elite Level Comparison Two -
   Behind Neck Press Strength - Very Serious Shoulder Injuries -
   Injured and Not Injured Players 111

30. RHH3Shoulder Specific - Elite Level Comparison Three -
   Shoulder Flexibility - Internal Rotation - Left and Right Arm -
   Total - Treatment and Control Players 112

31. RHH3Shoulder Specific - Elite Level Comparison Three -
   Shoulder Flexibility - Internal Rotation - Left and Right Arm - Total -
   Very Serious Shoulder Injuries - Injured and Not Injured Players 113

32. RHH3Shoulder Specific - Elite Level Comparison Four - Shoulder
   Flexibility - Lying Prone Rod Lift - Treatment and Control Players 114
LIST OF TABLES cont’d

33. RHH3 Shoulder Specific - Elite Level Comparison Four - Shoulder Flexibility - Lying Prone Rod Lift - Very Serious Shoulder Injuries - Injured and Not Injured Players 115

34. RHH4 Neck Specific - Non-elite Level Comparison One - Neck Strength - Flexion Left & Right - Total Repetitions - Treatment and Control Players 116

35. RHH4 Neck Specific - Non-elite Level Comparison One - Neck Strength - Flexion Left & Right - Total Repetitions - ‘Able to play on’ Neck Injuries - Injured and Not Injured Players 117

36. RHH4 Neck Specific - Non-elite Level Comparison Two - Neck Flexibility - Head Rotation - Left & Right - Total Degrees - Treatment and Control Players 118

37. RHH4 Neck Specific - Non-elite Level Comparison Two - Neck Flexibility - Head Rotation - Left & Right - Total Degrees - ‘Able to play on’ Neck Injuries - Injured and Not Injured Players 118

38. Elite and Non-elite Level Control Players - That the Study was Beneficial (%) 121
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Study Time Chart, 1995</td>
<td>73</td>
</tr>
<tr>
<td>2.</td>
<td>RHH₁Injuries - Non-elite Experimental Players - Benefit of Experimental Exercises for Increasing Resistance to Upper Body Injuries</td>
<td>86</td>
</tr>
<tr>
<td>3.</td>
<td>RHH₂NFitness Increases - Elite Experimental Players - Benefit of Experimental Exercises for Increasing Upper Body Fitness</td>
<td>100</td>
</tr>
<tr>
<td>4.</td>
<td>Elite and Non-elite Experimental Players - Time Taken Performing Experimental Exercises Could Have Been More Usefully Put Into Other Training</td>
<td>120</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

1.1 Background

"If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health."
Hippocrates 460 - 377 BC

Playing sport is often the means by which the "right amount" of exercise is achieved in our fast-paced modern society. Exercise through play and sport has self-evident beneficial effects upon our fitness and sense of well-being. Physical effects can be seen in increased stamina and better weight control, in the strengthening of muscles, and in improvements to mobility and balance. At the same time the benefits to our recreational and social lives are immense. In medical terms there are strong indications that regular physical activity contributes towards delaying those degenerative disorders which are an inevitable part of aging; particularly in contributing towards prevention of the major public health concern of cardiovascular disease. Peterson and Renstrom (1994) state;

Awareness of the potential benefits of exercise, together with a changing social and economic climate, has meant that most of us now have a considerable amount of leisure time during which we can undertake beneficial physical activity. This has led to greater numbers of people participating in sports on a regular basis. Simultaneously there have been changes in attitudes within competitive sport which have produced greater pressure upon individuals to produce even more spectacular results. Both developments have involved increased pressure on medical services (p. 12).
In our Australian context, it is essential that the prevention of sports injuries be recognised as a major public health goal. Several reports have identified the promotion of sports and recreational safety as an issue in need of urgent and thorough attention (Egger, 1990; Egger, 1991; The Australian National Health Goals and Targets (Nutbeam et al, 1993) and the 1994 Victorian Injury Control Strategy (Victorian Department of Health and Community Services, 1994)).

The costly problem of sports related injuries is a matter of concern. An additional problem is that, because of the threat of possible injury, people may be discouraged from undertaking beneficial physical activity through sporting pursuits. The financial burden to the community as a whole must be examined in terms of the medical expenses involved as well as in the reduced productive capacity of the injured individual and those who must care for them. Egger (1990) estimates an annual Australian sports injury toll of 1,000,000, which indicates that 1 in 17 Australians will incur a sports related injury in any year. He suggests that 200,000 of these sports injuries are regarded as serious, and that surgical intervention or hospitalisation are required by 40,000 of these cases. Egger (1990) also estimates that the cost of sports injuries to Australia is in the vicinity of $1 billion per year. These statistics are alarming, but of even greater concern to sports enthusiasts of all ages is that "between 30-50% of sports injuries are potentially preventable" (Egger, 1990, p.5).

The theme of this research was to investigate whether sporting injuries can be prevented, and in particular to show the need for programs to reduce the risk of upper body injuries in the body contact sport of Rugby League football. Finch (1995) states;

The goal of sports injury prevention is to reduce the incidence of injury without changing the essential nature or appeal of a sport. Experience has shown that many injuries can be prevented by the adoption of countermeasures such as adequate adult supervision of sport (for children); enforcement or modification of game procedures and rules; the use of protective equipment or clothing; modification of sporting equipment or sporting environments; changing training and preparation practices; or by updating coach/trainer education (p.129).
Adolescent Rugby League players were targeted for this research in view of the accessibility of the subjects due to the researcher's personal history both as a Rugby League coach and as a Secondary School Physical Education teacher. The researcher's personal history has provided access to, and experience in dealing with, adolescents of the same age groups as the Rugby League players in this study. Other research has found that preventive sports injury programs are best 'aimed primarily at adolescents for the most efficient use of resources' (Routley, 1991, p.8). Positive findings in this research add valuable knowledge to the field of preventive sports injury programs. School Physical Education (P.E.) and Sports activities generally are opportunities of primary importance for implementing such programs to instil positive attitudes and behaviours towards consistent preventive physical conditioning practices in the young athlete. There is a need for the young athlete to be better prepared for sporting pursuits, and hence by better preparation, the risks of sports injury could be decreased.

In New South Wales, programs have been introduced in the last ten years to address the problem of sports injury to the upper body. However, in a relatively short period of time after implementation, the effectiveness of these programs has decreased dramatically because they lacked continuity. Provision of more scientific background and research of relevance might have induced sports players and trainers to sustain enthusiasm rather than discontinuing the programs after an initial period of support had passed. Such an instance occurred in New South Wales with the 1987 SPORTSAFE program, The Prevention of Neck and Head Injuries in Sport (Department of Sport and Recreation, 1987) (Appendix A, p. 141) which was introduced as a preventive measure against neck injuries. This program emphasised neck exercises to better prepare the players, and also emphasised body type suitability to player position to reduce the risk of neck injury in the football codes. A major contributing factor to the creation of the 1987 SPORTSAFE program emerged from the case of accidental neck injury sustained by a Wollongong athlete who was rendered quadriplegic after a scrum incident in a school football match. He was injured whilst playing in an unfamiliar position at hooker (centre front row) in a scrum (Howell, 1989).
In the researcher’s own study of the lasting effects of this 1987 SPORTSAFE (Ritchie, 1994) it was found that 70% of players reported that their school football coaches did not utilise the SPORTSAFE neck warm-up and conditioning exercises at football training, and only 43% of school players reported that their coaches had them perform the exercises prior to an actual competition game. This meant that 57% of school players were not fully prepared, in terms of warm-up neck exercises, for the body contact sport they were playing. This 1994 finding was despite the explicit 1987 instructions of the Department of School Education that legal liability would result from inadequate neck warm-up preparation prior to competition. This relatively small study of Illawarra Year 11 school students (N = 55) also reported four injuries to the neck, resulting in considerable loss of playing/participation time. Recent personal discussions with those involved indicated that none of the injured were on a specific strength building program for the neck (Ritchie, 1994). This research addresses the problem of the reduced effectiveness of preventive conditioning programs after the passing of the initial support period by providing evidence of the usefulness of on-going preventive programs.

1.2 Purpose of the Study

This research sought to provide evidence that the Specialised Upper Body Exercise System for Injury Risk Reduction in Adolescent Rugby League Players could be effective in the prevention of injury in these players, and indeed for prevention of injury in players of all body contact sports where such upper body injuries are likely to occur. Such evidence should encourage coaches and trainers to employ positive practices to better prepare athletes for taking part in activities where the neck and shoulders are at risk to injury. Specifically, the principal purpose of this study was to investigate the effects of an upper body exercise system in preventing upper body injuries to adolescent (generally aged 16 and 17 years old) Rugby League players.
1.3 Research Questions

The major research question investigated was:

Would a specialised upper body exercise and conditioning program reduce the incidence of sports injuries to upper body articulations in adolescent Rugby League players?

In addition, the following related research questions were investigated:

1. Would a specialised upper body exercise and conditioning program increase fitness as measured by select performance tests for strength, local muscle endurance and flexibility of the shoulders and neck?

2. Would a specialised upper body exercise and conditioning program produce changes in select upper body fitness measures that indicate areas of vulnerability to shoulder injury in adolescent Rugby League players?

3. Would a specialised upper body exercise and conditioning program produce changes in select upper body fitness measures that indicate areas of vulnerability to neck injury in adolescent Rugby League players?

Data gathered to provide answers to these questions were used for the purposes of testing the following research hypotheses:

H₁ Subjects on the upper body exercise program would not suffer as many upper body injuries as the non-program subjects.

The first statement of the hypothesis is based on the analysis of the injury rates in comparing the experimental group to the control group.

Null hypothesis, \( H₀ : \) All injury rates will be equal
Alternate hypothesis, \( H₁ : \) All injury rates will not be equal.
**H2** Subjects on the program would exhibit greater gains / increases on the upper body fitness parameters tested than those not on the program.

The second statement of the hypothesis is based on the analysis of the mean gains calculated from the pretests and posttests of upper body fitness parameters as tested.

Null hypothesis, $H_0 : \text{All mean gains will be equal}$

Alternate hypothesis, $H_1 : \text{All mean gains will not be equal}$

**H3** Subject performance tests of the shoulders for strength, local muscle endurance and flexibility will indicate areas of vulnerability to upper body injury in adolescent Rugby League players.

The third statement of the hypothesis is based on the analysis of the mean scores and mean gains calculated from the pretests and posttests of upper body fitness parameters as tested, these scores then compared to the analysis of the injury rates for the elite and the non-elite players.

Null hypothesis, $H_0 : \text{All mean scores and gains will be equal}$

Alternate hypothesis, $H_1 : \text{All mean scores and gains will not be equal}$

**H4** Subject performance tests of the neck for strength, local muscle endurance and flexibility will indicate areas of vulnerability to upper body injury in adolescent Rugby League players.

The fourth statement of the hypothesis is based on the analysis of the mean scores and mean gains calculated from the pretests and posttests of upper
body fitness parameters as tested, these scores then compared to the analysis of the injury rates of the elite and the non-elite players.

Null hypothesis, \( H_0 \) : All mean scores and gains will be equal.
Alternate hypothesis, \( H_1 \) : All mean scores and gains will not be equal

1.4 Key Terms

**Specialised Upper Body Exercise System**

The experimental exercises were designed for training and game venues not equipped with gymnasium facilities. The experimental treatment system included such exercises as assisted inclined push-ups, assisted handstand push-ups, static and dynamic neck exercises, and neck and shoulder flexibility exercises. (Appendix B, p. 147).

**Male Adolescent**

For the purposes of this study subjects were males between the ages of 16 years and 18 years.

**Sports Injury**

"Any condition which causes a player or athlete to miss a game or training, to leave the field of play, or to seek medical or First Aid attention" (Egger, 1991, p.28).

**Upper Body Injuries**

Those sports injuries occurring in the regions of the body above the level of the chest. There is particular reference in this study to injuries of the shoulder and the cervical spine.
Preventable Upper Body Injuries

Upper body injuries that are potentially preventable by means of a fitness and conditioning program such as conducted in this research. For example, a shoulder dislocation is potentially preventable by appropriate conditioning regimes, whilst a fracture of the nasal bone cannot be conditioned against and may only be preventable by means of appropriate rule changes in the conduct of the game, or by changes in the realms of stipulated protective equipment worn.

Elite Rugby League Player

For the purposes of this study an elite Rugby League player was one who competed in the S.G. Ball (Under 17 years of age) Sydney Metropolitan Competition in 1995. The SG Ball competition represents the highest level available for this age group, with teams representing four Winfield (now Optus) Cup professional Australian Rugby League clubs.

Non-elite Rugby League Player

For the purposes of this study a non-elite player was one who competed in the Under 16 years of age club competitions in 1995 in the areas from which the elite teams were drawn. These players had not been contracted to play for the elite teams (although there were players who were eligible to play Under 16's who were actually playing in the elite (SG Ball Under 17) category).

Progressive Overload Training Program

A system where the physical conditioning of a subject can be increased through a program using gradually increasing training loads. “Overload” refers to working with resistances greater than the subject is accustomed to. As the body adapts to the overload demands, new increases in load can be made to ensure that a rate of high adaptation (i.e.
increases in fitness) can be continually achieved. The body is “progressively overloaded” to yield higher and higher levels of physical fitness.

**Strength**

The maximal force or torque a muscle or muscle group can generate in performing a set activity at a specified or determined velocity. For example lifting a heavy barbell weight overhead in performing a 1 RM Military Press in 8 seconds.

**Endurance**

The muscle or muscle group’s ability to maintain specified actions involving combinations of concentric and / or eccentric muscle actions at a predetermined rate using sub-maximal loads to fatigue. For example, lifting sub-maximal barbell weights in the Behind Neck Press action at the rate of one repetition every 3 seconds to fatigue.

1.5 Significance of the Study

Injury prevention, where possible, is by far preferable to injury treatment. The adage “an ounce of prevention is worth a pound of cure” comes to mind. This study contributes to the body of knowledge and evidence that specific fitness programs can reduce the risks of injury in sport. Specifically, the neck or cervical region and the shoulder complex, as the subject body articulations under study, are in need of targeting as regions for specific conditioning regimens.

Specific conditioning regimens can be implemented at a relatively young age for players of body contact sports. By establishing in young people positive attitudes to scientific fitness programs a valuable contribution will be made for the betterment of the health of young athletes playing body contact sports.

The personal costs to the athlete in terms of the pain suffered and possible impairment as a result of disability incurred from sports injury is sufficient to warrant
preventive action. Add to this the cost of sports injury to the athlete and the community as a whole, in terms of medical costs and the loss of productivity of the sufferer and associated carers (Egger, 1991), and the problem becomes one of major importance. Preventive conditioning programs can reduce these costs by reducing the incidence of injury. Progressive implementation of such a program starts with the coaches, and as such, this study was also aimed at educating the coaches. The coaches should then implement the proven worthwhile programs into the training of the young athletes establishing an essential accepted body of practical knowledge and behaviour.

1.6 Design

The experimental design involved eight intact groups (teams). There were four elite teams and four non-elite teams, each elite team having a corresponding non-elite team drawn from the same geographical area eg. Western Suburbs (elite) and Campbelltown City (corresponding non-elite). Half of these four areas were randomly allocated as experimental and half as control. At the elite level there were 43 experimental players and 42 control players. At the non-elite level there were 37 experimental players and 33 control players.

The experimental players undertook the specialised upper body exercises at team training sessions under supervision of qualified training personnel, whilst the control players conducted their normal training regime without interference from the researcher. Player fitness and changes in player fitness were monitored by pretests and posttests during the period of the study. A pilot study had revealed a need to modify some of the prospective measurement procedures used to obtain the upper body fitness data, and these modifications were employed in the battery of fitness tests utilised for the study proper. Upper body injury rates were collected by the respective team training and management personnel, as well as by the researcher at the posttests. The researcher attended training and game situations on a rostered basis and appeared to the control players as a non-interfering skilled observer of training, games, and sports injury rates throughout the season.
There existed, however, circumstances which were unable to be controlled that could have affected the study results:

1. The elite experimental players were particularly affected by training time constraints since they were set specific quantities of training under professional supervision. There would have been times when the specific experimental treatment exercises would not have been performed because of these time constraints, or because of a waning or lack of complete conviction by training staff to implement the full specifications of the program.

2. The specialised strength training program may have provided a limitation to the study in having to be undertaken often without direct supervision of the researcher. At such times the program was implemented by the professional training personnel employed by each experimental team. This strength training program relied substantially on player and training personnel motivation to ensure completion of the exercises utilising maximal effort, and this may also have provided a limitation.

3. The strength testing program may have provided a limitation to the study in that measurement of the targeted upper body fitness parameters required tests that differed from the program exercises undertaken by the experimental players. This testing program was used to neutralise differences in player weight and height so that all test participants were working with identical loads. The testing personnel, although personally trained and repeatedly rehearsed by the researcher, may also have provided a limitation to the study.

4. The control players may have become aware of the parallel program being undertaken by the experimental players and thus adapted their own training programs without disclosing that they had changed their training. In fact, there was some awareness of the parallel program, but player surveys revealed that none of the control subjects had adapted their training in any way because of this (Appendix J, p. 211. Tables 34a & 34b).
5. That the control players may have been influenced by the testing program and the experimenter's presence to produce a distorted bias towards upper body conditioning over the course of the study. This did not occur, as revealed by the player survey responses to questions about the usefulness of the study and whether the control subjects had adapted their training to achieve better personal outcomes as a result of exposure to the pretests used in the study (Appendix J, p. 211. Tables 34a & 34b).

6. That various subjects may have been undertaking, under their own initiative, quite separate conditioning and weight training regimens both at team training and in their own free-time, without disclosing that information.

7. The players, when surveyed to ascertain the importance of the above limitations, could have provided answers they felt the researcher needed or wanted to receive. The players could also have provided biased answers about their perceptions of the researcher and the usefulness of the study.

8. The coaches and trainers interviewed could have provided biased answers toward what they felt the researcher needed or wanted to receive, and their own perceptions about the researcher and the usefulness of the study.

1.8 Test Reliability

Test reliability was controlled for by the test batteries being employed at pretest and posttest only, therefore there was no familiarity with this particular test form created by repeated testings. Test reliability was also controlled for by the strict prescription of procedures for the use of testing instruments and the protocols for achieving the scores on the various tests. Mechanical devices purchased from commercial suppliers were used for testing. The weight / barbell equipment was calibrated using Tanita Model 1567 / 1607 Digital (Electronic) Scales. These commercial testing apparatus were combined with common objective measurements such as a one weight lift repetition to ensure that the tests could be readily replicable. The neck testing apparatus operated on
straightforward weight resistance principles employed in many gymnasium multi-station weight training units. The neck apparatus consisted of simple mechanical devices such as cables, pulleys and commercially available weight plates. Test assistants were personally trained by the researcher and trial tests conducted repeatedly in training until the assistant's results approximated those of the researcher.

1.9 Validity

1.9.1 Internal Validity

The history factor affecting internal validity was controlled for by the secretive nature of the experimental treatment exercise program. The experimental players were informed of the importance of this study and the need to keep the other (control) players uninformed on the nature of the specialised exercises. Player surveys yielded control group responses as to their awareness of any parallel study program, and as to whether they (the control subjects) actually changed any of their training practices according to any knowledge of the alternative program. The comparative rate of player involvement in the weight training programs was established from the survey response data.

The selection factor affecting internal validity was controlled for by the use of intact, randomly-selected groups whose category in the study were “drawn from a hat”. The four elite areas from which the players were drawn were placed “in a hat” and another four cards indicating the experimental or control categories (two of each) were placed in another separate “hat”. The draw was performed by Dr Ken Russell of the University of Wollongong Department of Statistics, and categories were allocated randomly according to the draw, determining which teams participated as experimental and which as control in the research. However, in controlling for selection the problem of randomisation took a turn for the worst early in proceedings. Approval of all club coaching and training personnel at the age levels to be studied had already been gained for the eight prospective clubs, and random selection had already taken place “from the hat”, allocating experimental and control status to both elite and non-elite levels, when a senior official (over-ruling his coaching staff) decided that his club was not to be included because of the interruption to the established normal training routine. Such
trials are sent to test the researcher, and it was rather disappointing from the perspective of this researcher because of particular allegiance to that club, and because the random selection of that club offered a chance to work with that club as an experimental elite group. Hasty reorganisation had to be made, and one of the formerly selected control teams had to be reallocated to experimental status because of that club’s training personnel support. Another club quickly accepted an offer to join the study, and was allocated the then vacant elite control team status. The researcher had absolutely no prior knowledge of intact group fitness levels, so from that point of view there was random selection of unknown intact groups.

The maturation factor affecting internal validity was controlled for by the elite level and non-elite level scores being kept separate for treatment purposes. Therefore, since each age group was compared only for its own age group, maturation over the season was assumed to have occurred consistently with no differences experienced by experimental or control subjects.

The testing factor affecting internal validity was controlled for by surveying the subjects to determine if any extra weight training was undertaken in order to achieve a better score on upper body fitness tests from pretest to posttest. Coach and trainer interviews were also utilised to determine the practices employed at team training, and whether these represented a marked deviation from their normal training practices.

The instrumentation factors affecting internal validity were controlled for by all testers being enthusiastic and creating an air of competition amongst the subjects so that maximal motivation for best test results was maintained. The tests measured the fitness parameters of local muscle endurance, strength and flexibility as intended. The same testers were maintained from pretest to posttest and the same measures were used from pretest to posttest. Also, prescriptive reporting of the degree of injury suffered was not open to instrumentation bias because of the researcher’s simple criteria for determining injury degree (Table 1. Severity Classification for Upper Body Injuries).

Table 1.
Severity Classification for Upper Body Injuries

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Able to play on</td>
<td>Injured during the game; not taken from the field. Or injured during game; taken from the field and replaced, then rejoined competition later in the same game. Missed no subsequent games; i.e. played next week.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Injured during game; taken from the field and replaced, did not rejoin the game. Missed no subsequent games; i.e. played next week.</td>
</tr>
<tr>
<td>Serious</td>
<td>Injured during game; taken from the field and replaced, did not rejoin the game. Missed only one subsequent game; i.e. next week’s game missed.</td>
</tr>
<tr>
<td>Very Serious</td>
<td>Injured during game; taken from the field and replaced, did not rejoin the game. Missed more than one subsequent game.</td>
</tr>
</tbody>
</table>

A pilot study of the prospective measurement procedure was used to obtain the normative upper body fitness data. The pilot study yielded a need to modify some of the techniques that were initially envisaged because of testing session time constraints (Appendix J. p. 209). As mentioned in Test Reliability, testers were personally trained by the researcher during this pilot study period on specific tests, and a number of trials
undertaken until the test assistants were deemed as accurate in measurement of their tests. Testing protocols adhered to were as set out in The Test Instrument - Upper Body Fitness (p.). The problem of statistical regression was controlled for by including all scores in the results.

Experimental mortality was controlled for by the use of a relatively large pool of subjects (N = 156). There were subjects who discontinued participation during the study and their date of cessation was recorded, the analysis of data plan cited being statistically adequate to cope with this occurrence. According to the analysis of data plan cited, stability as a factor affecting internal validity was also controlled.

Subject expectancy was also controlled since the greater proportion of the control group was unaware of the experimental treatment exercise program. The researcher also attended training sessions and games for every club team on a roster basis without favouring any one experimental or control team.

1.9.2 External Validity

To obtain the upper body fitness data the pretests were carried out at the commencement of 1995 and the posttests were completed in September, 1995. These tests used common equipment, except in the case of the neck testing apparatus which was (purpose) specially designed for the testing tasks. The reactive effects of testing were controlled for by the nature of the maximum effort required in each of the mechanical movements required in each test. There could be little chance of “sensitising” of the subjects as the length of one full season intervened between tests, and each subject had to perform to their maximum on each test at both pretest and posttest.

The interaction effects of selection bias were controlled for by the selection of team groups from a broad population where access was limited to teams willing to participate in the study. For example, for each team from the eastern suburbs of Sydney there was a corresponding team from the western suburbs of Sydney.
The reactive effects of experimental arrangements were controlled for by the researcher's attendance at training sessions and games for all elite and non-elite groups in the capacity of data collector. The data collected on overall upper body fitness and injury incidence was such so that no subject Hawthorne Effect bias was engendered by the presence of the researcher with any one subject group over another.
CHAPTER 2
RELATED LITERATURE

The literature was examined to provide a conceptual framework from within which to investigate the concepts involved in the research on this exercise system for injury risk reduction in adolescent Rugby League players. An overview was obtained on the sports pursued by young people, the locations where their sports injuries were suffered, and the prevalent anatomical sites of these sports injuries. The incidence of injury according to age and gender also provided a focus indicating the prevalence of sports injuries in adolescent males as opposed to males of other age groups or females of any age group. There was shown to be a high incidence of sports injuries in young males in the age group targeted by the study. The football codes were indicated as being responsible for a great number of the sports injuries suffered by adolescent males so there was a need to examine closely the literature on Rugby League, Rugby Union, Australian Football, and American "Gridiron" Football to identify possible similarities between codes in the types and causes of injury. Neck injuries and shoulder injuries warranted special attention so that a greater technical knowledge of the anatomy and mechanisms of injury of these injury-susceptible upper body sites could be gained. The literature on the role of physical training and conditioning in reducing the risk of upper body sports injury was of importance in establishing supporting evidence from past programs which had targeted strength and flexibility of the shoulder and neck.

2.1 Sports Injuries - Where They Occur

Sport Pursued and Location Where Injuries Occur

A one-year study in Springfield, Illinois (Zariczny, Shattuck, Mast, Robertson, and D’Elia, 1980) found that in a community of 100,000 people a total of 1,564
sporting injuries were suffered by 1,495 (6%) school-aged children out of the total school-aged population of 25,512. An injury was defined as "any traumatic act against the body sufficiently serious to have required first aid, filing of school and insurance accident reports, or medical treatment" (p. 318). Non-organized sports activities produced the largest number (637 or 47%) of injuries, followed by physical education classes (594 or 38%). Organised school sports produced 232 or 52% of the injuries, whilst community team sport accounted for an additional 111 or 7% of injuries. These findings indicate a greater danger in playing informal sport in that it is usually played away from adult supervision and often in the more dangerous "sandlot" or rough park physical environment.

Based on the Illinois data, there was definitely a need to address the problem of high incidence of injuries suffered within the confines of the school P.E. lessons under the supervision of the paid professional teacher. These data are for all sports, however, and when the data were examined it was found that 19% of all injuries were produced in football activity, which was the highest incidence of injury for any sport.

It was found that of all the injuries, one-half occurred in organised team sports, 36% in non-organised football games, and 14% in physical education classes. 27% of these injuries were classed as avoidable eg. injuries sustained by improper actions of other players (throwing a bat), and collision with obstacles in the line of play (eg. fences, parked cars).

Examining the Australian setting, Routley and Ozanne-Smith (1991) found, in a study of sports injuries to school children under 15 years of age, that the geographical locations of injuries were found to be; school playground 37%, sports court & oval 29%, residential 9%, school-not playground 5%, and other 20% (n = 2,654). These results would indicate a need to examine carefully the school environment since the high incidence of injury demonstrates a need for more "control" in that so-called "controlled" environment.
In another Australian study of Rugby Union players at Newington College, Sydney, Davidson, Kennedy, Kennedy and Vanderfield (1978) found that, for injuries presented at the school casualty room, the home team presented more serious injuries at their school site (1.65 / 1) than their visiting opponents. This was in part explained by the fact that the ‘Newington boys, no doubt, play harder on their home ground, therefore increasing their risk of injury’ (p.249). Personal experience would indicate that the “home crowd advantage” does indeed motivate most players to lessen notions of self-preservation in pursuit of victory at home.

2.1.2 Injuries By Anatomical Site

Sugerman (1983) tabulated a listing of 37 anatomical sites for injury registration (i.e. from ‘Scalp’ to ‘Toe’) in his study of 45,885 player/games during one season of Australian Schools Rugby Union. He found that the highest incidence of injury was recorded at the knee (12.1%), followed by the ankle (11.9%), then the shoulder (6.6%). This result (the greatest vulnerability being toward knee and ankle injuries) is consistent with other findings from the body contact football codes (Egger, 1990), (Zariczny et al., 1980). However, a number of studies of the football codes have found the incidence of sports injuries to be greater in body areas other than the knee and ankle. Carey (1991) found that, of 1,207 children and adolescent players of Rugby League and Rugby Union who presented at the N.S.W. Health Department Accident and Emergency Departments, the predominant injury sites were; arm injuries (24%), fingers (17%), shoulder (13%), head (14%), knee (8%) and ankle (6%). Davidson et al. (1978) indicated a greater proportion of serious injuries of the upper limb than those of the lower limbs.

In summary, the literature suggests that injury occurrence is influenced by the sport played, particularly indicating the dangers of sports involving body contact such as Rugby League, Rugby Union and Australian Football. Injury incidence is influenced by the venue at which the competition takes place, particularly highlighting the need for greater precaution at school and at non-organised “park” venues. Examination of the literature on the susceptibility of specific anatomical sites to sports injury produced some
evidence that the knee was the anatomical site most at risk, whilst other literature indicated that the shoulder and arm were more at risk. Dislocation of the shoulder was a common injury, with recurrent shoulder dislocation often necessitating surgical correction. Neck injuries had the potential to be the most serious, with injuries to the cervical spine sometimes resulting in quadriplegia, and the leading cause of fatal sports injuries in body contact sports.

2.2 Gender and Age

Sports injury distribution can be seen as a function of both gender and age. Routley and Valuri (1993) state that in Victoria;

Children’s sport injuries, although predominantly to boys, were somewhat more evenly distributed among the sexes than adult injuries. (Eighty-two percent of adult sports injuries were to men and 75% of children’s injuries were to boys). (p.2).

A study by Zariczny et al. (1980) which included schoolchildren of all grades, found that boys sustained double the number of sports injuries compared to girls; 1,055 (67%) to boys as opposed to 521 (33%) to girls. The highest rates of injury (8%) occurred for girls at age 14, whilst for boys this occurred at age 15, where 15% of boys incurred an injury.

Boys in the 10-14 years age group playing Australian Football in Victoria accounted for 81% of the total child injuries under 15 years (Routley, 1991), whilst the males who were 15 - 24 years of age suffered the greatest number of overall injuries (Routley and Valuri, 1993).

In Rugby League the Under 19 years age teams have been shown to sustain the highest injury frequency, ahead of the Under 17, followed by the Under 21 years teams. (Estell, Shenstone & Barnsley, 1995).
The fact that the playing population is predominantly male must be taken into account when considering injury rates in the football codes of Australian Football, Rugby Union, and Rugby League, although there has been a recent upsurge in the number of females playing these codes. As an indication of female participation in Rugby Union in New Zealand, a recent study has shown a trend for increasing female inpatient hospitalisations due to Rugby Union injuries. (Dixon, 1993)

The average age for spinal-cord injuries in both Rugby Union and Australian Football players is 24 years, whilst for Rugby League the average age of the spinal-cord injured player was 20 years. (Taylor and Coolican, 1987). It was also found that the peak spinal-cord injury frequency for the combined codes occurred at age 18 years.

Casualty room presentations in schoolboy Rugby Union indicated that the greatest incidence of injury occurred in boys aged from 16 - 18 years of age. (Davidson et al., 1978). The New Zealand Rugby Union (Dixon, 1993) reported an injury incidence of 7,063 / 100,000 (player position hours) for the under 15 years age group, and a considerable increase to 16,637 / 100,000 (player position hours) for the over 15 years age group.

In summary, there is little difference in injury rates according to gender in young children, but once adolescence is reached, the males are most at risk by the very nature of the sports they play. The most susceptible age for serious injuries in Rugby Union has been shown to be 16 - 18 years cohort, whilst the average age for spinal cord injured players in Rugby Union has been indicated as 24 years, and in Rugby League the average age for spinal cord injury has been indicated as 20 years of age.

2.3 Injuries - Football Code Specific

2.3.1 Rugby League

The Australian Sports Commission (1990) estimated injury risk rate in playing for one full season as being equal for the football codes; Rugby League, Rugby Union
and Australian Football. This injury risk was estimated as a 50% chance of suffering an injury in playing for one full season.

The total number of sports injuries attributed to Rugby League in proportion to that of the other football codes varies according to geographical location. The proportion of Rugby League injuries as a component of total injuries will naturally be greater in regions where Rugby League is the popular choice for participation. Naturally, this will differ when opposed to other regions where another football code such as Australian Football or Association Football (Soccer) may be more popular.

Personal contact with the respective national controlling authorities of the football codes in Australia revealed that the numbers of registered football players in 1995 were; Rugby Union 133,026 players, Rugby League 153,908 players, Australian Football 395,087 players, and Soccer 722,000 players. Recent studies of the football codes data indicate a higher percentage of Rugby League players are injured per year. An on-going study being conducted in the Junee area of N.S.W. reports that of the 507 member survey population, 68.5% of Rugby League players were injured in some way during the year, compared with 37.2% of Rugby Union players and 28.6% of basketballers (Walker, 1991).

The N.S.W. Sports Injury Committee calculates injury rates according to claims made against their Government run sports insurance scheme for both school and amateur level participants. The N.S.W. Sports Injury Committee (1988, cited in Australian Sports Commission, 1990) indicated that Rugby League was the highest risk category for catastrophic injuries encountered between 1983-1988. An incidence of 46.8% of the total 173 cases was accredited to Rugby League, whilst Rugby Union accounted for 13.8%, and Australian Football 11.5%. Allowance must be made for the scope of this study set in N.S.W., since there are greater numbers of players participating in Rugby League compared to the other (non-Soccer) football codes in N.S.W.. These data are contradicted by a study which indicates that Australia-wide the incidence of serious or “catastrophic” injuries (such as spinal cord injuries) is greater in Rugby Union rather than Rugby League (Taylor and Coolican, 1987).
A sports injury survey conducted at Westfield Sports High School (Anonymous, 1992) found that for sports injuries resulting in at least one day missed from school, Rugby League carried the greatest risk (25% of players), with Soccer the second greatest risk (21% of players). Personal experience holds for similar comparative risk for Rugby League players.

Analysing the findings of the Childsafe N.S.W. Injury Surveillance System, Carey (1991) reported that injuries to the head, neck, mouth and shoulder accounted for 54% of all upper body injuries to adolescents in Rugby League. Another study of injuries by body site indicated that lower limb injuries predominate in Rugby League (Alexander, Kennedy and Kennedy, 1979) with muscle haematomas, strains, and local contusion the diagnostic categories of highest incidence. These authors also state their concern at the incidence of head and neck injuries (16.5% of all injuries) since this anatomical region is 'potentially the greatest risk area'.

Injuries by player position were also a subject of the above study. In this study it was found that forwards suffered injury patterns differing from the backs. Forwards received more cuts, bruises, haematomas and head injuries, whilst backs were more susceptible to joint injuries. For concussion injuries, the ratio of forwards to backs was 12 : 1. (Alexander et al., 1979)

The danger of placing a player in a position to which he/she is unaccustomed, or unsuited by body build, is an unsafe practice evidenced by an unfortunate schoolboy quadriplegic case (Howell, 1989). The spinal-cord injury danger of playing out of position is significant. Findings by Taylor and Coolican (1987) reported that 22% of the spinal-cord injured players in their study were not playing in their usual positions and two-thirds of these players were injured in a scrum where they were probably not 'body equipped' for their position.

When researching Rugby League spinal-cord injuries by phase of play, Taylor and Coolican (1987) also recorded that 'tackles accounted for 69% of the injuries,
scrums for 29% of injuries, while 2% of players were injured in an unknown manner. The ball-carrier was injured in 76% of the tackles, and the tackler was injured in the remainder’ (p.116). Rule changes implemented to alleviate some of these dangers have been the enforcement of new laws on high tackles and “spear” tackles by the Australian Rugby League (Corcoran, 1994).

Australia-wide it would appear that the injury risk is shared equally amongst the football codes Rugby League, Rugby Union and Australian Football. However, in the greater part of New South Wales, Rugby League is the highest risk sport for upper body injuries. The tackle phase of play, both whilst being tackled and while being the tackler, is the riskiest activity for sustaining serious injury in the football codes.

2.3.2 Rugby Union

The playing of Rugby Union presents a high risk factor for sustaining sports injury. The high incidence of serious and even catastrophic head injuries incurred whilst playing Rugby Union is of concern. It was reported that there was a 50% risk of sustaining an injury if playing Rugby Union for one full season. (Australian Sports Commission, 1990) It was also found that the greatest incidence of casualty room presentations for schoolboy Rugby Union injuries occurred in boys between ages 16 -18 years. (Davidson et al., 1978) New Zealand research found that there was a considerable increase in New Zealand Rugby Union injuries for players over 15 years of age. (Dixon, 1993) In the New South Wales setting the Junee study found that 37.2% of players in Rugby Union were injured per year. (Walker, 1991)

Australia-wide there is a greater incidence of catastrophic injuries in Rugby Union than in the other football codes; and 24 years is the average age for spinal-cord injuries in this code. (Taylor and Coolican, 1987). By comparison, Silver (1984) found that the most vulnerable age for spinal injuries in British Rugby Union was between 15 and 21 years.
Dalley, Laing, Rowberry and Caird (1982) found that, with regard to age-related injury rates in New Zealand Rugby Union players, there were several interesting observations made about players in age/grades Under 20 years, Under 19 years and Under 18 years (grades at which the injury rates are highest);

Players in these grades are the more immature males, physically well developed but not hardened to the game, particularly so far as their mental approach is concerned. They display carelessness and unnecessary bravado, in their approach to the game. In the Under 18 grade, there is intense physical competition. This group also includes the ‘tough guys’ playing the ‘School Boys’ where ‘hardened’ school leavers of one to three years are playing their younger compatriots still in the school first fifteens. There is a glamour and ego satisfaction in the game for this age group and serious competitive spirit. Many players are trying to prove themselves and are vying for positions in top teams in their age group. Physical endeavour is maximal, and often this is the player’s first exposure to rugby of this intensity. Club selectors for representative games and the news media all accept this group of players as a nursery, or as a source for the champions of the future. Many players cannot cope with this sort of pressure (p. 8).

Injuries by body site have been observed as being more frequent in the knee and ankle regions in Rugby Union (Sugerman, 1983) and (Dalley et al., 1982). Conflicting findings by Sparks (1981) implicate concussions as being responsible for the greatest number of Rugby Union injuries. Sparks found almost twice as many concussion injuries as knee injuries when analysing 30 seasons of play, with players having notched up half a million hours of Rugby Union, at Rugby School, England. Whilst the above findings do differ, there is general concern surrounding the incidence and seriousness of upper body injuries generally in Rugby Union, and particular concern about injuries to the cervical region.

The superior skill level of the elite player is no safeguard against neck injury in Rugby Union. According to Howell (1989);

Even the expert player, according to the statistics, is not protected by his skill.
He is more at risk of paraplegia, either because of more vigorous play, or more deadly marking, and an overall excess of competitive effort (p.161).

Silver (1984) also found that skill level did not protect a player from injury in Rugby Union. He cited the high proportion of first class players injured from a total playing population including all grades. Similarly, Peterson and Renstrom (1986) offer the observation that as the level of competition increases the safety precautions also tend to increase, in part due to the increasing 'litigative nature of sporting involvement' (p.14).

The Dalley et al (1982) New Zealand examination of Rugby Union injuries by player position identified that head injuries were more common in forwards than backs, whilst leg injuries were more common in the backs. They also found that head, back, and chest injuries were more common in hookers and props, whilst hand injuries were most frequently observed in half-backs. Taylor and Coolican (1987) found that the player at the greatest risk of spinal-cord injuries in Rugby Union was the hooker in the scrum. Injuries in scrums occurred almost exclusively in players contesting the front row positions, hooker or prop.

Rugby Union injuries by phase of play strongly implicate as most frequent the player tackle. Dally et al. (1982) found the tackle twice as likely to cause injury as any other aspect of play, with 40% of severe injuries occurring during the tackle. The ball carrier was the most likely player to be injured in the tackle, but this statistic was only slightly greater than the injuries sustained in the tackle by the tackler. The outside backs were found to be the most susceptible to sustaining injury in the tackle, and the greater speed of the outside backs was cited as probably the reason for the greater injurious effect of the collision. Often the greater distance between opposing players in their respective backlines presented the situation whereby momentum could be built up, allowing for more errors in the timing and the lining up of the tackle. Therefore the tackle was more likely to be incorrect and/or technically dangerous.
Scher (1987) implicated the scrummage as the source of highest incidence of spine and spinal cord injuries for Rugby Union in South Africa. Tackles causing injury to the tackler’s head, injuries occurring as the result of a high tackle, and injuries as the result of a double or ‘sandwich’ tackle were identified as giving cause for great concern.

There have been a number of rule changes implemented to reduce what was an alarming increase in serious Rugby Union injuries. The work of Milburn (1990), which measured the forces involved in a scrum, has indicated the need for rule changes to “de-power” the Rugby Union scrummage. These findings have been acted upon by rule changes to this effect since 1990.

Reported in the literature is a considerable increase in risk of injury for players over 15 years of age in Rugby Union. Knee and ankle injuries, as well as concussions have been reported as being the predominant injuries to Rugby Union players. Players in the backs tend to suffer more leg injuries, whilst players in the forward pack tend to experience more head injuries, and once again the tackle was implicated as the main phase of play where the players were at risk to injury. However, rule changes implemented in Rugby Union have lessened the potentially injurious forces of the scrummage and future studies should report a lowered incidence of upper body injuries resulting from scrummmages.

2.3.3 Australian Football

Australian Football, whilst not subject to the same incidence of injury as Rugby League and Rugby Union, evidences sufficient injuries to warrant investigation. In Victoria boys of under 15 years who played Australian Football accounted for 81% of the total child injuries. (Routley, 1991). The age group 15 - 24 years is indicated as the grouping suffering the greatest number of injuries in Australian Football. (Routley & Valuri, 1993)

The average age for spinal-cord injury in Australian Football players is 24 years. (Taylor & Coolican, 1987) The estimated injury risk for one full season if playing

The Victorian Injury Surveillance System (VISS) data established that Australian Football had the highest presentation rate at Emergency Departments of participating VISS hospitals where the rate for Australian Football was 36% of all sports injury presentations. The majority of players injured were males (98%), and 11% of cases were admitted to hospital. (Routley & Valuri, 1993)

Australian Football injuries by body site indicate that lower limb injuries are the most common. Dicker, McColl and Sali (1986) found that lower limb injuries predominated with 60% of total Australian Football injuries, followed by head and neck injuries with 19%, upper limb with 12%, and trunk injuries with 9%. Routley and Valuri (1993) reported that although head injuries in Australian Football in Victoria represented only 6% of presentations to VISS Casualty Departments, 'a third of these were admitted to hospital, highlighting the severe nature of such injuries. Most of the head injuries were concussion and a third of these were admitted to hospital' (Routley & Valuri, 1993).

Injuries by phase of play produce interesting statistics. Taylor & Coolican (1987) concluded that in relation to spinal-cord injuries in Australian Football, 69% of the players were injured in a collision when neither player had the ball, and 19% of players were injured in tackles, whilst 12% of spinal-cord injuries occurred as the result of being hit by the ball in flight. A Victorian Injury Surveillance Scheme (VISS) study of Australian Football injuries resulting in hospital presentation showed that 47% of injuries were directly caused by an object or person hitting the victim; 25% by the victim hitting an object, surface or person; strain/over-exertion accounted for 17%; collisions accounted for 9%; and a very small percentage of cases (6 cases in all) involved the player either kicking or running into the goal post (Routley & Valuri, 1993).
In summary, Australian Football accounts for a very high percentage of injuries to players under the age of 15 years in Victoria where this code is the dominant football code. The lower body was the most common site of injury, but most interesting was the finding that a greater proportion of injuries actually occurred in collision when neither player had the ball.

2.3.4 American Football ("Gridiron")

The inclusion of American Football in this literature review has provided invaluable information because of the nature of American Football's incidence of serious sporting injuries in relation to our own Australian football codes. Although the codes of football which include Rugby League, Rugby Union and American Gridiron are similar in the physical contact of the games, the amount of protective padding, their use, and the types of padding used as "weaponry" have relevance to this study from the point of view of injuries sustained.

The incidence of cervical spine injuries in American football rose significantly when measured over two 5-year intervals as stated by Torg, Vegso, Sennett and Das (1985). For the period 1959 - 1963 there were 11.36 cervical spine injury cases per 100,000 injuries, compared to the period 1971-1975 when there were 4.14 cases per 100,000. Torg, Quedenfeld, Moyer et al. (1977) offer reasons for the above when they conclude;

These changes were attributed to the improved protective capabilities of the helmet-face mask unit developed during the 1960's and early 1970's, which provided better head and face protection. As a result, the use of the head as the primary source of contact in blocking, tackling, and head butting has occurred. (p.224 - 266).

The angle of the cervical spine most at risk was found to be approximately 30° of forward flexion, complicated by the striking of the opponent with the top of the helmet (top of the head). This caused axial loading of the cervical vertebra (discussed in next
section of Literature Review) which resulted in cervical fracture or fracture-dislocation
and spinal cord damage. (Torg, 1985)

Fatal injuries to the head and cervical spine in “Gridiron” by phase of play have
indicated that the tackler during the tackle as being significantly more at risk (Mueller
and Blyth, 1987). The risk of cervical spine injury and resultant quadriplegia by player
position in American football indicates that defensive backs are most at risk. Torg,
Quedenfeld and Burnstein (1977) found that at high-school level 52% of the injuries
resulting in quadriplegia were suffered by defensive backs, whilst at the college level,
73% of victims were defensive backs.

The problem has been recognised, and Rule changes implemented to remedy the
alarming increase in cervical spine injuries resulting from the use of the helmet as first
point of contact. The following American Football rules were implemented for the 1976
season and remain unchanged;

1. No player shall intentionally strike a runner with the crown or top of the
   helmet.
2. No player shall deliberately use his helmet to butt or ram an opponent.
3. Spearing is not permitted. Spearing is the deliberate use of the helmet in an
   attempt to punish an opponent.
   (National Collegiate Athletic Association, 1976, Articles 2-L & 2-N. cited in
   Torg, 1985, p.298).

Examination of the research conducted on American football greatly aids our
own knowledge of the mechanisms and incidences of serious injury. The far greater
financial and logistical resources available to American football researchers are of
invaluable support to our Australian situation where player numbers and finances
supporting research are relatively limited. While the Australian football codes present a
much different set of dangers because of the absence of reinforced “protective” padding,
the effectiveness of rule changes in American football offers encouragement to those in
Australia vested with the responsibility of implementing rule changes in the Australian
football codes should risks prove untenable under existing rules.
2.4 Prevention of Injury to the Upper Body

Education and behavioural change are recognized as two of the most important strategies contributing to injury prevention and control. These occur at the levels of coaching staff and player (Sleet, Egger and Albany, 1991). Egger (1990, p.5) also states that 'coach and trainer education and consequent improvements in player preparation' offers the best opportunities for prevention of injury in the Australian sporting context. The physical environments in which sports are played are being made safer, and the rules modified to create less hazard during the contest, but the basics of the player being best prepared for the contest are always of the utmost importance.

The planned conditioning of the athlete for greater strength and greater flexibility are of prime importance in ensuring that the athlete is better conditioned for the sport to be played. The better conditioned the player is, the more he is able to avoid potentially injurious situations. The cervical spine is an area of concern, and the importance of programs for the conditioning of both the strength and flexibility of this vulnerable region are of greater importance. Reid (1992) offers;

Furthermore, the neck may indeed be required to sustain tremendous torque loads such as occurs with a rugby tackle. It is obvious, then, that the otherwise frail anatomy of the cervical spine must be gradually and sequentially adapted by exercise and range of motion work to accept these stresses (p.739).

The education of the coaching staff, with the knowledge gained then implemented into an effective coaching program provides the greatest opportunity of maximal player preparation for the prevention of the potential injuries of body contact sports. The coaching staff should know and avoid utilizing players of unsuitable neck proportions in at risk scrummage positions; they should provide and enforce on-going neck strengthening programs, and they should provide practice in avoiding specific at risk behaviours eg. ducking the head into tackles. The shoulders of the players should be exercised regularly and at a variety of angles to provide some form of conditioned resistance to serious shoulder injuries. As such, the areas of flexibility and strength are deserving of special mention.
2.4.1 Strengthening and Increasing the Flexibility of the Body as a Whole

Strengthening and increasing the flexibility of the body as a whole, and in particular increasing the strength and flexibility of joints more susceptible to injury, will indeed tend to make the athlete less susceptible to injury overall. Watson (1981), in a study of Irish schoolboy rugby players, found that deficiencies in upper back strength and flexibility were factors predisposing to sports injuries of the upper body. In flexibility scores alone, more than 'half the team members scored below their age group average on one or more of three tests and in approximately one quarter of the subjects the lack of flexibility was alarming' (p.420). The deficiencies in flexibility were attributed to weight training programs lacking in stretching or flexibility components, whilst the deficiencies in upper back strength were attributed to omission of specific upper back exercises from their weight training programs.

2.4.2 Strengthening of the Neck

Strengthening of the neck as a preventive measure against cervical spine injury has been widely recommended in the literature in studies by; (Liedholt, 1973) (McCoy et al., 1984) (Cantu, 1992) (Howell, 1989) (Scher, 1987) (Mueller and Blyth, 1987) (Maroon, Kerin, Rehkopf and McMaster, 1977) (Kyle, 1964). However, given all conditions in all sports, the cervical spine cannot always be protected from injury risk.

Reid (1992) offers a harsh note of reality when he states that 'even the most muscular individual cannot protect the cervical spine under all circumstances' (p.739). Also sounding a note of caution on the possibility of conditioning to lessen the incidence of injuries to the shoulder complex and the cervical spine, a letter to The Medical Journal of Australia by Taylor and Coolican (1988) provided a view (highlighting their orthopaedic and traumatic surgery specialty) that the problems causing spinal injuries in sports rest more within the conduct of the sports themselves eg. the Rugby Union and Rugby League scrummage laws being in urgent need of change. Taylor and Coolican (1988) state the view;

Cervical spine dislocations in scrummage, as do shoulder dislocations and
“whiplash” injuries in rear-end motor-vehicle accidents, occur when an individual is “off-guard” and has no opportunity to protect the spine by muscle splinting, no matter how well the neck musculature may be developed (p.224).

Nevertheless, positive action is called for in recommending strengthening exercises of the cervical region to perhaps prevent or reduce the trauma in those cases where a stronger neck would be beneficial.

A further study of spinal-cord injuries in Australian footballers (Taylor and Coolican, 1987) suggests that those injured had little interest in neck exercise programs for developing greater neck musculature. Taylor and Coolican (1987) found in spinal-cord injured patients, only 33% (of Rugby Union players), 12% (of Rugby League players), and 15% (of Australian Football players) had performed strengthening or isometric exercises to specifically develop the neck musculature.

In specifically referring to the Rugby codes, Reid (1992) offers; “Neck strengthening needs to be emphasised far more in Rugby, as frequently injuries occur at slower velocities than with other sports and are more amenable to prevention. The neck can be significantly strengthened” (p.790). To understand more fully the unique character of the risks to the cervical region, the anatomy of the neck and the mechanisms of neck injury need to be examined.

2.4.3 The Cervical Spine - Anatomy and Mechanisms of Injury

The incidence of cervical spine injury must be examined from the standpoint of background knowledge in the anatomy of the neck region combined with knowledge of the mechanisms often present in the cause of such serious injury. Sports-related cervical spine injury is potentially the most serious form of injury the participants in this research could possibly incur. Cases of death and quadriplegia occur every year in Australia as a result of spinal cord trauma suffered in sporting accidents, and the football codes provide incidence of such injuries. Specific parts of the cervical spine aligned at specific angles, and in collision with specific directional forces present the most at risk situations
the young athlete can face. Therefore, the anatomy of the cervical spine and the various mechanisms of cervical spine trauma are examined here in separate sections.

2.4.3.1 Anatomy of the Cervical Spine

The anatomical structure of the cervical vertebrae is of importance since such disastrous consequences can result from injuries to these structures. There are seven cervical vertebrae of which the first two, C1 (the atlas) and C2 (the axis) are markedly atypical. The atlas is different from other vertebrae in that it has no body or spinous process and is shaped like a ring (Appendix D - Part 1, p. 170). The axis differs from other vertebrae in that the anterior portion of the body extends inferiorly and a vertical projection called the dens arises from the superior surface of the body (Appendix D - Part 2, p. 171). The remaining cervical vertebrae C3 - C7 are more typical of the remaining vertebrae of the vertebral column. (Appendix D - Part 3, p. 172). The cervical spine differs from the lower spine of the thoracic and lumbar regions in that it carries less weight and has to be generally more mobile.

The loads imposed on the cervical vertebrae vary according to the position of the head and the body, in a well-supported reclining body posture these loads being minimal. Compressive loads during erect stance and sitting are relatively low, but during the end ranges of flexion and extension they are high (Norkin and Levangie, 1992). The joint capsules of the cervical spine are relatively lax and therefore allow greater motion than in the lumbar and thoracic regions. Stability of the cervical vertebral column is of prime importance in preventing injuries resulting from displacement of the vertebrae. Since the spinal cord is relatively more vulnerable to lesion in the more mobile cervical region than in the lower vertebral column, additional cervical stability is supplied by the uncinate processes which reinforce the posterolateral aspects of the disks to limit flexion. The cervical spine accommodates the motions flexion, extension, lateral flexion and rotation but slight forwards flexion combined with rotation are considered the most at risk mechanisms for serious sporting cervical spine injuries.
2.4.3.2 Mechanisms of Injury of the Cervical Spine

As suggested by Torg (1985), the manner in which injury occurs to a specific body part must be accurately defined before appropriate measures can be implemented to effect prevention programs. The potential for serious and life-threatening injury to the cervical spinal cord is a daunting problem for administrators of all sports, not just for the competitive body contact sports. Diving (off a beach or rocks, off a pier, or into a swimming pool) is an exercise with the highest risk of spinal injuries. Reid (1992) found that 45% of all sporting injuries due to diving were injuries to the cervical spine, compared with the football codes with 1% of all injuries presenting as cervical spine trauma.

There is some disagreement as to the prevalent mechanisms of cervical spinal cord trauma resulting from injuries incurred whilst playing body contact sports. The main mechanisms of vulnerability toward cervical spinal cord trauma are extreme flexion (hyperflexion), vertical loading, and axial loading occurring as a result of compression in combination with rotation. (Reid, 1992)

a) Hyperflexion - In the past, hyperflexion has been thought of as the major cause of sporting cervical spine trauma (Schneider, 1973). Roaf (1960) subjected spinal units to forces differing in magnitude and direction, finding that pure hyperflexion injuries were almost impossible to produce in a normal, intact spinal unit.

b) Vertical Loading - Bauze (1978) subjected the spines of human cadavers to loads in a compression apparatus designed to simulate the clinical situation for dislocations. He produced forward dislocation of the cervical spine by subjecting it to purely vertical loads. The maximum vertical loading required was measured at 145 kg (319 lb), producing rupture of the posterior ligament and capsule with the severing of the anterior longitudinal ligament prior to dislocation. The peculiar vulnerability of the cervical spine to forces from this vertical direction is instanced by these relatively low loads causing dislocation.
c) Axial Loading - Compression in Combination with Rotation - The majority of cervical spine trauma is now recognised as being caused by the combination of compression and/or flexion-rotation, the concept of axial loading becoming increasingly more recognised as an important determining factor. The critical angle of neck flexion appears to be approximately 30 degrees forward flexion in such cases (Torg, Vegso, and O'Neill, 1990). Such 30 degrees forward flexion produces a straightening out of the slight curve attributable to the normal cervical spine lordosis inherent in the anatomical position (Appendix D - Part 4, p. 173). The slight normal lordotic curve of the cervical spine in the anatomical position has an impact-absorbing function. Torg (1985, p.297) stresses the fact that 'most energy inputs on the cervical spine are effectively dissipated in lateral bending, flexion, or extension by the energy-absorbing capabilities of the cervical paravertebral musculature, the intervertebral discs or, to a lesser extent, the ligaments.'

Torg (1985) goes on to offer;

Slight flexion of the neck resulting in alignment of the cervical vertebrae can produce a vulnerable situation (ie. a segmented column) should force be applied to the top of the head such that the forces are transmitted along the axis of the cervical spine, by-passing the energy-absorbing capacities of these structures, and should these forces exceed the energy-absorbing capabilities of the cervical structures, injury to the cervical spine results' (Torg, 1985, p.297).

Reid (1992) found that from 1976 to 1987 49 percent of non-quadriplegic cervical spinal injuries and 52 percent of the quadriplegic injuries were attributed to slight forwards flexion with force applied to the top of the head. Cervical spine injuries from axial loading are more common in American football ("Gridiron") than in Australian football codes, since in the American game a safety helmet inspires the player to use the head more as a battering ram. However, the cervical spine structures are placed at greater risk of injury by the axial loading components of such techniques. The modern encouragement of "head-up" techniques during play hopefully avoids the tendency for players to "duck" their heads slightly just prior to impact. Maintaining the
“head-up” position avoids the slight forwards flexion of the neck (approximately 30%) which would align the vertebrae into the susceptible segmented column mentioned above.

A study of Irish schoolboy Rugby Union (McCoy, Piggot, MacAfee and Adair, 1984) found little evidence to support the view that rotation plays an important part in cervical spine injuries. They found that in the scrum injuries studied ‘hyperflexion of the neck, accompanied by some restraint of the top of the head, appears to be the mechanism involved.’ Also examined were the mechanisms of cervical spine injuries suffered in tackles, but these ‘appear to be produced when extreme flexion is applied to the head, and the trunk is relatively static’ (Appendix D - Part 5, p. 174).

Roaf (1960) was able to produce almost every type of spinal injury by a combination of compression and/or flexion-rotation. Rotation is also indicated by Torg (1985) as a major contributing factor in cervical spine trauma. Torg outlined the mechanics of forward dislocation of the cervical vertebrae resulting from pure vertical loads, noting that with the neck flexed forwards at 30° and with vertical forces acting after maximum vertical compression deformation has been reached cervical spine flexion or rotation occurs with fracture, subluxation, or unilateral or bilateral facet dislocation.

A South African study of Rugby players suffering injuries to the spine and spinal cord implicated the rotational component as contributing to injury. In this study Scher found:

Firstly, the common mechanism of injury is hyperflexion trauma as the major injuring force, with a rotational component in the three cases of unilateral facet dislocation. Secondly, a striking majority of players suffered anterior dislocation with bilateral locking of facets. In cervical spinal cord injury due to causes other than Rugby, the percentage of patients with bilateral locking of facets is much lower..... This marked preponderance of one particular type of orthopaedic injury is of considerable importance because it is indicative of a mechanism of injury, and because of all the orthopaedic injuries to the cervical spine, it is the one with the most grave prognosis regarding paralysis and death. When
complete dislocation and bilateral locking of facets occurs, the laminal arch of the upper vertebra at the level of injury comes forward, compressing the dorsal aspect of the spinal cord against the posterosuperior surface of the next lower vertebral body. Injury to the spinal cord is usually severe (Scher, 1987, p.88).

Scher (1987) also implicated the high tackle in Rugby, noting that quite often it produced rotational forces on the cervical spine resulting in cervical ligament tearing and vertebral dislocation. In Australian findings, Yeo (1983, cited by Milburn in Morrison (Ed.), 1989) identified a combination of flexion and rotation as the mechanism for cervical spinal trauma in football players.

The “Watson” case in New South Wales provided an instance of quadriplegia caused by slight flexion of the neck and applied rotational forces in a football scrum. The player, who was injured whilst playing in an unfamiliar position at hooker, successfully sued the N.S.W. Education Department in 1987, and was awarded substantial damages. Howell outlines the case;

He claimed teacher negligence in playing him as a hooker between two shorter props, in failing to instruct him in neck strengthening exercises before choosing him in that position, and in failing to instruct him in the technique of scrums. In evidence the boy said that he was looking down and to his left to watch his half-back.... when he felt a sharp pain in the neck (Howell, 1989, p.163).

In summary, examination of the anatomy of the susceptible cervical region and the mechanisms that can produce serious spinal cord trauma offer a strong case for those associated with body contact sports to implement educational and physical conditioning programs to offset the dangers of such trauma where possible. “Depowering” the scrummages in Rugby Union, targeting high tackles and spear tackles, and encouraging neck strengthening exercise regimes may contribute greatly to avoiding future neck injury catastrophes. Advising the player not to “duck” the head into a tackle, or not to drive into a ruck head-first with the neck tilted down to 30 degrees forward flexion, may prevent a potentially fatal injury from occurring. Hence the understanding of the
knowledge of the anatomy of the cervical spine and the mechanisms of serious injury to that region could prove invaluable to coaching staff and players.

2.4.4 Increased Flexibility and Strength of the Shoulder Girdle

Increased flexibility and strength of the shoulder girdle has been reported by Morris (1984, p.82) as aiding in ‘improving the overall integrity of the musculature and tendons of the shoulder’, and hence decreasing the risk of injury to that joint. Reilly (1981) states that muscular strength achieved by overload training of the shoulder musculature enhances shoulder stability.

Komi (1994, p. 178) reports that strength training improves ‘muscle stiffness, especially in the explosive type of force production’ which enhances the stability of the joint when resisting impact forces. Wilson (1994, p.3) also supports the view that resistance training develops the ‘musculo-skeletal structures to such an extent that the incidence of injury from training and competitive performance is reduced’.

However, shoulder injury rehabilitation programs stress the return of a full range of movement before a strength training program is introduced to restore full stability to the joint. (Ellison, ed., 1985); (Peterson & Renstrom, 1986). To understand more fully the unique character of the risks to the shoulder joint, the anatomy of the shoulder and the mechanisms of shoulder injury need to be examined.

2.4.4.1 The Shoulder Complex - Anatomy and Mechanisms of Injury

The shoulder complex as an upper body injury site warrants special concern. Shoulder injuries are invariably never fatal, and therefore not to be considered nearly as serious as potentially fatal cervical spine injuries. However, shoulder injuries are important as many players’ careers are prematurely ended with recurrent shoulder dislocations. The shoulder complex consists of the scapula, clavicle, and humerus, plus the ligaments and muscles that combine for the most mobile joint in the human body.
The most debilitating shoulder injuries occur in two main sites, the Acromio-clavicular Joint (AC joint) and the Gleno-humeral joint. A knowledge of the anatomy of the shoulder girdle (Appendix D - Part 6, p. 175) and the many angles of movement possible with the shoulder (Appendix D - Part 7, p. 176) must be examined and understood when considering any injury of the shoulder region.

2.4.4.2 The Acromio-clavicular Joint (or AC joint) - Anatomy and Mechanisms of Injury

The acromio-clavicular joint appends the clavicle to the scapula, with a primary function of maintaining the relationship between the clavicle and the scapula in the early stages of elevation of the upper limb, and, in the latter stages of elevation of the arm, to allow the scapula additional range of rotation on the thorax.

Injuries of the acromio-clavicular joint and the clavicle have been shown to occur with less frequency than injuries to the remainder of the shoulder complex (Sugerman, 1983). Vertical dislocation of the AC joint is almost always accompanied by tearing of the coraco-clavicular ligament' (Post, 1985, cited in Norkin & Levangie, 1992). The mechanism of injury is usually assumed to be depression of the acromion due to a fall onto the point of the shoulder. However, in most studies on this injury, the patients have been unable to state exactly how the injury was sustained (Dias and Gregg, 1991). The sign indicating dislocation of the AC joint usually presents as an obvious step at the site of the joint, the lateral end of the clavicle being prominent. Although the AC joint is a relatively unstable joint, it appears to respond well after injury ‘regardless of whether or not the periarticular structures remain loose and plastic or the joint is overstabilized through some form of internal fixation’. (Norkin & Levangie, 1992)

2.4.4.3 The Gleno-humeral Joint - Anatomy and Mechanisms of Injury

The gleno-humeral joint is a ball-and-socket synovial joint with a capsule and several associated ligaments and bursae. This joint is the most mobile joint in the body,
made up of the large head of the humerus and the small glenoid fossa. (Appendix D - Part 8, p. 177).

In a study of Irish Rugby Union, Kyle noted that injuries to the shoulder region make up 18 percent of all injuries received, and ...are among the most incapacitating. (Kyle, in Armstrong and Tucker, 1964, p.232). Within the researcher’s recent personal injury history the degree of incapacitation as the result of shoulder injury has particular relevance, having undergone corrective surgery for recurrent anterior dislocation of the gleno-humeral joint in late 1993. This injury was suffered initially at age 41 years whilst demonstrating football tackling technique to schoolboy footballers during a school team training session.

Aronen (1986) suggests that there is a price to pay (in potential instability) for the freedom of movement of the shoulder since the gleno-humeral articulation is designed more to allow mobility than to offer stability.

The glenoid labrum enhances the total available articular surface of the glenoid fossa. The glenoid labrum surrounds and is attached to the periphery of the glenoid fossa, enhancing the depth or curvature of this fossa. (Appendix D - Part 9, p. 178). If the rim of the glenoid labrum is injured or detached, the stability of the joint at that angle is somewhat reduced, and may present in recurrent dislocation. In the researcher’s case recurrent anterior dislocation and X-ray evidence indicated a detached portion of the glenoid labrum, necessitating surgical correction to restore joint integrity.

The gleno-humeral joint capsule consists of a fibrous material which attaches peripherally to the margins of the glenoid cavity and the anatomic neck of the humerus. The relative laxity of the capsule allows the joint great range of movement. The humeral head is able to spin, roll, and slide over the relatively small glenoid fossa surface, allowing an increased available range of movement whilst three intrinsic capsular ligaments, the gleno-humeral ligaments, reinforce the stability of the joint.
The much needed dynamic stability of the gleno-humeral joint is supplied by the rotator cuff which consists of four interrelated muscles originating at the scapula. The tendons of these interrelated muscles are intimately associated with the joint capsule and are in sufficient proximity to form a tendonous cuff around the head and upper half of the anatomic neck of the humerus (Reid, 1992). The fine adjustments of the humeral head demand intricate control by the rotator cuff muscles during forceful throwing or in the repetitive movements of sporting pursuits.

A number of sites within the shoulder girdle are susceptible to injury, particularly for those injuries associated with the forces inherent in the collisions of body contact sports. Recurrent anterior shoulder dislocation is one of the more serious conditions, Hawkins and Bell (1987) stating that it is 'the most common form of recurrent instability' of the shoulder (p. 68). Grana, Holder and Schelberg-Karnes (1988, p.88) noted that shoulder dislocations 'account for up to 50% of all dislocations'. Dislocation should not to be confused with subluxation; subluxation being a slipping in and out of the joint which does not require reduction (i.e spontaneously reduces), whilst dislocation requires reduction to restore full movement to the joint, and often this reduction must be performed by someone else.

In prescribing specialised exercise systems to strengthen the shoulder girdle and thus offset the risk of injury to the shoulder, particularly the risk of recurrent anterior dislocation, the mechanism of many of these injuries must be more fully understood. Specific angles for arm actions in strengthening programs need to be implemented to offset particularly prevalent injuries eg anterior gleno-humeral dislocation. To this end, specific knowledge of susceptible joint angles is offered by Aronen (1986);

Because of the anatomical makeup of the gleno-humeral joint with the glenoid fossa facing laterally, anteriorly and upward, the humeral head has the tendency to dislocate anteriorly (versus posteriorly) in the vast majority of shoulder dislocations. The most common mechanisms to dislocate the shoulder anteriorly with an indirect force to the humeral head are; (a) forced external rotation and abduction of the humerus as is seen in a basketball player who attempts to block a shot or stop a high pass; and (b) a fall onto an outstretched arm forcing the
humerus into forward extension and abduction as is seen in a baseball player sliding head first into a base or diving to catch a ball (p.226).

2.5 Summary

The literature indicates that injuries to the upper body in body contact sports, and those injuries sustained in football codes in particular, are of great concern to all involved in sport. Education of coaches and trainers is of prime importance since, if well-informed, those charged with the education and training of the players may be able to provide positive action to avoid risky behaviours and to optimally condition their players' bodies to reduce the risk of upper body injuries. The literature has specific relevance to coaches and trainers at both school and club levels.

The body contact involved in the various football codes of Rugby League, Rugby Union, Australian Football, and American "Gridiron", presents specific risks of which the coaching staff and player must be constantly aware. Player preparation must be of prime importance. Certain forms of player conduct should not be tolerated eg. head-high tackles, even if the referee of the game does not notice, nor should unsafe practices such as "ducking" the head into a tackle. The player must also be best prepared physically for the game.

All coaches were made acutely aware of the furore surrounding the Watson quadriplegia case of 1986, and the use of Royal North Shore's prescriptive neck exercises and warm-up exercises (Appendix A, p. 155) was widespread in 1987 following the 1987 SPORTSAFE - "Necksafe" campaign. However, these exercises were not as widely used in 1994 as they were in 1987 (Ritchie, 1994) and this would suggest that players are being placed at risk by diminished support for such programs after the initial implementation. Knowledge of anatomy and how the articulations at risk respond to mechanisms that might cause injury can provide an important base from which to best prepare the player, but unfortunately this readily-obtainable knowledge is not as valued by coaches and trainers as common sense would dictate.

44
Sports injury programs are best 'aimed primarily at adolescents for the most efficient use of resources' (Routley, 1991, p.8). The researcher's support of Routley's statement, and the realities of player accessibility, suggested the selection of 16-18 years old Rugby League players as the subjects for this research.

The design of the exercise intervention used in this research emerged from the evidence identified in the literature. The researcher formulated various upper body conditioning exercises which could be completed by the adolescent subjects at their normal (non-gymnasium) training venues. The exercises in the case of the shoulder complex comprised conditioning programs to improve strength, endurance, and flexibility which are identified as being important in improving shoulder joint integrity by Reilly (1981). These exercises were specific in targeting at-risk angles in shoulder injuries such as anterior dislocation of the gleno-humeral joint. The exercises utilised the players' own body weight at specific angles to achieve the desired training effect. The neck exercises were the identical resistance neck exercises of the 1987 SPORTSAFE program as formulated by Royal North Shore Hospital's Spinal Research Unit. Pretests at the commencement of the study, and posttests upon conclusion of the study, were conducted for various upper body fitness parameters. Shoulder fitness parameters which measured strength and local muscle endurance were those suggested by De Lorme and Watkins (1951), and shoulder flexibility parameters were as suggested by Reid (1992). Neck fitness was assessed using neck actions as suggested by Royal North Shore Hospital Spinal Unit (Department of Sport and Recreation, 1987), and by the researcher's neck testing machine specially constructed for the study. The pretest and posttest scores were then compared and analysed with reference to the recorded upper body injury incidences for the period of the study. By these means the effectiveness of the experimental program was ascertained.

Injuries were recorded using the researcher's recording classifications shown in Table 1. (p. 15). These classifications were arrived at with due consideration given to convenience and utility for the coaches and managers of the teams involved in the study. Formulation of the classification of injury for this study was derived with reference to
CHAPTER 3

METHOD

3.1. Overview

The purpose of the study was to evaluate the effects of a training program on the development of greater physical fitness in the upper body articulations of the sample population of 156 adolescent Rugby League players. Select upper body articulations were targeted according to whether they were considered accessible to injury risk reduction by means of training method intervention. In particular, the sites of the shoulder complex and the cervical spine were targeted. Upper body injury rates were monitored and recorded, and these were compared in light of the injury prevention program implemented.

Evaluation of upper body fitness included measurement of such components of fitness as flexibility, strength, and local muscular endurance. No participant underwent the exercises in the program without the presence of a qualified club doctor, qualified trainer or coach, or the researcher. Subjects were examined in view of the hypothesised reduction in preventable upper body injury incidences incurred by the experimental treatment subjects relative to the control (non-treatment) subjects during the course of the study.

The duration of the actual implementation of the study was one full Rugby League season. This included the preseason training period and ceased after the final game for the 1995 season for each team. Initially it was envisaged that a much greater time frame would be employed, but uncertainty concerning the structure of competitions
and the future of clubs involved necessitated the compression of the study to one full Rugby League season. While this study was being formulated and during its implementation from late 1994 throughout 1995 the game of Rugby League was undergoing unprecedented upheaval as a result of a dispute between the Australian Rugby League and Super League. Such uncertainty gave cause for the research to be completed in 1994-1995 since completion of posttests was essential and there was no certainty of continuing access to the players in 1996.

The study involved the use of eight intact groups, each group being a club team drawn from a separate football club. All groups undertook identical tests for selected upper body fitness parameters. Pretests on these parameters determined upper body fitness before commencement of the program, and posttests at the completion of the 1995 season determined upper body fitness at the completion of the program. The experimental teams completed the specialised upper body training and education program as part of their regular training schedule while the control teams performed their regular club training schedule. The pretests and posttests were used to form an upper body fitness profile for each subject, using such measures as upper body flexibility, strength and local muscle endurance for the particular sites and ranges of movement under investigation. Injuries prior to the commencement of the study were ascertained, and injuries occurring thereafter were categorised and recorded.

The study involved a mixed mode of enquiry utilising both quantitative and qualitative research elements. Quantitative data was obtained from pretests and posttests which yielded upper body fitness data, from survey data on subject adherence to the exercise program, and from the recording of injury rates. Coach and trainer interviews, open-ended surveyed items and site observations were utilised to obtain qualitative data about the approach and behaviour of each team to the study.

Hawthorne Effects were controlled for by the researcher’s attendance at experimental and control group training sessions and at games for all elite and non-elite groups in the capacity of collector of data for overall upper body fitness and injury
incidence. Therefore no subject Hawthorne Effect bias was engendered by the presence of the researcher with any one team over another. This necessitated a roster being adhered to by the researcher. During the course of the study almost every week night was employed in football training appearances, sometimes two separate games were viewed on the Saturday, and often one game was attended on Sunday as well. These visits were dependent on the varying game times and realistic travel times in travelling between venues as diverse as Penrith, Campbelltown, Narellan, Kogarah, Fairfield and Cronulla in the greater Sydney metropolitan area. In the case of the elite teams, sometimes two teams from the study played against each other, with the researcher always in attendance on such occasions. A total of 92 training sessions and 39 games were attended throughout the 1995 season.
3.1.1. The Experimental Design

The experimental design is represented as follows:

<table>
<thead>
<tr>
<th></th>
<th>ELITE</th>
<th></th>
<th>NON-ELITE</th>
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</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>O₁</td>
<td>X</td>
<td>O₂</td>
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<tr>
<td>R</td>
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<td>H</td>
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<tr>
<td>R</td>
<td>O₇</td>
<td>H</td>
<td>O₈</td>
</tr>
</tbody>
</table>

Key to the Experimental Design

R - Random selection of both elite and non-elite participant groups.
O₁ - Pretest of elite experimental club group A.
X - The experimental treatment (the exercise system).
O₂ - Posttest of elite experimental club group A.
O₃ - Pretest of elite experimental club group B.
O₄ - Posttest of elite experimental club group B.
O₅ - Pretest of elite control club group C.
H - Control - (Researcher attendance at training, games etc.)
O₆ - Posttest of elite control club group C.
O₇ - Pretest of elite control club group D.
O₈ - Posttest of elite control club group D.
O₉ - Pretest of non-elite experimental club group V.
O₁₀ - Posttest of non-elite experimental club group V.
O₁₁ - Pretest of non-elite experimental club group W.
O₁₂ - Posttest of non-elite experimental club group W.
O₁₃ - Pretest of non-elite control club group X.
O₁₄ - Posttest of non-elite control club group X.
O₁₅ - Pretest of non-elite control club group Y.
O₁₆ - Posttest of non-elite control club group Y.
3.2. The Subjects

The study was conducted using 156 players; 71 of whom were eligible to compete in Under 16 Years competition in 1995 (the non-elite group), and 85 of whom were eligible to compete in the 1995 Under 17 Years SG Ball Competition (the elite group) of the (then) Winfield Cup under the auspices of the New South Wales Rugby League (NSWRL).

The players were divided into these age groups according to the competition levels available to them. In 1995 there was no under 17 years competition outside of the elite SG Ball competition in any area. The non-elite competition age divisions being only Under 16 years and Under 18 years in 1995. The Australian Rugby League scheduled this age structure to change, from the commencement of 1997, to Under 16 years and Under 18 years in the elite competition so that uniformity in age division at both elite and non-elite levels could be created.

There were eight separate club teams of player participants in the study; four teams from the non-elite level, and four teams from the elite level. There were only four players who discontinued participation during the study with the date of cessation recorded, the analysis of data plan cited being statistically adequate to cope with this withdrawal of players.

The elite level teams were drawn from the NSWRL Winfield Cup Under 17 years SG Ball competition 1995; with the Penrith, St. George, Cronulla and Western Suburbs clubs participating. The non-elite level members were drawn from the normal local club level in corresponding areas to each elite group; teams included Narellan Jets Under 16's (Penrith area), Fairfield Patrician Brothers Under 16's (St George area), Cronulla-Caringbah Black Cats Under 16's (Cronulla area), and Campbelltown City Under 16's (Western Suburbs area).
There was random allocation to all control and experimental categories. In addition, all subjects were treated as their own controls. All subjects were male and Under 17 years of age as at 1st January, 1995.

3.3. Research Preparation and Procedures

- After the research protocol was formulated the various clubs were approached to ascertain if the study was viable to them.

- A pilot study of 17 high school Opens grade Rugby League footballers was undertaken in 1994 using participants from a high school Open Division Rugby League team coached by the researcher. There were a number of items within the initial upper body fitness test battery that were either omitted or revised. The final test battery was refined from the original tested pilot study (Appendix J. p. 209).

- Submission was made to the University of Wollongong Human Research Ethics Committee to undertake the research, and approval was subsequently granted.

- Written permission to undertake the study with the various clubs was obtained from the New South Wales Rugby League and the respective clubs involved.

- Random selection of the intact club teams into experimental and control groups was completed.

- Permission to undertake the study, including the various upper body exercises, was obtained from the player subjects involved. Formats used appear in Appendix H - Subject Participant Consent Forms (p. 191). The various forms for the experimental players include the Participant Consent Form (p. 192), the Parent/Guardian Consent Form (p. 194) and the Neck Exercise Consent Form (p. 196), whilst one format was used for all control players, the control Research Consent Form (p. 198).

- Various upper body fitness testing apparatus were obtained. In the case of the neck strength testing apparatus, a design was formulated by the researcher in
conjunction with University of Wollongong technician, Mario Solitro, and this unique portable apparatus was then manufactured in partnership utilising funding from the University of Wollongong. (Appendix C. The Test Instrument - Upper Body Fitness).

3.4. The Experimental Treatment

The experimental treatment consisted of a number of upper body exercises which were performed at football training under supervision of properly qualified training and coaching personnel. Particularly targeted were the upper body articulations under examination, the neck/cervical region and the shoulder complex. Changes in the level of strength and endurance in these targeted regions and the indications of this towards risks to injury were examined. Also of particular interest were the use of consistent stretching practices in producing gradual increases in flexibility in these upper body articulations, and the importance of the back-up theoretical input from the researcher on these concepts where such were not covered by the coaching staffs of the respective clubs involved.

3.4.1. Theoretical Background

3.4.1.1 The Strength Training Program

The subject must perform regular strenous workouts of the targeted muscles to achieve maximal benefit from this exercise system designed to increase strength and local muscle endurance. At least three sessions or workouts per week is optimum with returns reducing in proportion to the irregularity of workouts per week and the reduction in the number of workouts per week (less than three). Three workouts per week will yield results, but at the top end of the scale i.e. one workout per day, the returns will be less per session.

For the purposes of this study, the experimental treatment was undertaken at each team training session (both in-season and out-of-season) under direct supervision of qualified club coaching and training personnel. The experimental training exercises
required 10-15 minutes of each experimental team training session. There were on average three sessions per week in total. Normally the subject played competition matches on Saturday.

The research of DeLorme (1945) in working with the rehabilitation of the wounded soldiers of World War II showed that by using 4 repetitions at high resistance (heavy weight) muscle power is produced, whilst using 10 repetitions at low resistance (low weight) produced muscle endurance and later an extension of the work was developed by De Lorme and Watkins (1951).

3.4.1.2 Factors in Injury of Specific Upper Body Articulations

As stated, the upper body regions targeted for strength building in this study are the shoulder and the neck regions. The critical angle of the upper body articulation predisposing it to injury is of crucial importance in prevention of injury.

The cervical spine is particularly susceptible to crush injury when the natural lordosis of the anatomical position is straightened by forward flexion of approximately 30o. (Fine, Vegso, Sennett & Torg. 1991). (Appendix D.). However the combined flexion, compression and rotation of the cervical region is also indicated in many Rugby Union and Rugby League injuries (as discussed in the literature review).

In this study, the experimental subjects undertook a sustained neck exercising regime as provided by the Awareness and Prevention Team of the Royal North Shore Hospital, Sydney, to increase neck musculature strength and endurance. In addition, neck flexibility exercises were also taught and it was hypothesised that these would also help increase resistance to injurious conditions.

The shoulder is particularly susceptible to anterior dislocation (quite often causing subsequent recurrent anterior dislocation to occur) when a player falls forward onto the outstretched arm, a forced movement of flexion and usually abduction where the humeral head is levered from its socket by the shear forces of impact. The
experimental subjects also performed specific exercises for shoulder strength, flexibility and endurance concentrating on these joint angles to enhance resistance to such injurious forces.

It was hypothesised that overall improvements in strength, flexibility and local muscle endurance of the upper body articulations under study would increase resistance to injury in these regions, and potentially reduce the incidence of injury.

3.4.2 The Exercise System

3.4.2.1 Exercises for the Neck

1) Neck Musculature Strength. The neck exercises were as recommended by the Awareness and Prevention Team of the Spinal Unit, Royal North Shore Hospital, St. Leonards, N.S.W. (Appendix B. p.161). These exercises were issued to all schools and football clubs by the N.S.W. Department of Recreation and Sport in 1987 and included in the SPORTSAFE Prevention of Neck and Head Injuries in Sport (Department of Sport and Recreation, 1987) kit. All neck strength exercises utilised the subjects' own hands and arm strength to provide resistance in a safe approach to the program. No participant performed exercises in the program without the presence of a qualified club trainer or the researcher.

For the first week the exercises were completed as "static" exercises where there was no movement of the head. This was a form of isometric contraction with equal and opposite force applied from both the hands and the head. After the initial week the exercise system utilised both "static" and "dynamic" components. Each session the exercises were first completed from the "static" component, then the "dynamic" exercise component was completed. The dynamic component involved the head moving whilst producing slightly more force than the resisting hands. Each experimental player performed both the static and dynamic exercises. The component exercises were:
Static - Firstly, the head was pressed firmly and slowly forwards for 5 seconds; then slowly backwards for 5 seconds; then slowly to each side tensing for 5 more seconds. Each repetition was increased to 10 seconds duration over the first few weeks of training. Each subject completed 10 repetitions in each of the four directions.

Dynamic - Using a full range of movement, the hands were used to provide resistance, 10 repetitions of each of the following movements were completed: the head was flexed slowly forwards, then extended slowly backwards, then slowly flexed sideways, and slowly rotated to each side. 10 repetitions of shoulder shrugging were also completed.

2) Neck Flexibility

a) Flexion - neck flexed as far forward as possible, applying a little extra pressure with hands to back of head. Held for 10 seconds X 3 reps.

b) Extension - neck extended as far back as possible, applying a little extra pressure with hands to forehead. Held for 10 seconds X 3 reps.

c) Rotation - A seated spine twist, combining both neck rotation and shoulder flexibility exercise, was performed. This twist position was slowly adopted while sitting on the ground with the arms and legs acting as an additional support. Held for 10 seconds X 3 reps.

3.4.2.2 Exercises for the shoulder girdle

1) Shoulder Girdle Strength -

a) Deep push-ups - the objective of this exercise was to achieve a push-up which allowed the performer to actually lower the torso below the level of the hands/palms. The standard push-up is usually completed with the palms placed downwards on the ground and the lowest portion of the torso at the bottom of the down stroke can only be
when the torso touches the ground. By elevating the hands off the ground using training ground seating, wooden blocks, the shin bones of a seated fellow player, or other suitable platforms, a “deep” push-up can be performed where the torso can be lowered below the level of the supporting hands. 3 sets of 6 repetitions per session recommended.

b) Inclined push-ups - with the feet supported 60 cm above the level of the hands, an inclined push-up was performed to produce a different angle of stress to the standard push-up where both hands and supporting feet are on the same level. The inclined push-ups were performed initially with hands contacting the floor at the sides of the chest, however, over time the arms were gradually extended out in front of the head along the floor. 3 sets of 6 repetitions per session recommended.

c) Handstand push-ups against a wall or with partner and without wall support - gradual introduction to handstands against a wall at training sessions. Subjects worked in pairs with one subject supporting the other’s legs both for balance and to aid the lowering and pushing back up of the body whilst maintaining the handstand. The objective was to have each subject confident of holding a handstand against the wall without assistance, and to gradually develop the upper body strength to perform handstand push-ups by lowering the shoulders towards the ground and then pushing back up to a straight-armed handstand while being supported by the assistant. 3 sets of 6 repetitions will be completed, with assistance in the balance and push-up provided by the training partner.

2) Shoulder Girdle Flexibility -

a) Seated spine twist - as illustrated for the neck flexibility exercises (Appendix B. p. 163)

b) Upper and lower hands clasped behind back - subject reaches behind back with the lower arm extended and slowly rotates inward whilst the upper arm is flexed above the head. The elbow is flexed, with the subject reaching as far as possible down
along spine behind back of neck. The object is to be able to eventually clasp hands behind back. Each attempt held for 10 seconds. 3 attempts on each arm. Both arms are to take turn at being the lower arm.

The purpose of the study was to implement the experimental exercise program and examine differences in gains for the experimental and control players in measures of strength, flexibility and local muscle endurance of the upper body. Differences in injury incidence were also analysed and conclusions were drawn about specific injury sites and changes on parameter tests for fitness of those specific upper body sites.

3.5. Control Players

The control players did not undergo any specific exercise training implemented by the researcher. However, the researcher's presence and testing (nullifying the Hawthorne Effect) was justified by an accepted role as skilled observer and data collector. The control players undertook their normal club training with the researcher often present to note any similarities in control player training to the experimental treatment exercises.

3.6. Fitness Tests and Data Gathering Procedures

An upper body fitness test instrument was employed to measure strength, flexibility and local muscle endurance specific to the upper body articulations under examination. The fitness parameters tested appear in Table 2.

Data were collected from pretests of the upper body fitness parameters for all participants, and these data were retained for later comparison with posttest data from the end of the 1995 season. For both pretests and the posttests of the upper body fitness parameters tested, all six testers were personally trained by the researcher and subjected to repeated trials of the assigned tests in comparison with the researcher's trials on the same subjects. This procedure was repeated until reliable scores by the testers indicated consistent testing protocols and procedures.
Specific tests were used eg. Military Press Strength using barbells, which did not mirror the experimental training exercises eg. inclined pushups. This ensured that identical weights (barbells) were lifted by the participants at testing, and thus the wide variation in player body weights (body weight providing the "resistance" in pushups) did not provide variations in the actual loads being lifted for different participants for the various tests.

Table 2

Upper Body Fitness Indicators As Tested

<table>
<thead>
<tr>
<th>Code</th>
<th>Test</th>
</tr>
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<tbody>
<tr>
<td>1b.</td>
<td>Military Press Strength.</td>
</tr>
<tr>
<td>2b.</td>
<td>Behind Neck Press Strength.</td>
</tr>
<tr>
<td>3a.</td>
<td>Shoulder-Arm Dynamometer - Press In.</td>
</tr>
<tr>
<td>3b.</td>
<td>Shoulder-Arm Dynamometer - Pull Out.</td>
</tr>
<tr>
<td>4a.</td>
<td>Shoulder Flexibility - Internal Rotation - Left &amp; Right Arm - Total.</td>
</tr>
<tr>
<td>4b.</td>
<td>Shoulder Flexibility - External Rotation - Left &amp; Right Arm - Total.</td>
</tr>
<tr>
<td>5a.</td>
<td>Shoulder Flexibility - Prone Rod Lift.</td>
</tr>
<tr>
<td>5b.</td>
<td>Neck Flexibility - Flex + Extend - Total Degrees.</td>
</tr>
<tr>
<td>6a.</td>
<td>Neck Flexibility - Lateral Flex - Left + Right - Total Degrees.</td>
</tr>
<tr>
<td>6b.</td>
<td>Neck Flexibility - Head Rotation - Left + Right - Total Degrees.</td>
</tr>
<tr>
<td>7a.</td>
<td>Neck Strength - Forwards Flex.</td>
</tr>
<tr>
<td>8ab.</td>
<td>Neck Strength - Flexing to Left &amp; Right.</td>
</tr>
</tbody>
</table>
3.6.1 Test Protocols For Measurement of Fitness of the Neck / Cervical Region

3.6.1.1 Neck Flexion & Extension - Total Degrees of Flexibility (Test # 5b)

1. Subject warms up neck musculature using standard static and dynamic gentle neck exercises illustrated by the SPORTSAFE - The Prevention of Head and Neck Injuries in Sport Campaign. (Department of Sport and Recreation, 1987).

2. Subject seated, head in anatomical position, total range of movement involving forward flexion and backwards extension of head measured using MIE Clinical Goniometer calibrated by, and purchased from Hadland Phototonics Pty. Ltd., Glen Waverley, Victoria.

3.6.1.2 Neck Lateral Flexion Left and Right - Total Degrees of Flexibility (Test # 6a)

1. Subject warms up neck musculature using standard static and dynamic gentle neck exercises illustrated by the SPORTSAFE - The Prevention of Head and Neck Injuries in Sport Campaign. (Department of Sport and Recreation, 1987).

2. Subject seated, head in anatomical position, total range of movement involving lateral flex of the head from left to right measured using MIE Clinical Goniometer calibrated by, and purchased from Hadland Phototonics Pty. Ltd., Glen Waverley, Victoria.

3.6.1.3 Neck Rotation Left and Right - Total Degrees of Flexibility (Test # 6b)

1. Subject warms up neck musculature using standard static and dynamic gentle neck exercises illustrated by the SPORTSAFE - The Prevention of Head and Neck Injuries in Sport Campaign. (Department of Sport and Recreation, 1987).
2. On bench provided by researcher, subject placed in supine position on back, head in neutral position, mid-neck supported by pad provided, total range of movement involving rotational of the head from left to right measured using MIE Clinical Goniometer calibrated by, and purchased from Hadland Phototonics Pty. Ltd., Glen Waverley, Victoria.

3.6.1.4 Neck Strength Forwards Flexion (Test # 7a)

1. Subject warms up neck musculature using standard static and dynamic gentle neck exercises illustrated by the N.S.W. Department of Sport and Recreation’s SPORTSAFE Campaign. (1987).

2. Neck musculature strength in forwards flexion tested using a portable device of free weights, pulleys, cord and head harness as designed and manufactured by the researcher and Mario Solitro (See photograph pages following).

3.6.1.5 Neck Strength Backwards Extension (Test # 7b)

1. Subject warms up neck musculature using standard static and dynamic gentle neck exercises illustrated by the N.S.W. Department of Sport and Recreation’s SPORTSAFE Campaign. (1987).

2. Neck musculature strength in backwards extension tested using a portable device of free weights, pulleys, cord and head harness as designed and manufactured by the researcher and Mario Solitro (See photograph pages following).

3.6.1.6 Neck Strength Flexion to Left and Right - Total (Test # 8ab)

1. Subject warms up neck musculature using standard static and dynamic gentle neck exercises illustrated by the N.S.W. Department of Sport and Recreation’s SPORTSAFE Campaign. (1987).

2. Neck musculature strength in flexion to the left and right tested using a
portable device of free weights, pulleys, cord and head harness as designed and manufactured by the researcher and Mario Solitro (Appendix C. pp. 165 - 167 ).

3.6.2 Test Protocols for Measurement of Fitness of the Shoulder Complex

3.6.2.1 Military (Chest) Press Endurance (Overhead & Anterior) (Test # 1a)

Equipment - Barbell equipment was purchased from, Samson Pty. Ltd., Rydalmere, NSW. Calibration of this equipment was performed using Tanita Model 1567 / 1607 Digital (Electronic) Scales. The same set of weight equipment was used for both pretests and posttests.

Military Press Endurance weight load was 24.5 kg, comprised of:

8kg bar and collars + 2 X 6.95 kg plates + 2 X 1.3 kg plates. The weight of 24.5 kg was designated by the researcher as a suitable test for Military Press Endurance (ie. multiple lift repetitions possible from all participants) because of past experience in weight training programs for schoolboy players of these ages.

Testing procedure -
1. Subject warms up with appropriate stretching exercises and preliminaries.
2. Subject warms up further with very light free weights.
3. Subject must not flex knees to provide “bounce up” effect i.e. legs cannot be utilised in the lifts.
4. Military Press performed maximum number of repetitions (total weight = 24.5 Kg.) lifting from chest contact to full arms’ length overhead, one lift every 3 seconds. Testers were skilled in verbal advice of 3 second intervals by repeated rehearsal with the researcher prior to testing sessions.

3.6.2.2 Military (Chest) Press Strength (Overhead & Anterior) (Test # 1b)

Equipment - Barbell equipment was purchased from, Samson Pty. Ltd., Rydalmere, NSW. Calibration of this equipment was performed using Tanita Model
1567 / 1607 Digital (Electronic) Scales. The same set of weight equipment was used for both pretests and posttests. Spotters were used to ensure no accidents occurred as a result of participant fatigue.

Military Press Strength involved the use of varying weight loads, comprised of: 8kg bar and collars + a combination of 6.95 kg plates, 5.3 kg plates, 2.55 kg plates, and 1.3 kg plates. The work of Brzycki (1993) was used to predict a One-Repetition Maximum weight for each subject based on their Repetitions-to-Fatigue weight load. This particular protocol was used because it allowed a much greater leeway for assessment without needing to be constantly changing weights to evaluate by trial and error the One-Repetition Maximum of each subject as per the normal testing procedure. Logistical and time constraints were of major concern when dealing with a large number of athletes in one testing session at a time (often 20 + subjects), working within the confines of their home training grounds and the (sometimes begrudgingly) limited allowed interruption to their normal training routine.

Testing procedure -
1. Subject warms up with appropriate stretching exercises and preliminaries.
2. Subject warms up further with very light free weights.
3. Subject must not flex knees to provide "bounce up" effect i.e. legs cannot be utilised in the lifts.
4. Military Press performed maximum number of repetitions with heavy weight, aiming to limit subjects total number of repetitions to less than 10 by providing sufficient weight resistance. Each repetition involved lifting from chest contact to full arms' length overhead, one lift every 8 seconds. Testers were skilled in verbal advice of 8 second intervals by repeated rehearsal with the researcher prior to testing sessions.

3.6.2.3 Behind-Neck Press Endurance - (Overhead & Posterior) (Test # 2a)

Equipment - Barbell equipment was purchased from, Samson Pty. Ltd., Rydalmere, NSW. Calibration of this equipment was performed using Tanita Model 1567 / 1607 Digital (Electronic) Scales. The same set of weight equipment was used for both pretests and posttests.
Behind Neck Press Endurance weight load was 21.2 kg, comprised of: 8kg bar and collars + 2 X 5.3 kg plates + 2 X 1.3 kg plates. The weight of 21.2 kg was designated by the researcher as a suitable test for Behind Neck Press Endurance (ie. multiple lift repetitions possible from all participants) because of past experience in weight training programs for schoolboy players of these ages. The researcher’s past experience also suggested that a slightly lighter endurance test load should be undertaken posterior to the neck (21.2 kg) as opposed to the load for the Military Press Endurance test (24.5 kg) with its lifts performed anterior to the neck, since most players of these ages exhibit greater fitness for lifts anterior to the neck.

Testing procedure -
1. Subject warms up with appropriate stretching exercises and preliminaries.
2. Subject warms up further with light free weights.
3. Subject must not flex knees to provide “bounce up” effect i.e. legs cannot be utilised in the lifts.
4. Behind Neck Press performed maximum number of repetitions (total weight = 21.2 Kg.) lifting from back of neck contact to full arms’ length overhead, one lift every 3 seconds. Testers were skilled in verbal advice of 3 second intervals by repeated rehearsal with the researcher prior to testing sessions.

3.6.2.4 Behind-Neck Press Strength - (Overhead & Posterior) (Test # 2b)

Equipment - Barbell equipment was purchased from, Samson Pty. Ltd., Rydalmere, NSW. Calibration of this equipment was performed using Tanita Model 1567 / 1607 Digital (Electronic) Scales. The same set of weight equipment was used for both pretests and posttests. Spotters were used to ensure no accidents occurred as a result of participant fatigue.

Behind Neck Press Strength test involved the use of varying weight loads, comprised of: 8kg bar and collars + a combination of 6.95 kg plates, 5.3 kg plates, 2.55 kg plates, and 1.3 kg plates.
The work of Brzycki (1993) was again used to predict a One-Repetition Maximum weight for each subject based on their Repetitions-to-Fatigue weight load. This particular protocol was used because it allowed a much greater leeway for assessment without needing to be constantly changing weights to evaluate by trial and error the One-Repetition Maximum of each subject as per the normal testing procedure. Logistical and time constraints were of major concern when dealing with a large number of athletes in one testing session at a time (often 20 + subjects), working within the confines of their home training grounds and the (sometimes begrudgingly) limited allowed interruption to their normal training routine.

**Testing procedure -**

1. Subject warms up with appropriate stretching exercises and preliminaries.
2. Subject warms up further with very light free weights.
3. Subject must not flex knees to provide “bounce up” effect i.e. legs cannot be utilised in the lifts.
4. Behind Neck Press performed maximum number of repetitions with heavy weight, aiming to limit subjects total number of repetitions to less than 10 by providing sufficient weight resistance. Each repetition involved lifting from back of neck contact up to full arms’ length overhead, one lift every 8 seconds. Testers were skilled in verbal advice of 8 second intervals by repeated rehearsal with the researcher prior to testing sessions.

3.6.2.5 Shoulder and Arm Dynamometer Test (Tests # 3a & #3b)

The maximal pressure applied by, and the pulling power of, the subjects’ shoulder musculature was measured using the Shoulder and Arm Dynamometer calibrated by and purchased from Mentone Educational Centre, Carnegie, Victoria.

3.6.2.6 Shoulder Internal Rotation - Left & Right Arms (Shoulder Flexibility) (Test # 4a)

1. Subject rested and standing. Subject asked to place hand in the pocket; then
on the hip; then on the small of the back; then slide hand up behind back as far as possible up the thoracic spine.

2. Measurement in millimetres of distance from finger tip to marked Vertebra prominence of C7 vertebra. Final measure is the average of three trials.

3. Measurements obtained for both left and right arms.

3.6.2.7 Shoulder External Rotation - Left & Right Arms (Shoulder Flexibility) (Test # 4b)

1. Subject rested and standing. Subject asked to touch the opposite shoulder; then the mouth; then the top of the head; then slide the hand down the back of the neck to reach as low as possible down along the spine (palm inward toward body).

2. Measurement in millimetres of distance from marked Vertebra prominence of C7 vertebra to finger tip of longest finger. Final measure is the average of three trials.

3. Measurements obtained for both left and right arms.

3.6.2.8 Lying Prone (face down) Rod Lift (Shoulder Flexibility) (Test # 5a)

1. Subject rested. Subject assumes prone (face down) position on floor. Chin must remain in contact with floor throughout trial.

2. Wooden rod held with both hands, hands 30cm apart on the rod. Object is to flex shoulders as far as possible, measurement taken in millimetres of distance from floor to inferior surface of wooden rod. Final measure is the average of three trials.

3.6.3 Player Fitness Biography

Information indicating previous injury was collected using a specific Medical History Form (Appendix E, p. 179), and data on injury incidence during the period of study was collected using a specific Team Injury Report Form (Appendix E, p. 181).
3.6.4 Player Surveys

Player surveys to provide qualitative data about the perceived benefits of the exercises and of the overall study were conducted toward the end of the season using the formats appearing in Appendix F - Player Survey Forms (p. 182) with separate forms necessary for experimental players (p. 183) and control players (p. 186). The player surveys were mailed out to each player at the end of the 1995 season. Follow-up letters, and in some cases telephone reminder calls, were made to ensure a strong rate of survey return. The overall rate of survey return was 76%. Data from the surveys was collated, entered into a data base and appropriate statistical tests were undertaken to determine emergent trends.

3.6.5 Coach and Trainer Interviews

Coach and trainer interviews were conducted following prior notification of interview content themes by means of written advice of the questions to be asked (Appendix G - Standard Format - Coach & Trainer Interview, p. 189). The interviews were recorded on studio quality audiotape cassette for later coding. Key informant statements were coded using tape play-back method, and the data were grouped to identify trends and recurrent themes. Key quotes from informants provided valuable information expanding on the results of the study, and these key quotes are represented in Appendix I (p. 200).

3.6.6 Training Site Observation and Game Observation

Observation field notes of training sessions and games were maintained by the researcher. All of the training venues were attended on a rostered basis to ensure regular distribution of the researcher's time amongst all groups. The spread of varying training days, training times and venues allowed appearance at training almost every weekday afternoon. There was no experimental exercise treatment intervention upon any of the
control teams, with the researcher's attendance as skilled observer to ascertain this. Respective site observation (training) researcher appearance data were;

**Elite Level Site Observations**

- Elite experimental teams - Penrith (13), St George (11),
- Elite control teams - Cronulla (14), Western Suburbs (15).

**Non-elite Level Site Observations**

- Non-elite experimental teams - Narellan (9), Fairfield (10),
- Non-elite control teams - Caringbah (10), Campbelltown City (10).

Game observation was planned on a rotational basis, designed to maximise the number of games attended. Special efforts were made to attend elite games when two of the teams involved in the study were scheduled to play against each other.

Respective game observation data were;

**Elite Level Game Observations**

- Elite experimental teams - Penrith (6), St George (5),
- Elite control teams - Cronulla (6), Western Suburbs (5).

**Non-elite Level Game Observations**

- Non-elite experimental teams - Narellan (4), Fairfield (4),
- Non-elite control teams - Caringbah (4), Campbelltown City (5).

As set out above, the researcher's presence at training venues and at competition games was evenly spread throughout the groups. A greater number of appearances was possible with the elite level teams because their football season, and especially their preseason training period, was much more extensive than the non-elite local club teams.

### 3.7 Data Preparation and Analysis

#### 3.7.1 Data Preparation

Upper body fitness data for both pretests and posttests were recorded longhand on data compilation sheets and then entered onto input data files on an Apple Macintosh...
Classic II computer. Means and Standard Deviations were calculated using ClarisWorks 2.0™ © 1993 Apple Computer Inc. software, and illustrative graphs also were derived using the Spreadsheet format on this software. Further statistical calculations were performed using Statview SE™ + Graphics © 1988 Abacus Concepts, Inc. and Minitab Statistical Software™ ©, Minitab Inc. Pennsylvania, U.S.A.

Increases or decreases in the measured upper body fitness parameters from pretest to posttest were calculated and the t-test used to establish whether or not there were significant differences between groups. Comparisons were also made for upper body injury incidences of experimental and control groups using a chi-square statistical analysis.

The player surveys provided both quantitative and qualitative data. Player survey responses that could be treated quantitatively were coded, with the results commented upon or tabulated and graphed where appropriate. Open-ended survey items in this category included questions requiring information about; amount of playing time in 1995 (including all school, representative, and club playing time), number of training sessions attended, injuries incurred, playing time lost due to injury, and time spent doing the experimental treatment exercises. These data were tabulated and the results treated statistically where possible to obtain mean behaviours or trends and the associated standard deviations by club team and experimental/control group.

Player survey responses yielding qualitative data were coded, with the results commented upon or tabulated and graphed where appropriate. Open-ended questions required written answers concerning player knowledge of parallel studies being conducted by the researcher, and responses as to whether players had modified their training as a result of knowledge of parallel studies were tabulated. Responses concerning the perceived influence of the study on the overall football year were also elicited. These open-ended items were treated individually and trends or categories of responses were represented in tabular or graphical form.
Further quantitative data were obtained from fixed-alternate items requiring a Yes/No response. These included subject participation in weight training programs separate from the normal load of football training eg. “home gym training”, as well as awareness of parallel researcher work. These fixed-alternate items were percentage grouped and graphed to add to the information to be interpreted. Items dealing with issues relating to the perceived benefit of the study utilised a 5-point response format Very Beneficial (5) to No Benefit (1), and contained items of relevance to both the experimental and control groups.

A similar type of measure utilising a 5-point Likert response format (Strongly Disagree (5), Disagree (4), Unsure (3), Agree (2), Strongly Agree (1)) was developed for the experimental teams to determine their perception as to whether the time taken implementing the researcher’s preventive exercise system could have been more usefully put into other training. (Appendix F, p. 182). The survey responses were treated individually with each question broken down into response percentages, the mean and standard deviation calculated and the data graphed by means of a pie chart. Emergent trends were analysed and noted for comment.

Triangulation of data was accomplished by means of interviews with the respective team coaches and trainers plus an examination of player survey responses which were completed after the posttesting of upper body fitness levels at the end of the 1995 Rugby League season. The structure for this data was derived from the respective research questions, and the data was viewed systematically to provide evidence to support or reject the various hypotheses. Researcher observation was also utilised to ascertain adherence to the experimental program and also to ascertain if there were any training methods undertaken during the control teams’ training sessions that may have been influenced by player knowledge of the experimental program implemented in the experimental teams’ training sessions.

3.7.2 Statistical Analyses

Upper Body Fitness parameter dependent variables were identified (Table 2. Upper Body Fitness Indicators As Tested, p. 59) and respective test instruments were
developed specifically to measure performance. Prior to the analysis of the differences in increases of measured upper body fitness parameters between subjects, data were tested for the assumptions of normality and homogeneity of variance within groups. These assumptions of normality and homogeneity of variance within groups were satisfied.

The requirements for the two-sample pooled t-test were satisfied. There were two separate groups, the experimental group and the control group, and two separate bell-shaped curves were derived from the observations gained from these groups. The sample variances were similar in value, and hence did not contradict the assumption that the population variances are equal.

Data analyses of upper body fitness test scores involved calculating mean scores and standard deviations for the unpaired preimplementation and postimplementation data of each of the upper body fitness parameters. Two-sample pooled t-tests were used to test the directional hypotheses that there would be increases in the various fitness parameters according to participation in the experimental treatment program. In support of the use of the t-test, Tuckman (1988) offers, “A t-test is a statistical test that allows you to compare two means to determine the probability that the difference between the means is a real difference rather than a chance difference” (p.271).

Upper body injury incidence data were collected and recorded. chi-square $\chi^2$ tests were performed to test the hypothesis that the proportion of upper body injuries would decrease according to participation in the experimental treatment. McMillan and Schumacher (1984) provide an explanation of the chi-square $\chi^2$ test when they state;

Chi-square is a means of answering questions about association or relationship based on frequencies of observations in categories. The frequencies can be in most any form - people, objects, votes - and are simply counted in each category. The researcher thus forms the categories and then counts the frequency of observations or occurrences in each category. (p.268).

Player surveys responses were grouped, with the results tabulated and graphed where appropriate. One open-ended survey item required information about amount of
playing time undertaken by participants in 1995 (including all school, representative, and club playing time). To control against variations in amount of playing time between groups being a confounding factor (injury risk is greatest during competition playing time) two-sample pooled t-tests were conducted and the results were examined.

Another open-ended survey item required player information about the number of training sessions attended. To control against number of training sessions variations between groups being a confounding factor, two-sample pooled t-tests were conducted and the results were examined. A further open-ended survey item required information about time spent performing the experimental treatment exercises. To control against amount of time spent performing experimental treatment exercises variations within the experimental groups being a confounding factor, data was treated statistically using two-sample pooled t-tests on the relevant data from each experimental team and the results were tabulated.

Qualitative aspects of the player surveys were tabulated and graphed where appropriate. This data was coded and examined to provide an overall body of information for the purposes of informing the research questions. The variety of data sources enabled the triangulation of the key findings.

Coach and Trainer Interviews provided key informant responses which were recorded and coded for utilisation with relevance to the overall study. These data were examined and analysed by means of percentage groupings of a classification of key statements, with recurrent themes or notable trends commented upon. Where possible, percentage groupings of responses by category were undertaken and these results tabulated for further analysis. Researcher attendances at training venues and at competition games were logged and observations worthy of note recorded with particular reference to potential influences on study outcomes.

A time chart for the implementation of the study during the 1995 season appears overleaf in Figure 1 (p. 73).
<table>
<thead>
<tr>
<th>Month</th>
<th>Season Phase</th>
<th>Research Tasks Undertaken</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td></td>
<td>Pilot study and modifications.</td>
</tr>
<tr>
<td>February</td>
<td>Preseason Phase</td>
<td>Player informed consent obtained.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pretesting fitness parameters.</td>
</tr>
<tr>
<td>March</td>
<td></td>
<td>Non-elite player pretesting and start of Elite player competition</td>
</tr>
<tr>
<td>April</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>Competition Phase</td>
<td>Researcher as data collector and skilled observer at games and training sessions March to September.</td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td></td>
<td>Post-testing. Player surveys conducted.</td>
</tr>
<tr>
<td>October</td>
<td>Post-season Phase</td>
<td>Coach and trainer interviews.</td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1. Study Time Chart, 1995.**
CHAPTER 4
RESULTS

4.1. Overview

This study was undertaken to determine the effects of an upper body fitness training program on upper body injury incidences in adolescent Rugby League players. The adolescent players in the study were competing at either the elite or non-elite levels.

Data derived from the upper body fitness parameters of strength, local muscle endurance and flexibility involved conducting select upper body fitness tests (Table 2. p. 52). Pretests and posttests produced normative upper body fitness data indicating changes in fitness levels over the period of the study. Data on injury incidence were also collected and analysed by appropriate statistical methods. The player surveys provided both qualitative and quantitative data on playing time, time devoted to performing the experimental exercises, and attitudes to the program and the study overall. The audiotaped coach and trainer interviews provided further data on player application to the program and its reception by the players. The results of this study are reported for each of the research questions and their respective hypotheses posed in Chapter 1 (p. 5 - 7).

4.2 The Major Research Question

The major research question explored was tested to determine whether a specialised upper body exercise and conditioning program reduced the incidence of upper body injuries in adolescent Rugby League players. For the corresponding research hypothesis $H_1$ (RHH$_1$Injuries) tested, rejection of the null hypothesis would
offer the conclusion that the experimental players on the upper body exercise program
did not suffer as many upper body injuries as the non-program players.

The experimental exercise system (the specialised upper body exercise system)
was initiated and carried out during the 1995 season. Data collected indicated a number
of upper body injuries suffered during the period of the study, and these injuries were
classified according to their severity (Table 1, p. 15). The main finding was that the
experimental exercise program significantly reduced the number of ‘Very Serious’
shoulder injuries in the elite level experimental players in comparison to the elite level
control players. However, at the non-elite level the exercise program was not effective,
and the number of minor (‘Able to play on’ severity classification) neck injuries suffered
by the non-elite experimental players was significantly greater than those of the non-elite
control players.

The elite level and non-elite level data were treated separately because findings
indicated that the types and severity of injuries suffered by the elite players were not
correspondingly suffered by the non-elite players, and vice versa. The elite experimental
and control teams displayed evidence of only one neck injury of a minor kind during the
period of the study, but they had a number of shoulder injuries of the ‘Very Serious’
classification. The non-elite teams, on the other hand, suffered a number of neck injuries
of the ‘Able to play on’ classification, but at this non-elite level few shoulder injuries
occurred. Therefore the injury data and possible contributing factors were treated
separately for the elite and non-elite players.

4.2.1. RHH1 Injuries - Elite Level - Upper Body Injury Incidence

For the purposes of examining Research Hypothesis RHH1, data for upper
body injuries in the elite players were collated, categorised and statistically analysed by
means of the chi-square test. Shoulder specific data were the focus of consideration for
the elite level players, since shoulder injuries were the significant injuries at the elite
level. Elite level neck specific data were treated as separate from elite shoulder specific
data because the elite players did not suffer a significant number of neck injuries during
the course of the study. The shoulder specific data for the non-elite players was also treated separately because the non-elite players indicated no significant shoulder injuries. The prevalence of elite level ‘Very Serious’ shoulder injuries warranted a closer examination of all elite level shoulder specific data.

The chi-square test for the elite level shoulder injury severity classification ‘Very Serious’ produced a significant result $\chi^2 (\, df = 1, \, n = 85) = 6.276, \, p = 0.012$. The contingency table for this classification is represented in Table 3, below, with expected frequencies contained in parentheses after the observed frequencies;

Table 3

<table>
<thead>
<tr>
<th></th>
<th>injured</th>
<th>not injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>1 (4.55)</td>
<td>42 (38.45)</td>
</tr>
<tr>
<td>Control</td>
<td>8 (4.45)</td>
<td>34 (37.55)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th>76</th>
<th>85 (total participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>total injured</td>
<td>total not injured</td>
<td></td>
</tr>
</tbody>
</table>

Therefore, for elite level shoulder injuries of the ‘Very Serious’ severity the analysis indicated the rejection of the null hypothesis at the 5% level of significance and the research hypothesis $RHH_{1}Injures$ was accepted. It was concluded that there was a significant difference in elite level ‘Very Serious’ shoulder injuries according to variation in the independent variables, experimental or control group. The elite control players suffered the significantly greater number of shoulder injuries in this category.
The remaining elite shoulder injury severity classifications indicated no significant difference (\( p > 0.05 \)) between experimental treatment and control players using the chi-square test. The incidence of injuries for the shoulder injury classifications which indicated no significant differences are represented in Table 4 below:

Table 4
RHH1 Injuries - Elite Level - Shoulder Injury Incidence - Severity Classifications Not Statistically Significant

<table>
<thead>
<tr>
<th>Subject Status</th>
<th>Severity Classification</th>
<th>Injured</th>
<th>Not injured</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Able to play on</td>
<td>Experimental</td>
<td>2</td>
<td>41</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>0</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Moderate</td>
<td>Experimental</td>
<td>4</td>
<td>39</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>3</td>
<td>39</td>
<td>42</td>
</tr>
<tr>
<td>Serious</td>
<td>Experimental</td>
<td>1</td>
<td>41</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1</td>
<td>42</td>
<td>41</td>
</tr>
</tbody>
</table>

4.2.2. RHH1 Injuries - Elite Experimental Players - Experimental Exercises as Beneficial for Increased Resistance to Upper Body Injuries - Survey Responses

Survey responses from the elite level experimental players registered unanimous support that the experimental treatment exercises were beneficial for increased resistance to upper body injuries. Surveys were prepared and distributed to the sample population.

77
of 85 elite players. Completed survey responses were received from 61 (72%) of the elite players. The survey item relevant to the major research question, was;

In your opinion, how effective were the prescribed neck and shoulder exercises in increasing your resistance to upper body injuries?

This survey item employed a 5-point scale requiring a response ranging from Very Beneficial (5) to No Benefit (1). This survey item was treated individually with the response frequencies and percentages represented in Table 5. below:

Table 5
RHH1 Injuries - Elite Experimental Players - Benefit of Experimental Exercises in Increased Resistance to Upper Body Injuries - Cumulative Rating Scores

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Frequency</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 = Very Beneficial</td>
<td>8</td>
<td>34.8</td>
<td>8</td>
<td>34.8</td>
</tr>
<tr>
<td>4 = Somewhat Beneficial</td>
<td>11</td>
<td>47.8</td>
<td>19</td>
<td>82.6</td>
</tr>
<tr>
<td>3 = Beneficial</td>
<td>4</td>
<td>17.4</td>
<td>23</td>
<td>100</td>
</tr>
<tr>
<td>2 = Almost No Benefit</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>100</td>
</tr>
<tr>
<td>1 = No Benefit</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>100</td>
</tr>
</tbody>
</table>

All players at the end of the season were of the opinion that the experimental treatment exercises were beneficial in increasing resistance to upper body injuries.

4.2.3 RHH1 Injuries - Elite Level Experimental Players - Consistency in Training Time Allocated to Experimental Exercises

Player survey, key informant interview and researcher observation data suggested that there was no significant difference in elite level experimental team training
time allocated to the exercise program by the two elite experimental teams. It was calculated that an average of five minutes per session throughout the 1995 season was allocated by the elite level experimental players to completion of the specialised exercise regimen.

The possibility of unequal allocation of team training time was raised during the course of the study, and this could have proved a possible confounding variable. The researcher made rostered appearances at eight different training venues and attended game days for all teams. Because of this demanding schedule, attendance at every training session for every team was impossible, therefore there was a reliance on the enthusiasm of the coaching staffs to implement the exercise program consistently in the absence of the researcher. The coaching and training staff of one elite experimental team was noticeably more lax in enthusiasm toward the exercise program as the season progressed. Informal discussions with one of the players during the latter part of the study indicated that the experimental treatment exercises were not being followed consistently in my absence from the training venue, even though the coaching staff had agreed to participate and were reporting regular implementation of the sequence. This turn of events threatened to produce a confounding variable in the study since a positive finding in favour of the injury prevention value of the experimental program would not be particularly valid if 50% of the elite experimental players were not consistently completing the program exercises. This problem was discovered too late in the period of the study to enforce more rigid training staff adherence to the program, so the player survey was initiated to gain information from all of the experimental players as to the time they had spent performing the experimental exercises at training.

Player survey respondents from the club in question indicated that the experimental exercise program was being done consistently, although in some cases not rigorously at every training session. Survey response information on both elite level experimental teams produced data on the total time each had performed the exercises. These data were tested for statistical significance using the t-test for normal data and it was found that there was no significant difference ( p > 0.05) between the two elite experimental teams. This data is represented in Table 6 (p. 80).
Table 6

RHH1 Injuries - Elite Experimental Players - Comparison of Total Time Performing Experimental Treatment Exercises In Minutes.

<table>
<thead>
<tr>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>-0.089</td>
<td>0.465</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count:</th>
<th>Mean:</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite#1</td>
<td>15</td>
<td>249.267</td>
<td>166.881</td>
<td>43.089</td>
</tr>
<tr>
<td>Elite#2</td>
<td>8</td>
<td>256.5</td>
<td>218.686</td>
<td>77.317</td>
</tr>
</tbody>
</table>

The number of training sessions attended was examined to gain an indication of the average in minutes per training session allocated to the experimental exercises. The survey responses indicated a mean number of team training sessions attended per elite experimental player of $X = 43.84$. When combined with the findings above that the Mean Total Time allocated to performance of the exercises (for both elite#1 and elite#2) was $X = 252.88$, these results indicate that the average time performing the experimental exercises per training session was 5.77 minutes. There would have been some training sessions with more time allocated to the exercise program, and other sessions that no doubt involved less exercise program time. Indeed, the coach and trainer interviews revealed that, although the experimental treatment exercises were sometimes not performed, the sentiment of the coaching staff ensured that the program was pursued right up until the last games of the season ie. a consistent spread of the exercises throughout the 1995 season. Therefore there was sufficient time allocated to the exercises to implicate the exercises as significantly contributing to the outcomes of the study. It must be also taken into account that some respondents may have had interrupted attendance at training sessions through injury and absences but their respective survey return figures had to be included in the overall results because their injury statistic was indeed important to the study.
The total amount of game time played by the elite level players was analysed to determine if there was a significant difference between experimental and control players. The game situation presents far more hazardous circumstances for injury than leisure or training activities, and significant differences in playing time between experimental and control groups could have provided a confounding variable. There was found to be no significant difference in playing time over the 1995 season between elite level experimental and control groups. The player surveys returned the most accurate calculation of this factor in minutes played. These figures were tested for statistical significance using the t-test for normal data, the results are represented in Table 7 below:

Table 7

RHHJ Injuries - Elite Level - Comparison of Total Game Time in Minutes - Experimental and Control Players

<table>
<thead>
<tr>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>1.437</td>
<td>0.078</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count:</th>
<th>Mean:</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>25</td>
<td>1211.96</td>
<td>665.084</td>
<td>133.017</td>
</tr>
<tr>
<td>Control</td>
<td>38</td>
<td>956</td>
<td>708.548</td>
<td>114.942</td>
</tr>
</tbody>
</table>

For the elite level players there was no significant difference (p > 0.05) between experimental and control players for Total Game Time. The amount of game time is critical because of the high intensity level approached only in the game situation, and it is in the game situation when all of these shoulder injuries of the elite players were incurred. The amount of exercise undertaken outside of the study cannot be controlled for. However, minimal exercise by any one team of players in comparison to another
would be represented by lower fitness parameter test scores because exercise levels need to be achieved on a regular basis to maintain fitness. Therefore the total game time factor was not significant in influencing the study results in the elite category where the significant number of 'Very Serious' shoulder injuries occurred.

4.2.5. RHH\textsubscript{1}Injuries - Non Elite Level - Upper Body Injury Incidence

There were significant minor neck injuries of the 'Able to play on' classification in the non-elite level experimental players. This finding contra-indicated the effectiveness of the experimental exercise program at the non-elite level, but there were concerns regarding the statistical significance of the non-elite experimental players' injury rates. There were also other concerns raised surrounding mitigating circumstances that led to all of the injuries being suffered by one team in one game, and these concerns are examined below.

The quantitative data for upper body injuries of the non-elite players were collated, categorised and statistically analysed by means of the chi-square test. Although there were a number of non-elite upper body injuries, only the neck region returned chi-square test figures of statistical significance ($p < 0.05$) and therefore non-elite neck specific data were treated as separate to all other data.

For the non-elite neck injury severity classification 'Able to play on' the chi-square test reported a significant result $\chi^2 (d\!\!f = 1, n = 71) = 3.895$, $p = 0.048$. The contingency table for this classification appears in Table 8 (p. 83); note that the expected frequencies are contained in parentheses after their relevant observed frequencies.
Table 8
RHH Injuries - Contingency Table - Non-elite Level - Neck Injury - Severity Classification: Able to play on.

<table>
<thead>
<tr>
<th></th>
<th>injured</th>
<th>not injured</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 (2.08)</td>
<td>33 (34.92)</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>0 (1.92)</td>
<td>34 (32.08)</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>67</td>
<td>71</td>
</tr>
<tr>
<td>total</td>
<td>injured</td>
<td>not injured</td>
<td>total</td>
</tr>
</tbody>
</table>

The above result represents a negative finding. The significant numbers of neck injuries in the 'Able to play on' severity classification were suffered by the experimental groups (four injuries), and not the control groups (no injuries), which indicated that the experimental treatment program was not effective in preventing injuries in this non-elite case.

However, these results must be treated tentatively since the expected frequencies ($E_{ij}$s) for the injured players were less than 5 ie. non-elite experimental groups $E_{ij} = 2.08$ and control groups $E_{ij} = 1.92$. Assuming the $\chi^2$ value comes from a Chi-square distribution with 1 degree of freedom if there is no association between the two factors, then there probably is an association between the group to which the players belong and the incidence of injuries.

Although traditionally many statisticians have not performed a $\chi^2$ when any expected frequency is less than 5, this is now thought to be conservative. Conover argues;

Because the asymptomatic distribution is used, the approximate value for $\alpha$ as found here, is a good approximation to the true value of $\alpha$ if the $E_{ij}$s are fairly
large. However, if some of the $E_{ij}$s are small, the approximation may be very poor. Cochran (1952) states that if any $E_{ij}$ is less than 1 or if more than 20% of the $E_{ij}$ are less than 5, the approximation may be poor. This seems to be overly conservative according to unpublished studies by various researchers, including students of Oscar Kempthorne and students of B.L. van der Waerden, and an article by Roscoe and Byars (1971). If $r$ and $c$ are not too small, I feel that the $E_{ij}$s may be as small as 1.0 without endangering the validity of the test. If some of the $E_{ij}$s are too small, several categories may be combined to eliminate the $E_{ij}$s that are too small. Just which categories should be combined is a matter of judgment. Generally, categories are combined only if they are similar in some respects, so that the hypotheses retain their meaning. (Conover, 1980, p. 156).

A further outcome which gave cause to treat this result tentatively was that the above non-elite Neck Injury Severity Classification 'Able to play on' statistic presented a level of significance of $p = 0.048$ which is very close to the 0.05 determining level of significance.

The significant minor neck injuries suffered by the non-elite experimental group must also be examined after taking into account that unusual circumstances of illegal game tactics led to all of these injuries being suffered by the one experimental team in their very last game of the 1995 season. The coach and trainer interviews provided testimony to these unusual circumstances and the researcher's observation of this game noted the occurrences of the injuries as a result of dangerous scrummaging techniques used by the opposition. These unusual contributing circumstances will be further examined in Chapter 5. Discussion and Recommendations (p. 128). However, significant data were provided by non-elite neck fitness parameter tests data and these must be examined for relevance to the finding of significant differences between groups in the occurrence of minor neck injuries.

There were no non-elite category neck injuries in severity classifications 'Serious' and 'Very Serious'. There was one neck injury in the severity classification
'Moderate' during the course of the study but there was no significant statistical result (p > 0.05) for this severity classification using the chi-square test of the data. The data for non-elite level “Moderate” neck injuries appear in Table 9 below:

Table 9

<table>
<thead>
<tr>
<th>Subject Status</th>
<th>Severity Classification</th>
<th>Injured</th>
<th>Not injured</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>1</td>
<td>36</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>35</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

4.2.6 RHHiInjuries - Non-elite Level - Experimental Players - Experimental Exercises as Beneficial for Increased Resistance to Upper Body Injuries - Survey Responses

Of the non-elite level experimental player responses, 85% were of the opinion that the exercise system was beneficial in increasing resistance to upper body injuries. Surveys were prepared and distributed to the sample population of 71 non-elite players. Completed survey responses were received from 57 or 80% of players from the non-elite level.

The survey question relevant to the non-elite experimental players, and relevant to this the major research question was;

In your opinion, how effective were the prescribed neck and shoulder exercises in increasing your resistance to upper body injuries?
This survey item employed a 5-point scale and required a response ranging from Very Beneficial (5) to No Benefit (1). This survey item was completed individually with the responses broken down into percentages and graphed by means of a pie chart. A total of 23 players agreed that the program exercises were beneficial. This number represents 85.1% of all non-elite responses. Four players disagreed with the statement, representing 14.9% of all respondents. These results are presented below in Figure 2:

![Pie chart showing survey results](image)

**Figure 2.** RHH Injuries - Non-elite Experimental Players - Benefit of Experimental Exercises for Increasing Resistance to Upper Body Injuries.

### 4.2.7 RHH Injuries - Non-elite Experimental Players - Consistency in Training Time Allocated to Experimental Exercises.

At the non-elite level it was also necessary to examine the actual time taken performing the experimental exercise program to feel confident that the exercises were in fact a contributing factor to the results indicated. No significant difference between the two non-elite experimental teams was indicated in non-elite level experimental training time allocated to completion of the exercise program.

The player survey indicated that the experimental exercise program was being followed consistently. However, similarly to the elite experimental group, in some cases
the experimental program at the non-elite level was not adhered to rigorously at every training session and because of this the total time allocated to the experimental program by the non-elite experimental teams was examined. To ascertain if there were differences in time performing the exercises between non-elite experimental teams, survey response information on total time performing the exercises was tested for statistical significance using the t-test for normal data and no significant difference (p > 0.05) between the two non-elite experimental teams was indicated. These results are represented in Table 10 below:

Table 10

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-elite #1</td>
<td>14</td>
<td>259.929</td>
<td>247.719</td>
<td>66.206</td>
</tr>
<tr>
<td>Non-elite #2</td>
<td>13</td>
<td>242.077</td>
<td>184.251</td>
<td>51.102</td>
</tr>
</tbody>
</table>

The number of training sessions attended was examined to gain an overall indication of the average minutes allocated to performance of the exercises per training session. The survey responses produced a mean number of training sessions attended per non-elite experimental player of $X = 36.89$. When combined with the finding above that the mean total time allocated to performance of the exercises was $X = 251.00$ these results indicated an average time performing the experimental exercises of 6.8 minutes per training session. This would allow some training sessions to utilise more time on the exercise program, and other sessions to no doubt involve less time. As was the case for the elite experimental groups, the non-elite level coach and trainer interviews revealed that, although the experimental treatment exercises were sometimes not performed, the sentiment of the coaching staff ensured that the program was pursued consistently right
up until the last games of the season. Therefore it is considered that there was sufficient time allocated to performing the exercises to implicate the exercises as significantly contributing to the outcomes of the study.

4.2.8 RHH Injuries - Non-Elite Level - Comparison of Total Game Time, 1995.

Experimental and Control Players

The total amount of game time undertaken by the players was analysed to determine if this factor had significant influence in creating a confounding difference between the non-elite experimental and control players. There was found to be no significant difference in game time undertaken between non-elite experimental and control players (p > 0.05). The player surveys returned the most accurate calculation of this factor in minutes played. These figures were tested for statistical significance using the t-test for normal data, the results represented in Table 11 below:

Table 11

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>28</td>
<td>1085.179</td>
<td>676.716</td>
<td>133.017</td>
</tr>
<tr>
<td>Control</td>
<td>29</td>
<td>1253.069</td>
<td>697.922</td>
<td>129.601</td>
</tr>
</tbody>
</table>

There was no significant difference (p > 0.05) between the non-elite experimental and control players for Total Game Time undertaken by non-elite players. Therefore this factor was not significant in influencing the study results for the non-elite level where the significant number of ('Able to play on') neck injuries occurred.
4.2.9 Injuries - The Coach and Trainer Interviews

The coaches and trainers found the study to be of value to the experimental and control players. In essence the coach and trainer consensus for the experimental players was that the players found the specialised upper body exercise system was effective in reducing the incidence of upper body injuries in their players during the period of the study. A detailed report of the coach and trainer interviews is shown in Appendix I, and a selection of important responses from the interviews is presented below.

"We were all round stronger than most of the other teams, and we didn’t have any injuries to the shoulders and neck because of that." This reflection was made by the coach of the "strongest" team in the study (which was a randomly selected experimental team). This particular team required more weight for the tests, and more repetitions were performed at set weights, but the results of this team alone were insufficient to skew the results on the pretests and posttests.

"I can see how we need to be a bit more scientific in how we prepare the boys. We hadn’t seen anything like those exercises before, and although the boys were a bit slow to take to it at first they started to really enjoy competing against each other to see who could do the most of each lot". This was a statement made by an elite level experimental team trainer, a person with whom the researcher shared an affinity, and probably the most innovative and knowledgeable of the training personnel involved in the study.

"We weren’t even allowed in the weights room. They always said that the First Grade were using the gym, but they wouldn’t be there when we could have used it and we still couldn’t use it. I really believe in weights at this level, but we couldn’t get near them, and I reckon that if we’d have done weights we wouldn’t have had all those shoulder injuries we had. But what can you do?" This was the frustrated opinion recorded by an elite level control group coach who was disappointed by the lack of club support on this issue. His team recorded by far the greatest number of ‘Very Serious’ shoulder injuries, surgical correction being indicated for at least one unfortunate player.
"We couldn't do the exercises all the time. There just wasn't enough time to fit everything in. I found the concepts involved to be of good value, and we didn't have any injuries in particular so it might have been helpful there". This view was registered by an elite level experimental team coach. Indeed, the possibility of wavering support from this particular club resulted in the need to formulate and conduct the player survey.

"Having you do the study was really good for the boys. It made them keener to get fitter. Hearing them talking about how many times they could lift the heavy weights, and how strong they were at pressing in on that arm dynamometer gave them a whole new language and they felt more professional because of what you did. So the study was a good thing that we all got a lot out of.... No.. No down side." This was the sentiment expressed by the greater proportion of the control teams’ coaches and trainers, at both the elite and non-elite levels. It must be remembered that, within the ranks of the control teams and their training personnel, the researcher succeeded in prolonging the impression that the study of all teams only involved the collection of fitness test data and injury incidence data. (The Coach and Trainer Interviews report is in Appendix I, p. 200).

4.3 Related Research Questions

4.3.1 Related Research Question One

Would a specialised upper body exercise and conditioning program produce increases in fitness as measured by select performance tests for strength, local muscle endurance and flexibility of the shoulders and neck?

Data gathered to provide answers to Related Research Question One (p. 5) were used for the purposes of testing Research Hypothesis H2 (RHH2Fitness Increases, p. 6) that subjects on the program would exhibit greater gains on scores for the upper body fitness parameters tested. The select performance tests for strength, local muscle endurance and flexibility of the shoulders and neck are set out in Table 2 (p. 59). Pretests and posttests were completed for these select upper body fitness parameters.
The differences from pretest to posttest were calculated for each player and mean scores and standard deviations were determined. Two-sample pooled $t$-tests were used to analyse the statistical significance of variations in mean scores. The select upper body fitness parameters represented the dependent variables, whilst the independent variables were defined according to whether the player belonged to the experimental or control group.

Unfortunately, the combined results of the subject categories for the Table 2 tests produced findings indicating that classification according to elite or non-elite status was a confounding factor. This happened in a number of tests and an example of this is presented below in Table 12, illustrating the comparison of mean increases between elite and non-elite players for the Shoulder Flexibility - Lying Prone Rod Lift test which produced results that differed markedly.

Table 12

RHH2Fitness Increases - Elite and Non-elite Levels - Comparison of $t$-Test Results - Mean Scores Changes From Pretest To Posttest - Shoulder Flexibility - Prone Rod Lift

<table>
<thead>
<tr>
<th></th>
<th>DF:</th>
<th>Unpaired $t$ Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite</td>
<td>69</td>
<td>3.285</td>
<td>.0008</td>
</tr>
<tr>
<td>Non-elite</td>
<td>59</td>
<td>-.349</td>
<td>.364</td>
</tr>
</tbody>
</table>

Thus for the elite level upper body fitness test - Shoulder Flexibility - Prone Rod Lift the directional hypothesis (RHH2Fitness Increases) was accepted ($p_\text{= 0.0008}$) indicating a significant increase in the elite experimental group ($t = 3.285$) over the elite control group from pretest to posttest. But by comparison the same parameter for the non-elite level teams produced $t$-test results whereby the directional hypothesis was rejected ($p > 0.05$) because there was no significant change from pretest to posttest between non-elite experimental and control players. These markedly different elite and non-elite level results, if combined, do not provide a clear indication of how each level

91
performed separately on this parameter. Hence, results for the elite and non-elite levels were treated separately for investigation of the research hypothesis RHH2Fitness Increases.

4.3.1.1 RHH2Fitness Increases - Elite Level - Significant Mean Scores Increases From Pretest To Posttest - Experimental and Control Players

It was found that the exercise program significantly increased mean test scores from pretest to posttest on only one of the measured fitness parameters at the elite level. The elite experimental players indicated a significant increase in fitness for only Neck Flexibility - Head Rotation - Left & Right. The table of t-test results for this elite level test protocol is represented in Table 13 below:

Table 13
RHH2Fitness Increases - Elite level - Upper Body Fitness Test - Neck Flexibility - Head Rotation - Left + Right - Total Degrees - Experimental and Control Players

<table>
<thead>
<tr>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>1.877</td>
<td>0.0325</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count:</th>
<th>Mean:</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>34</td>
<td>3.059</td>
<td>22.636</td>
<td>4.568</td>
</tr>
<tr>
<td>Control</td>
<td>33</td>
<td>-11.515</td>
<td>36.31</td>
<td>6.321</td>
</tr>
</tbody>
</table>

Thus for upper body fitness test for Neck Flexibility - Head Rotation - Left + Right - Total Degrees the directional hypothesis (RHH2Fitness Increases) was accepted \((p = 0.0325)\) as there was a significant mean increase in Neck Flexibility - Head Rotation - Left + Right - Total Degrees scores between the experimental group and the control group over the period of program. The mean increase in this test for neck flexibility for the experimental group was positive \(\bar{X} = 3.059\), an increase in flexibility, whilst the control group mean scores were negative \(\bar{X} = -11.515\) with a
significant decrease in this type of neck flexibility as measured on this test over the period of the program.

There were, however, significant changes in elite player fitness that were not actual increases in fitness over the course of the study, but these changes were of importance to the conclusions drawn from the study. On some parameters there were decreases in fitness scores for both elite experimental and control player groups, but significant differences were indicated between between groups in the amounts by which they decreased scores. In other cases there were decreases in fitness parameter scores for the elite experimental players compared to increases in the control players. These cases, although not increases in elite level upper body fitness, were important to the discussion and conclusions drawn from the study and will be represented below under the continuing examination of Research Hypothesis H2 - RHH\textsubscript{2}Fitness Increases.

4.3.1.2 RHH\textsubscript{2}Fitness Increases - Elite Level - Significant Mean Scores Changes From Pretest To Posttest Indicating Program Effectiveness - Experimental and Control Players

At the elite level there were a number of significant negative changes in mean scores for the upper body fitness parameters tested. There were a number of changes in the elite experimental and control players which represented decreases in fitness on these measures but there was significantly greater decrease in fitness in the control players. Elite level tests that produced negative results were; i) Shoulder Flexibility - Prone Rod Lift (Table 14, p. 94), ii) Neck Flexibility - Flex & Extend - Total Degrees (Table 15, p. 95), and iii) Neck Flexibility - Lateral Rex - Left & Right - Total Degrees (Table 16, p. 96) and these elite parameter results are represented below as “Mean Scores Changes”.

i) RHH\textsubscript{2}Fitness Increases - Elite Level Significant Mean Scores Changes - Upper Body Fitness Test - Shoulder Flexibility - Prone Rod Lift. There was a significant finding for the program in elite level tests on this parameter, although there
was no significant increase in scores from pretest to posttest. The table of t-tests results for this elite level test protocol is represented in Table 14 below:

Table 14
RHH2Fitness Increases - Elite Level Significant Mean Scores Changes - Upper Body Fitness Test - Shoulder Flexibility - Prone Rod Lift - Experimental and Control Players

<table>
<thead>
<tr>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>69</td>
<td>3.285</td>
<td>0.0008</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count</th>
<th>Mean:</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>36</td>
<td>-1.883</td>
<td>5.208</td>
<td>0.868</td>
</tr>
<tr>
<td>Control</td>
<td>35</td>
<td>-6.863</td>
<td>7.406</td>
<td>1.252</td>
</tr>
</tbody>
</table>

For this elite level upper body fitness test - Shoulder Flexibility - Prone Rod Lift, the directional hypothesis RHH2Fitness Increases was rejected because there was no actual increase in scores attributable to the experimental program. However, the change in scores between groups over the course of the study was significant (p = 0.0008) although there were actual decreases in mean scores for Shoulder Flexibility Prone Rod Lift in both experimental and control player groups during the period of the program. The elite experimental player decreases in flexibility on this parameter were significantly less than the loss of flexibility of this type in the control players over the 1995 season (experimental X = -1.883 and control X = -6.863 respectively; p = 0.0008). The program had a significant effect on this parameter, albeit not an increase in scores on this test. The importance of this finding is discussed further in Related Research Question Two and Chapter 5 - Discussion and Recommendations (p. 128).

ii) RHH2Fitness Increases - Elite Level Significant Mean Scores Changes - Upper Body Fitness Test - Neck Flexibility - Flex + Extend - Total Degrees. There was a significant finding of importance to the study in this type of neck flexibility at the elite
level. The table of \( t \)-tests results for this elite level test protocol is represented in Table 15 below:

Table 15

<table>
<thead>
<tr>
<th>Fitness Test - Neck Flexibility - Flex and Extend - Total Degrees - Experimental and Control Players</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>Exper</td>
</tr>
<tr>
<td>Control</td>
</tr>
</tbody>
</table>

Thus for upper body fitness test - Neck Flexibility - Flex + Extend - Total Degrees, the directional hypothesis \( \text{RHH}_2 \text{Fitness Increases} \) was rejected because there was no increase in scores. However, a significant \( (p = 0.0134) \) change in mean scores occurred between the elite experimental and control players over the period of program. Again, these changes in mean scores for both experimental and control player groups were actually negative (experimental \( X = -0.941 \) and control \( X = -10.114 \)), i.e. there was a significantly greater decrease in mean scores for the elite control players for the fitness parameter Neck Flexibility - Flex + Extend - Total Degrees.

iii) \( \text{RHH}_2 \text{Fitness Increases} \) - Elite Level Significant Mean Scores Changes - Upper Body Fitness Test - Neck Flexibility - Lateral Flex - Left + Right - Total Degrees. There was a significant finding of importance to the study in Neck Flexibility - Lateral Flex - Left + Right - Total Degrees. The table of \( t \)-tests results for this test protocol is represented in Table 16 (p. 96).
Table 16
RHH2Fitness Increases - Elite Level Significant Mean Scores Changes - Upper Body Fitness Test - Neck Flexibility - Lateral Flex - Left & Right - Total Degrees - Experimental and Control Players

<table>
<thead>
<tr>
<th></th>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>67</td>
<td>1.91</td>
<td>0.0302</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>34</td>
<td>-5.382</td>
<td>22.648</td>
<td>3.884</td>
</tr>
<tr>
<td>Control</td>
<td>35</td>
<td>-15.771</td>
<td>22.539</td>
<td>3.81</td>
</tr>
</tbody>
</table>

Thus for upper body fitness test - Neck Flexibility - Lateral Flex - Left + Right - Total Degrees the directional hypothesis RHH2Fitness Increases was again rejected because there was no increase from pretest to posttest. There was a significant change ($p = 0.0302$) in Neck Flexibility - Lateral Flex - Left + Right - Total Degrees scores between the elite experimental and control players over the period of program. There were actual decreases in mean scores for Neck Flexibility - Lateral Flex - Left + Right - Total Degrees in both groups (experimental $X = -5.382$ and control $X = -15.771$ respectively) during the program, but there was a significantly greater decrease in mean scores in the control group.

4.3.1.3 RHH2Fitness Increases - Elite Level Significant Mean Scores Decreases From Pretest To Posttest - Experimental and Control Players

There were significant negative elite level findings against the program’s effectiveness. Tests for these parameters indicated an actual decrease in test scores when comparing the elite experimental and control players over the period of the program. Such parameters as i) Behind Neck Press Endurance (Table 17 p. 97) and ii) Shoulder Flexibility - Internal Rotation - Left & Right Arm - Total (Table 18 p. 98) produced
significant decreases in scores in the elite experimental players, but these findings are important to the discussion and conclusions drawn from the study and they will be examined below.

i) RHH₂Fitness Increases - Elite Level Significant Mean Scores Decreases - Upper Body Fitness Test - Behind Neck Press Endurance - Experimental and Control Players. There was a significant negative finding for the program on this parameter at the elite level. The table of t-tests results for this test protocol is represented in Table 17 below:

Table 17
RHH₂Fitness Increases - Elite Level Significant Mean Scores Decreases - Upper Body Fitness Test - Behind Neck Press Endurance - Experimental and Control Players

<table>
<thead>
<tr>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>-3.77</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count:</th>
<th>Mean:</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>28</td>
<td>-5.5</td>
<td>11.358</td>
<td>2.146</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>3.467</td>
<td>6.174</td>
<td>1.127</td>
</tr>
</tbody>
</table>

Thus the directional hypothesis RHH₂Fitness Increases was rejected indicating that the experimental treatment program did not produce significant increases in the elite experimental players. However, there was a significant (p = 0.0002) change in scores for Behind Neck Press Endurance between the elite experimental and control players over the period of the program. The significant (p = 0.0002) mean scores changes from pretest to posttest indicated an actual decrease (X = -5.5) for the elite experimental players, whilst the mean score for the control players increased (X = 3.467). On this parameter the elite experimental players decreased in fitness whilst the control players actually increased their fitness scores. Therefore, the program did have a significant effect on this parameter, albeit a negative one, and this result is considered the critical
finding in the study. Its importance to the research hypothesis RHH₂Fitness Increases and the research conclusions drawn are discussed in Chapter 5 - Discussion and Recommendations (p. 128).

ii) RHH₂Fitness Increases - Elite Level Significant Mean Scores Decreases -
Upper Body Fitness Test - Shoulder Flexibility - Internal Rotation - Left & Right Arm -
Total. There was a significant negative finding for elite level tests on this parameter. The table of t-tests results for this elite level test protocol is represented below in Table 18.

Table 18

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>34</td>
<td>1.515</td>
<td>10.34</td>
<td>1.773</td>
</tr>
<tr>
<td>Control</td>
<td>34</td>
<td>-2.579</td>
<td>8.601</td>
<td>1.475</td>
</tr>
</tbody>
</table>

Of importance here is that a lower score represents a higher level of flexibility since the measure was how far the participant could reach up behind the back toward the spinous process of C7 vertebra. The greater the flexibility, the greater the reach up behind the back, and therefore the lower the score for distance between fingertips and the C7 spinous process. Thus for Upper Body Fitness Test - Shoulder Flexibility - Internal Rotation - Left & Right Arm - Total the directional hypothesis RHH₂Fitness Increases was rejected indicating that the experimental treatment program did not produce a significant increase score at the elite level. On this test there was a significant change \((p = 0.0002)\) in scores between the elite experimental and control players over the period of program. The mean increase for the experimental players' scores \((X = \)
1.515) represented an actual decrease in Shoulder Flexibility - Internal Rotation - Left and Right Arm - Total as a result of implementation of the experimental treatment program. The mean score of the elite control players decreased ($X = -2.579$), which indicated greater flexibility in the control players. The program had a significant effect on this parameter, albeit a negative effect, and this negative result is discussed in Chapter 5 - Discussion and Recommendations (p. 128).

### 4.3.1.4 RHH\textsubscript{2}Fitness Increases - Elite Level Mean Scores Changes That Were Not Significant - Experimental Groups and Control Players

The research tests for normative fitness data produced results from pretest to posttest indicating that mean score changes in a number of the upper body fitness parameters were not considered statistically significant ($p > 0.05$). These elite level non-significant upper body fitness parameters tests are represented in Table 19 below:


<table>
<thead>
<tr>
<th>Number</th>
<th>Test</th>
<th>$t$ - Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a.</td>
<td>Military Press Endurance.</td>
<td>$t (53) = 0.457, p &gt; 0.05$.</td>
</tr>
<tr>
<td>1b.</td>
<td>Military Press Strength.</td>
<td>$t (58) = 0.208, p &gt; 0.05$.</td>
</tr>
<tr>
<td>2b.</td>
<td>Behind Neck Press Strength.</td>
<td>$t (49) = 1.131, p &gt; 0.05$.</td>
</tr>
<tr>
<td>3a.</td>
<td>Shoulder-Arm Dynamometer - Press In.</td>
<td>$t (62) = -0.362, p &gt; 0.05$.</td>
</tr>
<tr>
<td>3b.</td>
<td>Shoulder-Arm Dynamometer - Pull Out.</td>
<td>$t (61) = -0.809, p &gt; 0.05$.</td>
</tr>
<tr>
<td>4b.</td>
<td>Shoulder Flexibility - External Rotation - Left &amp; Right Arm - Total</td>
<td>$t (66) = 0.884, p &gt; 0.05$.</td>
</tr>
<tr>
<td>7a.</td>
<td>Neck Strength - Forwards Flex.</td>
<td>$t (56) = 1.284, p &gt; 0.05$.</td>
</tr>
<tr>
<td>7b.</td>
<td>Neck Strength - Backwards Extension.</td>
<td>$t (56) = -0.318, p &gt; 0.05$.</td>
</tr>
<tr>
<td>8ab.</td>
<td>Neck Strength - Flexing to Left &amp; Right.</td>
<td>$t (49) = -1.565, p &gt; 0.05$.</td>
</tr>
</tbody>
</table>
4.3.1.5 RHH2Fitness Increases - Survey Responses - Elite Experimental Players - Benefit of Experimental Exercises for Increasing Upper Body Fitness

A survey (Appendix F, p. 182) was used to ascertain the attitudes of the elite level experimental players towards the effectiveness of the experimental treatment exercise program in increasing their upper body fitness. Surveys were prepared and distributed to the whole sample population of 84 elite players. Completed survey responses were received from 61 (72%) of players from the elite player category. Of the elite level experimental player respondents, 95.8% were of the opinion that the experimental exercises were beneficial for increasing upper body fitness. The survey question asked; how effective were the prescribed neck and shoulder exercises in increasing upper body fitness?

This fixed-alternate survey item employed a 5-point scale ranging from Very Beneficial (5) to No Benefit (1) and percentage data is presented in Figure 3 below:

![Figure 3](image_url)

**Figure 3.** RHH2Fitness Increases - Elite Experimental Players - Benefit of Experimental Exercises for Increasing Upper Body Fitness
23 out of 24 respondents (95.8%) agreed that the experimental treatment exercises were beneficial in increasing upper body fitness. Only one respondent thought that the program was of little benefit in increasing upper body fitness, whilst no respondent thought that the program was of absolutely no benefit.

Data for the elite level players were treated as separate from the non-elite data because of the wide variance in fitness parameter tests scores between these levels, and because of their vastly differing injury incidences. In continuing the examination of Related Research Question One on the program's influence on the upper body fitness parameters tested, the results of the non-elite level players were then examined and discussed below.

4.3.1.6 RHH2Fitness Increases - Non-elite Level - Significant Mean Scores Increases - Experimental and Control Players

It was found that the experimental exercise program significantly increased only 1 (Behind Neck Press Strength) of the 15 measured fitness parameters for the non-elite level experimental players. However, there was a significant change in mean scores for Shoulder Flexibility - Internal Rotation - Left & Right - Total, although this was a negative finding against the effectiveness of the program. These findings are represented below.

i) RHH2Fitness Increases - Non-elite Level - Upper Body Fitness Test - Behind Neck Press Strength - Experimental and Control Players. The non-elite Behind The Neck Press Strength tests reported increased mean scores for the experimental players. The improved Behind Neck Press Strength scores were a significant factor which indicated the effectiveness of the program for the shoulder region at the non-elite level. Results were tabulated for the two-sample pooled t-tests of tests for this parameter and are represented in Table 20 (p. 102).
Table 20

RHH\textsuperscript{2}Fitness Increases - Non-elite Level - Mean Scores Increases - Upper Body
Fitness Test - Behind Neck Press Strength - Experimental and Control Players

<table>
<thead>
<tr>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>1.707</td>
<td>0.047</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count</th>
<th>Mean</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>25</td>
<td>3.78</td>
<td>5.605</td>
<td>1.121</td>
</tr>
<tr>
<td>Control</td>
<td>28</td>
<td>1.361</td>
<td>4.713</td>
<td>0.891</td>
</tr>
</tbody>
</table>

The directional hypothesis RHH\textsuperscript{2}Fitness Increases was accepted ($p = 0.047$) as there was a significant mean increase in Behind Neck Strength between the non-elite experimental and control players over the period of program implementation as tested.

4.3.1.7 RHH\textsuperscript{2}Fitness Increases - Non-elite Level - Significant Mean Scores Decreases From Pretest To Posttest - Experimental and Control Players

Tests at the non-elite level for shoulder flexibility - Internal Rotation - Left & Right Arm - Total indicated there was no significant positive finding for this parameter, but there was a significant change in mean scores from pretest to posttest, albeit a significant negative finding against the experimental program. The table of t-tests results for this non-elite level test protocol is represented in Table 21 (p. 103).
Table 21
RHH2Fitness Increases - Non-elite Level - Mean Scores Decreases - Upper Body
Fitness Test - Shoulder Flexibility - Internal Rotation - Left & Right Arm - Total -
Experimental and Control Players

<table>
<thead>
<tr>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>2.156</td>
<td>0.0176</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count:</th>
<th>Mean:</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>29</td>
<td>-0.262</td>
<td>5.054</td>
<td>0.939</td>
</tr>
<tr>
<td>Control</td>
<td>33</td>
<td>-2.982</td>
<td>4.87</td>
<td>0.848</td>
</tr>
</tbody>
</table>

Of importance in interpreting the results of this test (t-test results - Table 21) is
that a lower score represented a higher level of flexibility since the measure was how far
the participant could reach up behind the back toward the spinous process of C7
vertebra, the tester measuring distance between the fingertips and C7. The greater the
flexibility, the greater was the reach up behind the back, and the lower was the resulting
distance between fingertips and the C7 spinous process. Thus for Upper Body Fitness
Test - Shoulder Flexibility - Internal Rotation - Left & Right Arm - Total the directional
hypothesis RHH2Fitness Increases was rejected indicating that the experimental
treatment program did not produce a significant increase in the non-elite experimental
players.

The significant change ($p = 0.0176$) in non-elite scores for this parameter over
the period of program was also of importance to the study. The mean decrease scores
for the non-elite experimental players ($X = -0.262$) represented a small increase in
Shoulder Flexibility Internal Rotation - Total Left and Right Arm Total, but the mean
scores for the control players demonstrated a significantly greater increase in this type of
flexibility ($X = -2.982$). This finding is discussed further in Chapter 5 - Discussion and
Recommendations (p. 128).
### 4.3.1.8  RHH\textsuperscript{2}Fitness Increases - Non-elite Level - Mean Scores Changes That Were Not Significant - Experimental and Control Players

There were a number of non-elite tests for normative fitness data which were not statistically significant. For the non-elite level players the non-significant tested parameters and their appropriate statistical data are presented in Table 22 below:

#### Table 22  
**RHH\textsuperscript{2}Fitness Increases - Non-elite Level - Mean Increase Scores That Were Not Significant - Experimental and Control Players**

<table>
<thead>
<tr>
<th>Test</th>
<th>( t ) - Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Military Press Endurance.</td>
<td>( t (53) = 1.253, p &gt; 0.05 )</td>
</tr>
<tr>
<td>1b. Military Press Strength.</td>
<td>( t (52) = 0.506, p &gt; 0.05 )</td>
</tr>
<tr>
<td>2a. Behind Neck Press Endurance.</td>
<td>( t (54) = 1.271, p &gt; 0.05 )</td>
</tr>
<tr>
<td>3a. Shoulder-Arm Dynamometer - Press In.</td>
<td>( t (59) = 1.12, p &gt; 0.05 )</td>
</tr>
<tr>
<td>3b. Shoulder-Arm Dynamometer - Pull Out.</td>
<td>( t (59) = -0.993, p &gt; 0.05 )</td>
</tr>
<tr>
<td>4b. Shoulder Flexibility - External Rotation - Left &amp; Right Arm - Total.</td>
<td>( t (60) = 0.889, p &gt; 0.05 )</td>
</tr>
<tr>
<td>5a. Shoulder Flexibility - Prone Rod Lift.</td>
<td>( t (59) = -0.349, p &gt; 0.05 )</td>
</tr>
<tr>
<td>5b. Neck Flexibility - Flex + Extend - Total Degrees.</td>
<td>( t (60) = 1.018, p &gt; 0.05 )</td>
</tr>
<tr>
<td>6a. Neck Flexibility - Lateral Flex - Left + Right - Total Degrees.</td>
<td>( t (60) = 1.468, p &gt; 0.05 )</td>
</tr>
<tr>
<td>6b. Neck Flexibility - Head Rotation - Left + Right - Total Degrees.</td>
<td>( t (60) = -0.991, p &gt; 0.05 )</td>
</tr>
<tr>
<td>7a. Neck Strength - Forwards Flex.</td>
<td>( t (50) = -0.033, p &gt; 0.05 )</td>
</tr>
<tr>
<td>7b. Neck Strength - Backwards Extension.</td>
<td>( t (51) = -1.189, p &gt; 0.05 )</td>
</tr>
<tr>
<td>8ab. Neck Strength - Flexing to Left &amp; Right.</td>
<td>( t (48) = -0.776, p &gt; 0.05 )</td>
</tr>
</tbody>
</table>
4.3.1.9 RHH2Fitness Increases - Non-elite Experimental Players - Benefit of Experimental Exercises for Increasing Upper Body Fitness

The survey responses were used to ascertain the attitudes of the non-elite level experimental players towards the effectiveness of the experimental treatment exercise program in increasing their upper body fitness. Surveys were prepared and distributed to the whole sample population of 71 non-elite players. Completed survey responses were received from 57 (80%) of players from the non-elite level groups.

Of the non-elite level experimental player respondents, 25 of 28 (89.3%) were of the opinion that the experimental exercises were beneficial for increasing upper body fitness. The survey question asked; "how effective were the prescribed neck and shoulder exercises in increasing upper body fitness?" The 5-point fixed-alternate survey item responses are represented below in Table 23.

Table 23
RHH2Fitness Increases - Non-elite Experimental Players - Benefit of Experimental Exercises in Increasing Upper Body Fitness - Cumulative Rating Scores

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Frequency</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 = Very Beneficial</td>
<td>6</td>
<td>21.4</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>4 = Somewhat Beneficial</td>
<td>15</td>
<td>53.6</td>
<td>21</td>
<td>75</td>
</tr>
<tr>
<td>3 = Beneficial</td>
<td>4</td>
<td>14.3</td>
<td>25</td>
<td>89.3</td>
</tr>
<tr>
<td>2 = Almost No Benefit</td>
<td>3</td>
<td>10.7</td>
<td>28</td>
<td>100</td>
</tr>
<tr>
<td>1 = No Benefit</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>100</td>
</tr>
</tbody>
</table>

A total of 25 (89.3%) of non-elite level respondents were of the opinion that the experimental treatment exercises were beneficial in increasing upper body fitness. Three respondents thought that the program was of little benefit in increasing upper body fitness, whilst no respondent thought that the program was of no benefit at all.
4.3.2 Related Research Question Two

Would a specialised upper body exercise and conditioning program produce changes in select upper body fitness measures that indicate areas of vulnerability to shoulder injury in adolescent Rugby League players?

Data gathered to provide answers to Related Research Question Two (p. 5) were used for the purposes of testing Research Hypothesis H3 (RHH3Shoulder Specific) on the indication of areas of vulnerability to shoulder injuries. As there were significant differences in the incidence of shoulder injuries between the elite experimental and control players and no significant shoulder injuries at the non-elite level, the results of the elite shoulder specific tests were examined. The chi-square test for the elite level severity ‘Very Serious’ shoulder injuries indicated that the elite control teams suffered a significantly greater number \( \chi^2 (\text{df} = 1, n = 85) = 6.276, p = 0.012 \) of these injuries.

Elite level upper body fitness parameter such as for Behind Neck Press Endurance, Behind Neck Press Strength, Shoulder Flexibility - Internal Rotation - Left & Right Arm - Total, and Shoulder Flexibility - Lying Prone Rod Lift provided considerable evidence to indicate areas of vulnerability to serious shoulder injuries in the players. In examining data from these parameters, it was found that a somewhat incomplete picture emerged if only the changes from pretest to posttest were examined to ascertain the success of the experimental exercise program. The researcher found it necessary to examine whether the elite experimental and control players were in fact of equal fitness prowess at the commencement of the study, despite the normal assurances of random group selection. It was also necessary to determine their comparative scores at the conclusion of the study to gain a more comprehensive indication of areas of vulnerability to the elite level very serious shoulder injuries and the effect that the experimental program had on these.
4.3.2.1 RHHqShoulder Specific - Elite Level - Comparison Of Significant Upper Body Fitness Tests Results - Shoulder Specific

a) RHHqShoulder Specific - Elite Level Comparison One - Behind Neck Press Endurance. There was a significant ($p = 0.0002$) change in scores for this parameter over the period of the study (Table 17 p. 97). The pretest and posttest raw data were examined for possible evidence of vulnerability to the significant ‘Very Serious’ shoulder injuries suffered by the elite control players. The results are set out in Table 24 below:

Table 24
RHHqShoulder Specific - Elite Level Comparison One - Behind Neck Press Endurance - Treatment and Control Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>$t$</th>
<th>“p”-value</th>
<th>df</th>
<th>Exper Mean±SD</th>
<th>Control Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>1.964</td>
<td>0.0266</td>
<td>76</td>
<td>24.756±6.602</td>
<td>21.919±6.103</td>
</tr>
<tr>
<td>Posttest data</td>
<td>-2.117</td>
<td>0.0191</td>
<td>61</td>
<td>20.233±9.027</td>
<td>24.152±5.363</td>
</tr>
<tr>
<td>Increases</td>
<td>-3.77</td>
<td>0.0002</td>
<td>57</td>
<td>-5.5±11.358</td>
<td>3.467±6.174</td>
</tr>
</tbody>
</table>

At pretest the elite experimental players produced a significantly higher mean score ($p = 0.0266$) on Behind Neck Press Endurance. However, at posttest the control players produced a significantly higher mean score ($p = 0.019$) than the experimental players. The overall results indicated a significant finding against the effectiveness of the program ie. an increase in the elite control players in Behind Neck Press Endurance versus a decrease in the experimental players over the period of the program.

To further clarify the above finding, scores on this parameter were examined to compare the players who suffered the ‘Very Serious’ shoulder injuries with those who did not suffer this type of injury. These data are represented in Table 25 (p. 108).
Table 25

RHH\textsuperscript{3} Shoulder Specific - Elite Level Comparison One - Behind Neck Press Endurance

- Very Serious Shoulder Injuries - Injured and Not Injured Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t-value</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>Injured Mean±SD</th>
<th>Not Injured Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-0.529</td>
<td>0.2995</td>
<td>58</td>
<td>22.778±8.318</td>
<td>24.078±6.526</td>
</tr>
<tr>
<td>Posttest data</td>
<td>1.793</td>
<td>0.0396</td>
<td>49</td>
<td>27.6±6.348</td>
<td>21.783±6.938</td>
</tr>
<tr>
<td>Increases</td>
<td>-3.145</td>
<td>0.0015</td>
<td>46</td>
<td>9.00±5.177</td>
<td>-3.143±7.614</td>
</tr>
</tbody>
</table>

There was no significant difference in scores at pretest. However, the posttest data for this parameter indicated a significant difference (p = 0.0396) in scores between the injured and not injured players. The injured players displayed a significantly higher mean score (p = 0.0396) than the not injured players, although 4 of the 9 injured players were unable to complete the posttests because of on-going injury complications. When comparing increases from pretest to posttest, the differences between injured and not injured groups was highly significant (p = 0.0015), with the injured players displaying marked increases in this type of shoulder endurance, whilst the not injured players displayed an actual reduction in mean scores. This data provided a critical finding for the study in that significantly higher scores for Behind Neck Press Endurance by the elite control players and the elite injured players indicated that high scores on this parameter suggest a vulnerability to the "Very Serious" shoulder injuries suffered.

Discussions with key training personnel indicated that all injured players were involved in rehabilitation exercises which involved a great deal of endurance work, with slow swimming being the main exercise favoured. There was a possibility that such intense endurance work may have produced unusually high scores in the injured players which might have skewed or biased the results in differences between elite experimental and control players, particularly since five of the eight injured control players were able to complete the posttests, but the injured experimental player was not able to complete...
the posttest. It was decided to compare scores between elite experimental and control players at posttest and on increases, but scores for all injured players were omitted to gain a representation of the success of the program without any possibility of injury rehabilitation exercises influencing the overall trends between experimental and control players. Table 26 below represents the posttest scores comparison between elite experimental and control players with injured players scores omitted.

Table 26


<table>
<thead>
<tr>
<th></th>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56</td>
<td>-1.702</td>
<td>0.0471</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group:</th>
<th>Count:</th>
<th>Mean:</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>30</td>
<td>20.233</td>
<td>9.027</td>
<td>1.648</td>
</tr>
<tr>
<td>Control</td>
<td>28</td>
<td>23.536</td>
<td>5.051</td>
<td>0.955</td>
</tr>
</tbody>
</table>

Therefore, significant higher mean scores at posttest ($p = 0.0471$) were indicated for the elite control players and the deletion of the injured players’ scores gave clearer indication that the experimental exercise program was responsible for this, and that the results were not biased by the injured players’ shoulder injury rehabilitation exercises.

Mean scores increases, with the injured players’ scores omitted was also examined to gain an overall indication of the effectiveness of the experimental program without the possibility of the rehabilitation exercises mentioned above. Table 27 (p.110) represents the increases between elite experimental and control players with injured players scores omitted.
Table 27
**RHH Shoulder Specific - Elite Level Comparison One - Behind Neck Press Endurance**
*Very Serious Shoulder Injuries - Increases Scores - Experimental and Control Players*
*Injured Player Scores Omitted.*

<table>
<thead>
<tr>
<th></th>
<th>DF:</th>
<th>Unpaired t Value:</th>
<th>Prob. (1-tail):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52</td>
<td>-3.298</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Count</th>
<th>Mean</th>
<th>Std.Dev.:</th>
<th>Std. Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exper</td>
<td>28</td>
<td>-5.5</td>
<td>11.358</td>
<td>2.146</td>
</tr>
<tr>
<td>Control</td>
<td>26</td>
<td>2.692</td>
<td>5.802</td>
<td>1.138</td>
</tr>
</tbody>
</table>

The experimental program significantly reduced (p = 0.0009) scores for Behind Neck Press Endurance from pretest to posttest with the injured players’ scores omitted to be certain that shoulder injury rehabilitation exercise factors had not biased the results. The implications of this finding are discussed further in Chapter 5 Discussion and Recommendations (p. 128).

b) **RHH Shoulder Specific - Elite Level Comparison Two - Behind Neck Press Strength.** The Behind Neck Strength tests provided reason for conjecture on the pretest and posttest raw data as identifying areas of vulnerability to 'Very Serious’ shoulder injuries. The results are set out in Table 28 (p. 111).
Table 28

RHH³Shoulder Specific - Elite Level Comparison Two - Behind Neck Press Strength - Treatment and Control Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>“p”-value</th>
<th>df</th>
<th>Exper Mean±SD</th>
<th>Control Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-1.886</td>
<td>0.0317</td>
<td>71</td>
<td>45.561±8.484</td>
<td>49.231±8.135</td>
</tr>
<tr>
<td>Posttest data</td>
<td>-1.781</td>
<td>0.0402</td>
<td>55</td>
<td>44.018±5.764</td>
<td>46.841±6.187</td>
</tr>
<tr>
<td>Increases</td>
<td>1.131</td>
<td>0.1318</td>
<td>49</td>
<td>-0.796±5.918</td>
<td>-2.852±7.001</td>
</tr>
</tbody>
</table>

At pretest the elite control players displayed significantly higher scores in Behind Neck Press Strength and at posttest the control players again displayed significantly higher scores, indicating that the control players were stronger in Behind Neck Press Strength throughout the study. To examine the implications of scores on this parameter as indicators of areas of vulnerability towards the higher number of shoulder injuries suffered, scores were compared from the players who suffered the ‘Very Serious’ shoulder injuries and those who did not suffer this type of injury. This data is represented below in Table 29.

Table 29

RHH³Shoulder Specific - Elite Level Comparison Two - Behind Neck Press Strength - Very Serious Shoulder Injuries - Injured and Not Injured Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>“p”-value</th>
<th>df</th>
<th>Injured Mean±SD</th>
<th>NotInjur Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-1.16</td>
<td>0.1253</td>
<td>58</td>
<td>51.1±13.297</td>
<td>47.431±7.775</td>
</tr>
<tr>
<td>Posttest data</td>
<td>0.3</td>
<td>0.3829</td>
<td>44</td>
<td>43.95±4.152</td>
<td>44.757±5.211</td>
</tr>
<tr>
<td>Increases</td>
<td>2.617</td>
<td>0.0062</td>
<td>41</td>
<td>-10.802±10.924</td>
<td>-1.442±6.393</td>
</tr>
</tbody>
</table>

Although there was a significant difference between the elite injured players and the not injured players in score changes from pretest to posttest, it must be taken into
account that many of the injured players would not have regained full strength on this shoulder strength parameter because of the seriousness of their injuries. Indeed, only four of the nine injured players were able to participate at posttests of this parameter.

However, despite the non-participation or reduced strength of the players recovering from injury, the elite control players at posttest scored significantly higher than the elite experimental players, but significantly higher scores for this parameter did not prevent the elite control players from suffering the significantly higher number of ‘Very Serious’ shoulder injuries. The implications of this are further discussed in Chapter 5 (p. 128).

c) RHH₃Shoulder Specific - Elite Level Comparison Three - Shoulder Flexibility - Internal Rotation - Left and Right Arm - Total. The Shoulder Flexibility - Internal Rotation data were considered for identifying areas of vulnerability to the ‘Very Serious’ shoulder injuries suffered. The results are set out in Table 30 below:

Table 30
RHH₃Shoulder Specific - Elite Level Comparison Three - Shoulder Flexibility - Internal Rotation - Left and Right Arm - Total - Treatment and Control Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>Exper Mean±SD</th>
<th>Control Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-0.974</td>
<td>0.1666</td>
<td>74</td>
<td>23.631±12.542</td>
<td>26.082±8.456</td>
</tr>
<tr>
<td>Posttest data</td>
<td>1.116</td>
<td>0.1341</td>
<td>67</td>
<td>26.374±10.85</td>
<td>23.662±9.246</td>
</tr>
<tr>
<td>Increases</td>
<td>1.775</td>
<td>0.0403</td>
<td>66</td>
<td>1.515±10.34</td>
<td>-2.579±8.601</td>
</tr>
</tbody>
</table>

The Shoulder Flexibility - Internal Rotation fitness test involved flexibility in reaching up behind the back, measuring the distance between the fingertips and C7. Therefore a lower score indicated a higher level of flexibility. On this parameter, the pretest and posttest results indicated no significant differences between the elite experimental and control players. However, the overall results with reference to the
implementation of the program indicated that the increase mean scores for Shoulder Flexibility - Internal Rotation, were significant. Thus, for the elite level players the increase in overall mean scores on this parameter indicated a significant actual reduction in shoulder flexibility of the internal rotation type in the experimental players compared to an increase in flexibility for the control players. Since the elite control players suffered the significant number of serious shoulder injuries, and they also indicated increased flexibility on the shoulder internal rotation test, then this parameter Shoulder Flexibility - Internal Rotation must be considered to be of importance in identifying vulnerability to 'Very Serious' shoulder injuries.

Comparison was made to examine the scores on this parameter of players who suffered the 'Very Serious' shoulder injuries with the scores of those who did not suffer this type of injury. This data is represented below in Table 31.

Table 31
RHH3Shoulder Specific - Elite Level Comparison Three - Shoulder Flexibility - Internal Rotation - Left and Right Arm - Total - Very Serious Shoulder Injuries - Injured and Not Injured Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>Injured Mean±SD</th>
<th>NotInjur Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>1.012</td>
<td>0.1578</td>
<td>57</td>
<td>22.778±19.408</td>
<td>26.548±10.42</td>
</tr>
<tr>
<td>Posttest data</td>
<td>0.686</td>
<td>0.248</td>
<td>54</td>
<td>22.875±8.945</td>
<td>25.55±10.393</td>
</tr>
<tr>
<td>Increases</td>
<td>1.066</td>
<td>0.1457</td>
<td>53</td>
<td>-1.6±3.152</td>
<td>1.623±8.4</td>
</tr>
</tbody>
</table>

The above analysis indicates that there were no significant differences between the injured players and the not injured players on this parameter at pretest, posttest, or when considering fitness changes over the duration of the program. Eight of the nine injured players completed the posttests for this type of shoulder flexibility, which made the posttest data the more conclusive for comparing elite experimental and control players’ scores, and more conclusive for examining the importance of the scores on this
parameter for indicating vulnerability to serious shoulder injury. It was concluded that scores for elite level Shoulder Flexibility - Internal Rotation - Left and Right Arm - Total did not implicate this parameter as indicating vulnerability to the very serious shoulder injuries suffered.

c) RHH3_Shoulder Specific - Elite Level Comparison Four - Shoulder Flexibility - Lying Prone Rod Lift. The Shoulder Flexibility - Prone Rod Lift tests provided reason for conjecture on the pretest and posttest data as identifying areas of vulnerability to 'Very Serious' shoulder injuries. The results are set out below in Table 32.

Table 32
RHH3_Shoulder Specific - Elite Level Comparison Four - Shoulder Flexibility - Lying Prone Rod Lift - Treatment and Control Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>Exper Mean±SD</th>
<th>Control Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-1.909</td>
<td>0.03</td>
<td>78</td>
<td>27.872±9.206</td>
<td>31.553±7.877</td>
</tr>
<tr>
<td>Posttest data</td>
<td>0.126</td>
<td>0.4501</td>
<td>70</td>
<td>25.363±7.687</td>
<td>25.122±8.524</td>
</tr>
<tr>
<td>Increases</td>
<td>3.285</td>
<td>0.0008</td>
<td>69</td>
<td>-1.883±5.208</td>
<td>-6.863±7.406</td>
</tr>
</tbody>
</table>

The results obtained from the Lying Prone Rod Lift fitness tests reported that there was a significant decrease in this form of flexibility between groups. The elite experimental players suffered a significantly smaller decrease than the control players which indicated that the experimental treatment program somewhat offset a tendency for the players to decrease in this form of flexibility over the period of the study.

Scores on this parameter were further examined to compare the players who suffered the 'Very Serious' shoulder injuries with those who did not suffer this type of injury. This data is represented in Table 33 (p. 115).
The above analysis indicates that there was no significant difference between the injured and not injured players at pretest, but at posttest there was a significant difference \((p = 0.0079)\) between these two groups with the not injured players scoring significantly higher on this test. At posttest, eight of the nine injured players were able to complete the test for this parameter. The changes in this type of shoulder flexibility over the course of the study were significantly different with the injured players also indicating significantly decreased scores, although both player groups displayed decreased flexibility of this type from pretest to posttest. These results will be discussed further in Chapter 5 (p. 128).

### 4.3.3 Related Research Question Three

Would a specialised upper body exercise and conditioning program produce changes in select upper body fitness measures that indicate areas of vulnerability to neck injury in adolescent Rugby League players?

Data gathered to provide answers to Related Research Question Three (p. 5) were used for the purposes of testing Research Hypothesis H4 (RHH4Neck Specific, p. 6) on the indication of areas of vulnerability to neck injuries. There were significant \(\chi^2 (df = 1, n = 71) = 3.895, p = 0.048\) ‘Able to play on’ minor neck injuries suffered by the non-elite experimental players. However, there were no significant elite neck injuries
and therefore only the results of the non-elite level upper body fitness parameter tests were examined for the purposes of Related Research Question Three (p. 5).

4.3.3.1 RHH₄Neck Specific - Non-elite Level - Comparison Of Significant Upper Body Fitness Tests Results

a) RHH₄Neck Specific - Non-elite Level Comparison One - Neck Strength - Flexion Left & Right - Total Repetitions. At the non-elite level, Neck Strength - Flexion Left & Right - Total Repetitions tests provided reason for conjecture on the pretest and posttest data as identifying areas of vulnerability to 'Able to play on' neck injuries. The results are set out below in Table 34.

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>Exper Mean±SD</th>
<th>Control Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-1.472</td>
<td>0.0729</td>
<td>66</td>
<td>47.824±28.986</td>
<td>61.735±46.864</td>
</tr>
<tr>
<td>Posttest data</td>
<td>-2.03</td>
<td>0.0237</td>
<td>52</td>
<td>62.931±52.021</td>
<td>94.48±62.222</td>
</tr>
<tr>
<td>Increases</td>
<td>-0.776</td>
<td>0.2206</td>
<td>48</td>
<td>18.923±48.729</td>
<td>32.75±75.35</td>
</tr>
</tbody>
</table>

Significant differences were not identified (p > 0.05) at pretest, and the mean score increases as a result of the program were also not significant. However, at posttest the data indicated a significant difference between non-elite players in Neck Strength - Flexion Left & Right - Total Repetitions. Compared to the non-elite control players, the experimental players’ presented posttest weaknesses or deficiencies on this parameter which were represented by significantly lower mean scores. There was a significant difference between non-elite players, with this parameter considered as an area of vulnerability to neck injury.
To examine the above finding further, scores from the non-elite players who suffered the 'Able to play on' neck injuries were compared to the scores of the non-elite players who did not suffer this type of injury. This data is represented in Table 35 below:

Table 35
RHH4Neck Specific - Non-elite Level Comparison One - Neck Strength - Flexion Left & Right - Total Repetitions - 'Able to play on' Neck Injuries - Injured and Not Injured Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>Injured Mean±SD</th>
<th>NotInjur Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>0.774</td>
<td>0.2212</td>
<td>55</td>
<td>41±25.573</td>
<td>58±43.129</td>
</tr>
<tr>
<td>Posttest data</td>
<td>0.662</td>
<td>0.2556</td>
<td>45</td>
<td>40.00±0</td>
<td>80.717±60.81</td>
</tr>
<tr>
<td>Increases</td>
<td>0.39</td>
<td>0.3491</td>
<td>42</td>
<td>0±0</td>
<td>25.651±64.938</td>
</tr>
</tbody>
</table>

The above data indicated that there was no significant difference in scores between the injured and not injured players at pretest, posttest or on increase scores over the course of the study. It must be noted that only one of the four injured non-elite players was able to complete the posttests for this parameter. It was concluded that scores for non-elite level Neck Strength - Flexion Left and Right did not implicate this parameter as indicating vulnerability to the minor neck injuries suffered.

b) RHH4Neck Specific - Non-elite Level Comparison Two - Neck Flexibility - Head Rotation - Left & Right - Total Degrees. The Neck Flexibility - Head Rotation - Left & Right - Total Degrees tests provided reason for conjecture on the pretest and posttest data as identifying areas of vulnerability to 'Able to play on' severity classification neck injuries. The results are set out in Table 36 (p. 118).
Table 36

RHH4Neck Specific - Non-elite Level Comparison Two - Neck Flexibility - Head Rotation - Left & Right - Total Degrees - Treatment and Control Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>Exper Mean±SD</th>
<th>Control Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-1.356</td>
<td>0.0897</td>
<td>67</td>
<td>123.686±26.24</td>
<td>133.853±35.47</td>
</tr>
<tr>
<td>Posttest data</td>
<td>-2.413</td>
<td>0.0094</td>
<td>62</td>
<td>137.774±22.50</td>
<td>152.818±27.01</td>
</tr>
<tr>
<td>Increases</td>
<td>-0.991</td>
<td>0.1629</td>
<td>60</td>
<td>13.311±25.6</td>
<td>20.576±31.338</td>
</tr>
</tbody>
</table>

Posttest data, when examined alone, indicated a greater level of Neck Flexibility - Head Rotation - Left & Right - Total Degrees for the non-elite control players compared to the non-elite experimental players. At pretest there was no significant difference between non-elite experimental and control players on this parameter, and the mean increases scores in support of the experimental treatment program over the duration of the study were also not significant. Since there was a significant difference between non-elite player groups on scores for Neck Flexibility - Head Rotation - Left & Right - Total Degrees, this parameter was considered further. Scores on this parameter were compared for non-elite players who suffered the 'Able to play on' neck injuries and those who did not suffer this type of injury. This data is represented below in Table 37.

Table 37

RHH4Neck Specific - Non-elite Level Comparison Two - Neck Flexibility - Head Rotation - Left & Right - Total Degrees - ‘Able to play on’ Neck Injuries - Injured and Not Injured Players

<table>
<thead>
<tr>
<th>Test Data</th>
<th>t</th>
<th>&quot;p&quot;-value</th>
<th>df</th>
<th>InjuredMean±SD</th>
<th>NotInjurMean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest data</td>
<td>-0.7</td>
<td>0.4721</td>
<td>55</td>
<td>131±14.652</td>
<td>129.887±31.14</td>
</tr>
<tr>
<td>Posttest data</td>
<td>0.32</td>
<td>0.3749</td>
<td>55</td>
<td>141.333±6.658</td>
<td>146.426±27.26</td>
</tr>
<tr>
<td>Increases</td>
<td>-0.086</td>
<td>0.4661</td>
<td>53</td>
<td>17.333±7.371</td>
<td>15.885±29.049</td>
</tr>
</tbody>
</table>

118
The above analysis indicated that there was no significant difference in scores at pretest or posttest, or in scores increases between the non-elite injured players and those non-elite players not suffering this type of injury. Only one of the four injured non-elite players could not complete the posttest on this parameter. It was concluded that this parameter was not implicated as an indicator of vulnerability to the non-elite neck injuries suffered.

Therefore it was difficult to implicate any of the specific non-elite neck fitness parameters as indicating areas of vulnerability to the significant minor neck injuries suffered by the non-elite experimental players. However, the non-elite coach and trainer interview data indicated mitigating circumstances that probably gave cause for the significant minor experimental neck injuries suffered by players of the one non-elite experimental teams in the one isolated game. These circumstances will be discussed further in Chapter 5 - Discussion and Recommendations (p. 128).

4.4 Overall Reception of the Study - Elite and Non-elite Levels

The overall reception of the experimental and control study activities at elite and non-elite levels was encouraging for future research. Positive attitudes of the players to the study were observed at most times during the researcher’s consistent attendances at training sessions and games, and this was reflected by responses reported in the player surveys.

The survey responses of the experimental players at elite and non-elite levels revealed they felt the experimental exercise program was of benefit in increasing resistance to upper body injuries (Table 5, p.78). The survey responses also revealed that the elite and non-elite experimental players felt that the experimental exercise program was of benefit in increasing upper body fitness (Figure 3, p. 100). However, there was a contradiction offered by the survey responses on whether the experimental players thought the time allocated to the experimental exercise program at training could have been better used in other activities. The responses to this enquiry are represented below.
4.4.1 Elite & Non-elite Experimental Players - Time Taken Performing Experimental Treatment Exercises Could Have Been More Usefully Put Into Other Training - Survey Responses

The fixed-alternate item employed to survey this question utilised a 5-point scale requiring a response ranging from Strongly Disagree (5) to Strongly Agree (1). The responses were grouped and the percentage responses are graphed by means of a pie chart (See Figure 4 below).

A total of 19 (37.2%) respondents were of the opinion that the time taken at training by the experimental exercises was well spent. However, 12 (24%) respondents thought that the time could have been better used on some other form of training, and 20 (39%) respondents were unsure as to the usefulness of the time spent on the experimental exercises. These percentage responses are represented in Figure 4 below:

![Pie chart showing survey responses](image)

**Figure 4.** Elite and Non-elite Players - That Time Taken Performing Experimental Exercises Could Have Been More Usefully Put Into Other Training
4.4.2 - Elite & Non-elite Control Players - That the Study Was Beneficial - Survey Responses

Analysis of the elite and non-elite control players’ perceived benefit of the study is presented below in Table 38.

Table 38

<table>
<thead>
<tr>
<th>Elite and Non-elite Level Control Players - That the Study was Beneficial (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response</td>
</tr>
<tr>
<td>5 = Very Beneficial</td>
</tr>
<tr>
<td>4 = Somewhat Beneficial</td>
</tr>
<tr>
<td>3 = Beneficial</td>
</tr>
<tr>
<td>2 = Almost No Benefit</td>
</tr>
<tr>
<td>1 = No Benefit</td>
</tr>
</tbody>
</table>

The opinion that the study was beneficial was held by 93.8% of the control players, even though it had been necessary not to inform them of the experimental treatment exercise program. The control players were under the impression that all players involved in the research were receiving the same interaction as they (the control) were, with the researcher having no input into team training. It was necessary to convey the impression that the researcher was involved only in upper body fitness testing, attendance at training and games, and collection of injury statistics as they arose.

4.5 Summary of Results

One major and three related research questions were investigated in this study. It was found that the incidence and sites of upper body injuries during the course of the study varied markedly between elite and non-elite level players. The findings suggested that certain types of injuries were suffered by the elite players, but the same type and severity of injuries were not correspondingly suffered by the non-elite players, and vice
versa. The elite players suffered a number of shoulder injuries of the 'Very Serious' severity classification, and there was a significant difference in the occurrence of these shoulder injuries within the elite level (\( p = 0.012 \)). However, at the non-elite level this did not occur and a significant number of neck injuries, rather than shoulder injuries, were suffered by the non-elite players. The non-elite players suffered a significant (\( p = 0.048 \)) number of minor neck injuries of the 'Able to play on' severity classification. However, the elite players suffered only one neck injury of a minor kind during the period of the study and because of these differences in the sites and rates of injury between the elite and non-elite players, the injury data and the fitness test data were treated separately for the elite and non-elite level players.

The elite level experimental and control player test data for normative fitness reported significant mean increases on a number of parameters. However, the “problem” injuries for the elite level players were the 'Very Serious' shoulder injuries, and the shoulder fitness data for the elite level players were therefore treated separately to other data. Scores were obtained from the elite upper body fitness tests to determine whether there was increased fitness as a result of implementation of the experimental exercise program. However, there were negative results (decreases) in elite fitness recorded, but significant differences between experimental and control players gave cause to view these as important to the conclusions drawn from the study in Chapter 5 (p. 128). The results of the findings are summarised below in order of considered importance.

4.5.1 The Behind Neck Press Endurance test identified a significant negative finding on the effectiveness of the experimental exercise program to increase this type of endurance. The Behind Neck Press Endurance tests provided reason to consider this variable as an indicator of the 'Very Serious' shoulder injuries suffered by the elite level control players. Since the elite control players suffered the significant number of these injuries, high scores on this parameter are implicated as indicating vulnerability to this type of injury. At pretest the experimental players produced a significantly higher mean score in Behind Neck Press Endurance as tested (\( p = 0.0266 \)). However, at posttest the elite control players produced a significantly higher mean score (\( p = 0.0191 \)). The overall results indicated a significant (\( p = 0.0002 \)) increase in Behind Neck Press
Endurance in the elite control players versus a decrease in the Behind Neck Press Endurance for the experimental players over the period of the program.

The scores on the Behind Neck Press Endurance parameter were compared for elite injured and not injured players. The posttest data indicated a significant difference (p = 0.0396), with the injured players displaying a significantly higher score than the not injured players. When comparing increases from pretest to posttest, the differences between injured and not injured players was significant (p = 0.0015), with the injured players displaying marked increases in this type of shoulder endurance, whilst the not injured players displayed an actual reduction in scores.

However, a possible confounding variable was that the injured players were involved in intense shoulder injury rehabilitation exercises which might have been represented as very high scores for shoulder endurance of this type at posttest. Omitting the scores of the injured players at posttest revealed a reinforcement of the above results in that there were significant high elite control players’ scores at posttest, and on increases over the course of the program. The player scores were compared at posttest Therefore the significantly higher Behind Neck Press Endurance scores are implicated in the significant number of ‘Very Serious’ shoulder injuries incurred.

The significant decreases in elite experimental player scores for this parameter over the season provided evidence that the experimental treatment exercises were crucial in decreasing the experimental players’ scores. Therefore, the experimental treatment exercises were crucial in actually decreasing the risk of this type of shoulder injury because high scores on the Behind Neck Press Endurance tests indicate vulnerability to this type of injury.

4.5.2 The Behind Neck Press Strength test (which measured shoulder strength) provided reason for elite level pretest and posttest data to be considered as an indicator in the significant ‘Very Serious’ shoulder injuries suffered by the elite level control players. At pretest, the elite control players displayed significantly higher scores in Behind Neck Press Strength (p = 0.0317), and on posttest they also displayed
significantly higher scores ($p = 0.0402$). The elite control players were stronger in this Behind Neck Press Strength test from the outset, and although they scored significantly higher at posttest despite the reduced strength of players recovering from injury, significantly higher scores for this parameter did not prevent the control players from suffering the significant ‘Very Serious’ shoulder injuries.

Behind Neck Press Strength displayed a significant difference between elite experimental and control players, and thus this parameter must rate as a factor to be taken into account when analysing possible factors that indicate vulnerability to the serious shoulder injuries suffered by the elite control players. The implications of this are discussed in Chapter 5 (p. 128).

4.5.3 The Shoulder Flexibility - Internal Rotation test provided data to be considered as an indicator in the significant ‘Very Serious’ shoulder injuries suffered by the elite level control players. At pretest and posttest there was no significant difference between elite experimental and control players. Over the course of the study, changes in mean scores for Shoulder Flexibility - Internal Rotation were statistically highly significant ($p = 0.0002$). This represented as a significant actual reduction in shoulder flexibility of the internal rotation type in the elite experimental players compared to a significant increase in the control players. However, when the scores for the elite injured players were compared to the not injured players there were found to be no significant differences between groups at pretest, posttest, or on overall fitness changes over the duration of the study. Thus scores on this parameter were changed significantly as a result of the implementation of the experimental program, but this parameter is not considered significant when examining possible factors that may have indicated vulnerability to the serious shoulder injuries suffered by the elite level control players.

4.5.4 The Shoulder Flexibility - Prone Rod Lift test also provided elite level pretest and posttest data to be considered as an indicator in the significant ‘Very Serious’ shoulder injuries suffered by the elite level control players. From pretest to posttest the mean scores for Lying Prone Rod Lift indicated an actual decrease in this form of flexibility by both elite experimental and control player groups. The elite experimental
players suffered a significantly lower ($p = 0.0008$) decrease than the control players which indicated a significant result in terms of the effectiveness of the experimental treatment, albeit still not sufficient an effect within the study to prevent an overall decline both elite experimental and control player groups for this form of shoulder flexibility. Comparison of scores for the elite injured players and the not injured players indicated significantly lower scores at posttest for the injured players, and also significantly lower scores from pretest to posttest for the injured players. It must be taken into consideration that incomplete recovery from the serious shoulder injuries would restrict posttest performance on this shoulder flexibility parameter, although eight of the nine injured players were able to complete the posttests. Thus, no clear evidence is given that scores on this parameter indicated vulnerability to the significant number of serious shoulder injuries suffered by the elite level control players.

Results for the elite level neck fitness data were not considered further because no significant difference in neck injuries was indicated between elite experimental and control players. However, the “problem” injuries for the non-elite level groups were significant ‘Able to play on’ neck injuries for the non-elite level experimental players ($p = 0.048$), and there was no evidence of significant neck injuries at the elite level. Therefore the non-elite level neck fitness data were considered to be of importance and were treated separately.

4.5.5 The Neck Strength - Flexion Left & Right - Total Repetitions test provided posttest data to be considered as an indicator in the significant ‘Able to play on’ neck injuries suffered by the non-elite level experimental group. These results indicated a significant difference between groups at posttest in Neck Strength - Flexion Left & Right - Total Repetitions ($p = 0.0237$). The non-elite experimental players’ weaknesses (or deficiencies) were indicated by lower mean scores compared to the control players’ higher mean scores. However, there was no significant difference found when scores on this parameter were compared for the non-elite injured players and the not injured players. It must be noted that only one of the four non-elite experimental players who suffered this type of neck injury was able to complete the posttest. In view of these circumstances, there was no clear evidence on this parameter that indicated vulnerability
to the significant non-elite minor neck injuries suffered by the non-elite level experimental players.

4.5.6 The Neck Flexibility - Head Rotation - Left & Right - Total Degrees test provided posttest data to be considered as an indicator in the significant 'Able to play on' neck injuries suffered by the four non-elite level experimental players. The posttest data reported significantly greater Neck Flexibility - Head Rotation - Left & Right ($p = 0.0094$) in the non-elite control players. There were no significant differences between non-elite experimental and control players at pretest or in mean increases scores over the duration of the study. No significant differences were found between the non-elite experimental and control players. Therefore, there is no clear evidence that scores on this parameter are implicated as indicating vulnerability to the significant minor neck injuries suffered by the non-elite level experimental players.

There were, however, unusual circumstances that contributed to the occurrence of all four non-elite “Able to play on” neck injuries by the one experimental team during the one game. These circumstances were identified by the coach and trainer interviews, and also by the researcher’s own observation of that particular game. The implications of this are discussed further in Chapter 5 (p. 128).

Results for the non-elite level shoulder fitness data were not considered because there was no significant difference in shoulder injuries between groups at the non-elite level. However, it must be noted that non-elite level Behind Neck Press Strength was indicated as having significantly increased scores ($p = 0.047$) in the experimental players as a result of the experimental intervention.

The overall response of the players, according to survey results was positive, and upon interview their respective coaching staff also indicated positive sentiments about the conduct of the study and its usefulness in furthering knowledge in the field of preventive conditioning practices. The discussion and recommendations in Chapter 5 (p. 128) indicate that the study has furthered the knowledge in the field, and future research is encouraged in the utilisation of preventive exercise systems to reduce injury
risk in players of body contact sports. Access to Rugby League teams for future study is enhanced as a result of the positive attitudes displayed by the administrative and coaching staffs, and also by the players involved in the study.
CHAPTER 5
DISCUSSION AND RECOMMENDATIONS

This chapter discusses the results of the specialised upper body exercise and conditioning program and the effect the program had on the incidence of upper body injuries. Conclusions are drawn from the analysis of the data and recommendations are made for future research to expand upon the new knowledge revealed by the findings of this study. Recommendations are also made on unsafe practices encountered during the study and how to avoid them in future.

5.1 Discussion

Section one discusses the results and their implications with reference to the relevant literature. The specialised experimental exercise program resulted in a significantly lower number ($p = 0.012$) of serious shoulder injuries at the elite level. However, the non-elite experimental players suffered a significant number ($p = 0.048$) of minor neck injuries which might have indicated that the exercise program was harmful rather than beneficial if it were not for unusual mitigating circumstances causing all of these neck injuries to occur in the one game.

The experimental program resulted in increased fitness on a number of specific upper body fitness tests. There were also a number of changes in fitness levels which were not increases in fitness, but they did, however, indicate beneficial effects brought about by implementation of the experimental exercise program. A number of such changes in fitness levels also implicated specific areas of vulnerability to upper body injuries.
5.1.1 The Critical Finding

The critical finding in the study was that high scores for Behind Neck Press Endurance (shoulder endurance) were indicated as predisposing elite level adolescent Rugby League players to serious shoulder injuries. However, the experimental exercise system significantly reduced (p = 0.0002) scores on this parameter over the course of the study, hence reducing the players' vulnerability to serious shoulder injury as a result. Whilst results of the program on other parameters were implicated as highlighting areas of vulnerability to shoulder injuries, the behind the neck barbell press endurance factor was considered to be the most critical. This critical finding will be discussed further in section 5.1.3 (p. 130).

5.1.2 Research Implementation Factors

The implementation of this study relied on the willingness of the players in eight teams to participate. Two elite teams and two non-elite teams (the "experimental" teams) had to complete the specific exercises at their normal training facilities, which in most cases was at the sports training oval with no fixed specialised apparatus. The training equipment utilised was usually restricted to that which the coach or trainer could conveniently carry in a private motor vehicle. Research control was supplied by two further elite teams and two further non-elite teams (the "control" teams) which were tested at pretest and posttest but were not asked to undertake the experimental treatment exercise program.

The specific shoulder exercises of this study included handstand push-ups with a wall or partner support used to maintain balance, and inclined push-ups. These are exercises quite often utilised by enthusiasts who pursue developed levels of physical fitness, with a strength training effect being supplied by increasing repetitions of lifting the practitioner's own body weight, and by varying the angles at which the body is lifted. Such exercises require minimal outlay on equipment and facilities and are readily adaptable to public training venues such as those used by the non-professional junior teams in this study.
The specific neck exercises were those prescribed by the Royal North Shore Hospital Spinal Research Unit for players of body contact sports in response to the Watson case of quadriplegia in 1986 (Howell, 1989). However, these neck warm-up exercises prescribed in 1987 (Appendix A. p. 155) were not as widely practised in 1994 (Ritchie, 1994), and as time passed such preventive exercise programs needed reinforcement or else they tend to be gradually disregarded. However, little research has been generated on the effectiveness of such exercise systems in reducing the incidence of injuries since 1986.

Acceptance by the training and coaching personnel was crucial to the conduct of the study, as the program could not have been implemented without sustained support at club level. Sometimes support is given conditionally, as was the case demonstrated by the words of one head coach who was a full-time professional First Grade coach; "If I hear one murmur of you being in the way at all, you'll be on your bike." Consequently, that particular club was the least supportive in terms of player availability for fitness testing, although I am thankful for their participation. This type of attitude is often a problem to any research because the researcher is seen as a relative novice in the practical applications of theory in that field, and the research is also often perceived as somewhat of an interruption, welcome or otherwise, to the normal (proven) team training programs.

5.1.3 Shoulder Specific - Behind Neck Press Endurance

The critical finding of the study has particular relevance to this field of knowledge on two levels; i) that high elite player scores on the parameter Behind Neck Press Endurance indicate increased vulnerability to serious shoulder injuries, and ii) that the experimental exercise program effectively reduced scores on this parameter and consequently reduced vulnerability to serious shoulder injury.

The first part of the critical finding was that increased Behind Neck Press Endurance is indicated as a critical factor in increased vulnerability to serious shoulder
injuries. Significant 'Very Serious' shoulder injuries were suffered by the elite level control players (p = 0.012), and the elite control players revealed the higher mean scores at posttest (p = 0.0191) on this parameter. The overall results indicated a significant (p = 0.0002) increase in Behind Neck Press Endurance scores in the elite control players versus a decrease in the experimental players over the period of the program. Since the elite control players suffered the significant serious shoulder injuries, this evidence indicates that the higher the Behind Neck Press Endurance scores, and the greater the increase in these scores over a season, the more likely the chance a player has of suffering serious shoulder injury.

In further examining the above contention, comparison of elite injured and not injured player scores revealed that the injured players indicated increased scores (p = 0.0015) for Behind Neck Press Endurance. Posttest data comparison indicated a significant difference (p = 0.0396) between elite injured and not injured players, with the injured players displaying significantly higher mean scores than the not injured players, although four of the nine injured players were unable to complete the posttest due to on-going shoulder injury complications. Indeed, the high posttest scores for the injured players who were able to be tested at posttest indicate that these injured players were not at all impeded by incomplete recovery from their shoulder injuries. The elite level injured players’ posttest mean score (X = 27.6, SD = 6.348) was significantly higher (p = 0.0396) than the not injured players’ posttest mean score (X = 21.783, SD = 6.938), higher than the experimental players’ posttest mean score (X = 20.233, SD = 9.027) and higher than the control players’ posttest mean score (X = 24.152, SD = 5.363).

However, shoulder injury rehabilitation factors have to be taken into account. Researcher contact with the players and their injury rehabilitation personnel confirmed that high repetition / low resistance activities (particularly slow swimming) formed a large component of rehabilitative procedures for recovery from this type of shoulder injury. Such rehabilitation procedures may have produced higher scores for endurance of this type in the recovering or recovered elite shoulder-injured players, and this possible confounding variable gave cause for the data to be examined further. There was
a possibility that the scores of the five posttested injured control players might actually skew the overall results, since their mean score at posttest was higher than the not injured players posttest scores, higher than the experimental players’ posttest mean score and higher than the control players’ posttest mean score. But deletion of the injured players’ scores indicated again the significantly higher scores at posttest revealed by the elite control players, and the increases scores again indicated a significant reduction in the experimental players’ scores on this parameter over the course of the study.

The second part of the critical finding was that the experimental exercise program significantly reduced scores on the at-risk parameter Behind Neck Press Endurance \( (p = 0.0002) \) and this indicated that the experimental exercise program reduced vulnerability to serious shoulder injury because of this. As noted in the first part of the critical finding, high scores for Behind Neck Press Endurance indicate increased vulnerability to very serious shoulder injuries in adolescent Rugby League players. Although the elite experimental players revealed a significantly higher mean score \( (p = 0.0266) \) at pretest on this parameter, the changes in scores from pretest to posttest were far more significant \( (p = 0.0002) \). These changes in fitness indicated a significant \( (p = 0.0002) \) reduction in Behind Neck Press Endurance scores in the elite experimental players contrasted by an increase in control players’ scores over the period of the program. Since high scores on this fitness parameter indicate vulnerability to very serious shoulder injuries, the elite experimental players’ significant reductions in scores on this “at risk” parameter were considered a beneficial effect of the program.

In view of the possible confounding factor of intense shoulder injury rehabilitation programs tending to produce greater scores increases from pretest to posttest in the shoulder injured players, data were compared with the deletion of the injured players’ scores. However, the deletion of the injured players’ scores indicated again the significant reduction in the experimental players’ scores on this parameter over the course of the study. Therefore, the program had a significant effect on scores for the Behind Neck Press Endurance parameter, producing a significant reduction in scores which actually reduced vulnerability to very serious shoulder injuries. This result is important new knowledge in the field.
The players at risk of serious shoulder injury can be identified by testing for high levels of Behind Neck Press Endurance. These identified at-risk players can be placed on programs with a strength training bias at specific joint angles. By employing the specialised upper body exercise system studied in this research, the problematic high scores for Behind Neck Press Endurance were significantly reduced. However, the level of Behind Neck Press Strength development to be targeted in attempting to prevent very serious shoulder injuries is a matter for further research.

5.1.4 Shoulder Specific - Behind Neck Press Strength

High scores for Behind Neck Press Strength did not prevent the elite control players from an increased incidence of very serious shoulder injury and, therefore, heavy load resistance training at shoulder angles behind the neck should be approached with caution. At pretest, the elite control players displayed significantly higher scores in Behind Neck Press Strength ($p = 0.0317$), and at posttest they also displayed significantly higher scores ($p = 0.0402$). However, high scores at pretest and posttest did not prevent the significant elite level control 'Very Serious' shoulder injuries. Therefore, there has to be further research into optimal levels of Behind Neck Press Strength so that players identified as being at risk to injury from high Behind Neck Press Endurance can undertake sufficient specific strength conditioning programs to reduce this type of endurance and hence reduce their vulnerability to injury. Yet there must be caution so that these players do not undertake such a heavy load resistance training regimen that they become at risk with very high levels of Behind Neck Press Strength.

Another factor that must be taken into account is the consideration that the elite level (or more expert) player may compete at a much more vigorous competition level, competing with an elite attitude of relative invulnerability and a consequent lesser regard for self-preservation than the non-elite level payer. Howell (1989) suggests that such circumstances may place the elite competitor more at risk to serious injuries.
Comparisons of elite injured and not injured player scores for Behind Neck Press Strength over the course of the program were considered to be unreliable because four of the eight control players who had suffered the very serious shoulder injuries could not complete the posttests on this strength parameter due to incomplete recovery from their shoulder injuries. The experimental program was found to have no significant effect on the Behind Neck Press Strength parameter.

It is interesting to note that at the non-elite level, scores for the experimental players on the Behind Neck Press Strength parameter tests significantly increased from pretest to posttest ($p = 0.047$) indicating that the experimental exercises program was beneficial at the non-elite level in increasing this type of shoulder strength. This could be attributed to the differences in strength between elite and non-elite athletes. Elite level athletes were usually more developed by more intense conditioning, and were often of a strong physical stature more suited to compete at the elite level in this body contact sport. The non-elite athletes were often less developed and responded more to strength conditioning principles which they had often not encountered before the study.

All of the elite injured control players were able to complete the posttests on the Behind Neck Press Endurance parameter, but only half of the injured control groups players could participate at posttest for Behind Neck Press Strength. This must also be taken into account when considering which was the more critical fitness parameter in indicating vulnerability to very serious shoulder injuries. An incomplete picture of the overall elite control players' strength posttests results was indicated because all eight of the injured players' scores were included in calculations for endurance posttests mean scores, but half of the injured players' scores were excluded in calculating means for strength at posttest. An explanation of the injured player's ability or inability to complete the posttests is related to "Testing" procedure. The endurance tests utilised low weights / high repetitions, whilst the heavy weights / low repetitions of the strength tests proved to be an impossible or unwise load for four of the (shoulder) injured players to lift. However, Behind Neck Press Strength must rate as a factor to be taken into account when identifying areas of vulnerability to the serious shoulder injuries in the elite level.
control players but further research on optimal levels for strength of this type is required, and further research on the effects of the increased competitive effort of the elite player is also required.

Morris (1984, p.82) reported increased strength of the shoulder girdle improves "the overall integrity of the musculature and tendons of the shoulder", and hence decreases the risk of injury to that joint. Reilly (1981) also noted that muscular strength achieved by overload training of the shoulder musculature enhances shoulder stability. By these means vulnerability to injury should be decreased (ie. resistance to injury increased) by increased shoulder strength. However, in the current study the elite control players with the higher Behind Neck Press Strength actually incurred the most serious and significant shoulder injuries.

The evidence of the study and the literature suggests that strength training has an important effect on endurance performance. The experimental program, which was mainly a strength development program of heavy weight / low repetitions (with the player's own body weight supplying the resistance) significantly reduced Behind Neck Press Endurance ( \( p = 0.0002 \)) but did not provide significant changes in Behind Neck Press Strength ( \( p > 0.05 \)). The experimental program was essentially a strength development program by virtue of its design and the minimal available training time allocated to such out-of-the-ordinary exercises. Endurance exercises would have required many more repetitions of each exercise per session and hence would have encroached much more on normal training time.

Explaining the actual reduction in endurance by the utilisation of a strength training program, the work of Sale, MacDougall, Jacobs and Garner (1990) is of particular relevance. Sale et al suggest that there are "different and sometimes opposite adaptations induced by strength and endurance training. ... Strength training may also cause a decrease in capillary density and mitochondrial volume density, changes detrimental to endurance performance" (p. 348). They go on to postulate that there are important implications concerning muscle capillary density whenever an element of strength training is added to an endurance training regimen. They state further;
... the concurrent S (strength) and E (endurance) programs used in the present study caused a significant decrease in capillary density, to our knowledge the first report of a decrease in a longitudinal training study. Endurance training studies have shown an increase in capillary density, and cross-sectional studies have shown a decreased capillary density in strength trained athletes. In combined S and E training no change in capillary density might have been expected, because the tendency for E training to increase capillary density by increasing capillary number would be offset by S training tending to decrease capillary density secondary to muscle fibre hypertrophy. The S training adaptation prevailed in the present study (Sale et al, 1990, p. 355).

Wilson (1993) disagrees with the above contention by stating "heavy strength training methods would be most effective in the further development of strength - endurance" (p.6). It is interesting to note that in this current research the strength development bias of the experimental exercise program significantly reduced Behind Neck Press Endurance. However, the program did not increase Behind Neck Press Strength at the same angle of arm/shoulder press-up action.

Reduction in the incidence of very serious shoulder injuries attributable to the experimental exercise program in this current study indicated the beneficial preventive effects of strength conditioning programs utilising specific joint angle actions. Weight training often ignores a balanced conditioning approach which should include arm actions pressing up behind the neck. The preponderance of the weight training technique known as the Olympic lift in the preparation of power athletes such as those involved in Rugby League is a matter of concern for this researcher and others. A number of Australian Rugby League clubs concentrate on the Olympic lifts in their high-intensity training regimens. This matter was brought to the notice of the researcher by schoolboy proteges who have since achieved renown and professional status at the top level of the game. The exercise system developed and implemented in this study was in part in response to the obvious neglect of the concept of a "balanced" weight training program. Vern Gambetta, Director of Conditioning for the Chicago White Sox Baseball Team, highlights this concern when he offers;
There is a school of thought among strength coaches that has placed an inordinate emphasis on the Olympic-style lifts as the primary focus of strength training programs... Those movements produce very high power production in the vertical plane, but involve no rotational-diagonal component. This leads me to question the application of Olympic lifts to other sports (Gambetta, 1996. p. 21).

Many professional Rugby League organisations utilise the Olympic lift and the Bench Press as their dominant upper body weight training exercises, presenting a shortfall in specific exercises with a rotational or diagonal component. This experimental program utilised joint angles that targeted both rotational and diagonal components eg. the inclined push-ups used a diagonal component to the front of the body, whilst the assisted handstand push-ups utilised joint angles which often extended to pushing up from behind the line of the neck because of the body's tendency toward a back-arched position in maintaining the handstand balance whilst executing the handstand push-up.

The upper body fitness parameter tests of the program isolated angles of joint action that are often neglected by modern "specialised" weight training programs eg. joint angles behind the neck, and these joint angles were indeed significantly implicated as identifying areas of vulnerability for serious shoulder injuries. Accepted current practice discounts the importance of weight training exercises at angles behind the neck, and the researcher's tendency to favour a "more balanced" resistance training development of the body musculature has been vindicated by the findings of this study.

5.1.5 Shoulder Specific - Shoulder Flexibility - Prone Rod Lift test

The Prone Rod Lift test of shoulder flexibility indicated a contradiction in the implications between the elite player results at pretest and the results from pretest to posttest. The implications of the finding that high scores at pretest on the Prone Rod Lift test ($p = 0.03$) predisposed the elite control players to serious shoulder injuries contradicts the implications provided by the finding that there was a significantly greater decrease in this type of shoulder flexibility in the control players from pretest to posttest.
The contradiction is that it is difficult to determine a course of injury prevention action if presented with players of high scores on this parameter because it would seem that if high scores are implicated in vulnerability to injury, then exercise programs should be implemented to reduce this type of shoulder flexibility. However, the study also indicated that vulnerability to very serious shoulder injuries in the control players was increased by significant reductions in this type of flexibility from pretest to posttest. On one hand we have the higher flexibility scores indicating vulnerability to injury, and on the other hand we have the significantly greater reduction in these flexibility scores also implicated in vulnerability to injury. Future research could indicate the “optimal level” of this type of shoulder flexibility so that sports trainers could implement more appropriate compensating programs to reduce the risk of injuries. Such an approach of finding the right formula for the desired outcome of optimal conditioning has many implications in sport.

Increased flexibility of the shoulder girdle has been reported by Morris (1984, p.82) as aiding in ‘improving the overall integrity of the musculature and tendons of the shoulder’, and hence, according to Morris, the vulnerability to injury of the shoulder would be reduced by increased flexibility. However, the elite level results from this study for Prone Rod Lift at pretest do not support Morris’ contention since the control players who scored significantly higher at pretest suffered the significant serious shoulder injuries. It would seem that high levels of this type of shoulder flexibility cannot withstand the rigours of such body contact sport. The study reported a tendency for all of the players’ flexibility in this area to decrease over one playing season, but programs such as this can be implemented to significantly lower the loss of this type of flexibility, an outcome that has relevance to other sports where increased flexibility is considered advisable.

5.1.6 Shoulder Specific - Shoulder Flexibility - Internal Rotation

There was a significant reduction in shoulder flexibility of the type measured by the Shoulder Flexibility - Internal Rotation - Left and Right Arm - Total parameter test over the course of the program \( p = 0.0403 \), but since the pretest and posttest scores
displayed no significant difference between elite experimental and control players it is difficult to implicate this parameter as having an effect in predisposing the control players to serious shoulder injuries.

5.1.7 Neck Specific - Neck Injuries and Dangerous Game Practices

There was a finding against the effectiveness of the specialised experimental exercise program at the non-elite level as there were significant (\( p = 0.048 \)) minor 'Able to play on' neck injuries suffered by the non-elite experimental group players. This finding was treated with caution for two main reasons; firstly, that unusual and illegal scrummaging tactics resulted in all of these injuries being suffered by the one team in one game, and secondly, because the statistics presented a level of significance of \( p = 0.048 \) which is very close to the 0.05 determining level of significance. The discussion of major importance to this study centres around the possible consequences of dangerous scrummaging tactics if they are allowed in the game situation.

The neck fitness data indicated slight inadequacies in the neck fitness levels of the non-elite experimental group players who suffered the injuries. However, these will be examined after discussion on dangerous game tactics. The coach and trainer interviews blamed unsafe game practices for presenting very unusual hazardous circumstances which were strongly implicated in causing the neck injuries suffered in one isolated game by four players from the same non-elite experimental team. According to their coach’s report, this team suffered all of these injuries in their final (Grand Final) game of the 1995 season, when they were subjected to illegal and dangerous game tactics from their opposition. These practices were the repeated “screwing” and “collapsing” of the scrum by the opposition to gain ball possession advantage. This dangerous tactic is considered illegal but was allowed to pass unpunished by the officials of the game on the day and this aided the opposition in gaining an unusually high percentage of ball possession during that Grand Final. Probably as the result of greater ball possession, the opposition, given little chance of victory before the game, were victors in the Grand Final game and became that year’s premiers at the Under 16 level. Hence, the dangers of incorrect scrummage technique and practices are evidenced
by the events that led to all of the minor neck injuries of the non-elite experimental players occurring in the one game, and efforts should be made to ensure that the chances of this happening in the future are minimised.

The 'Able to play on' severity minor neck injuries suffered by the non-elite experimental players from Non-elite Team # 2 were all suffered as a result of forces of compression, slight flexion and rotation of the neck as the scrums screwed around and collapsed with the player's head "locked" into the scrum formation. Although the neck injuries incurred in this study were of a minor muscular nature, the circumstances present were those cited by many authorities as being responsible for most spinal chord trauma occurring in Rugby League and Rugby Union players.

The possibility of paraplegia and quadriplegia, and even death, as a result of spinal chord trauma makes neck injuries potentially the most serious of any injuries suffered on the football field. The work of Scher (1987) found that hyperflexion in combination with a rotational component presented the greatest danger to spinal chord trauma in South African Rugby Union players. Yeo (1983, cited by Milburn in Morrison (Ed.), 1989) identified a combination of flexion and rotation as the mechanism for cervical spinal trauma of football players in Australia. Roaf (1960) reported that a combination of compression and/or flexion-rotation produced almost every type of spinal injury. But McCoy, Piggot, MacAfee and Adair, (1984) found in a study of Irish schoolboy Rugby Union that there was little evidence to support the view that rotation plays an important part in cervical spine injuries. They found that in the scrum injuries studied 'hyperflexion of the neck, accompanied by some restraint on the top of the head, appears to be the mechanism involved' (McCoy, Piggot, MacAfee and Adair, 1984, p. 501 - 502). The straightening out of the natural cervical lordosis by flexion of some 30 degrees forwards presents a very dangerous situation, and no doubt the injured non-elite experimental players in this study would have had their necks forcibly flexed forwards to or through this critical angle at some stage during the many collapsed scrums of their Grand Final game. Torg (1985) offers; 'slight flexion of the neck resulting in alignment of the cervical vertebrae can produce a vulnerable situation (ie. a segmented column) should force be applied to the top of the head such that the forces
are transmitted along the axis of the cervical spine, by-passing the energy-absorbing capacities of these structures, and should these forces exceed the energy-absorbing capabilities of the cervical structures, injury to the cervical spine results’ (Torg, 1985, p.297).

On the basis of this evidence the dangerous practice of “screwing” and “collapsing” the scrum must be eliminated from the game, and it is within the rules of the game to penalise teams for indulging in this dangerous practice. Therefore the fault of allowing this tactic to take place in the non-elite Team #2 Grand Final rests unequivocally with the official referee in question on that day.

5.1.8 Neck Specific - Neck Strength - Flexion Left & Right

During the game accidental situations may present potentially injurious circumstances and the strengthening of the neck as a preventive measure against cervical spine injury has been widely recommended in the literature by; (Liedholt, 1973) (McCoy et al., 1984) (Cantu, 1992) (Howell, 1989) (Scher, 1987) (Mueller and Blyth, 1987) (Maroon, Kerin, Rehkopf and McMaster, 1977) (Kyle, 1964).

Specifically in the Rugby codes, the surgeon and rehabilitation authority, Reid (1992) recommended that; “Neck strengthening needs to be emphasised far more in Rugby, as frequently injuries occur at slower velocities than with other sports and are more amenable to prevention. The neck can be significantly strengthened” (p.790). It is interesting to note that a study of spinal-cord injuries in Australian footballers (Taylor and Coolican, 1987) suggested that in those injured there had been little interest shown toward neck exercise programs to develop greater neck musculature. They found that in spinal-cord injured patients, only 33% (of Rugby Union players), 12% (of Rugby League players), and 15% (of Australian Football players) had performed strengthening or isometric exercises to specifically develop the neck musculature.

Although the neck injury and neck fitness data from the study are treated with some caution, implications from these data suggest that elevated levels of neck strength may significantly reduce vulnerability to minor neck injuries. Posttest scores for the
parameter Neck Strength - Flexion Left & Right - Total Repetitions indicated a significant difference between non-elite experimental and control players ($p = 0.0237$). The lower mean scores of the non-elite experimental players who suffered the neck injuries indicated a significant weakness or deficiency in this type of neck strength. These findings represent the implication that weakness in neck strength in flexion to the left and right would indicate vulnerability to the neck injuries of the minor ‘Able to play on’ classification. The experimental exercise program did not produce significant increases in scores on this parameter but future research could concentrate on more intensive neck strengthening regimes. Commercial fixed apparatus are available for such specific intensive neck strengthening but these were not practical for the purposes of this study.

5.1.9 Neck Specific - Neck Flexibility - Head Rotation

Non-elite level posttest scores from the study also indicated differences for Neck Flexibility - Head Rotation - Left & Right - Total Degrees with the control players scoring significantly higher ($p = 0.0094$). These findings suggest that a lack of neck flexibility of this rotational type would indicate vulnerability to minor ‘Able to play on’ neck injuries. However, since the experimental exercise program did not produce significant increases in scores on this parameter, more specific exercises would have to be employed to test this suggestion.

More interest and further research in such topics may prevent some of these catastrophic neck injuries occurring in the future. Any single individual saved is an important outcome of controlled exercise programs.

5.2 Conclusions

On the basis of the available data the following conclusions are made:

1. The implementation of the specialised upper body exercise system for injury risk reduction reduced the incidence of upper body sports injuries for adolescent Rugby League players in the study.
2. The specialised upper body exercise system increased upper body fitness as measured by specific upper body fitness parameter tests, although the results varied markedly according to the status of the player ie. whether they were competing at the elite level or at the non-elite level. At the elite level, scores for the parameter Neck Flexibility - Head Rotation - Left and Right - Total Degrees indicated significant increase over the course of the experimental exercise program, although these scores did not indicate a vulnerability to neck injuries as there were no significant neck injuries at the elite level.

At the non-elite level, there were significant increases in scores on the parameter Behind Neck Press Strength, although scores on this parameter were not implicated as indicating areas of vulnerability to shoulder injuries in non-elite players because there were no significant shoulder injuries for the non-elite experimental and control players.

3. The specialised upper body exercise and conditioning program produced changes in upper body fitness measures that indicated areas of vulnerability to the incidence of shoulder injury in elite level adolescent Rugby League players. Upper body fitness parameters as measured by tests for Behind Neck Press Endurance, Behind Neck Press Strength, Shoulder Flexibility - Internal Rotation, and Shoulder Flexibility - Prone Rod Lift are significant indicators of areas of vulnerability to shoulder injury in elite level players.

4. Dangerous game tactics can present potentially hazardous neck trauma situations for the players if officials of the game do not act to prevent them occurring.

5. The specialised upper body exercise and conditioning program produced changes in upper body fitness measures that possibly indicated areas of vulnerability to the incidence of neck injury in non-elite level adolescent Rugby League players. Upper body fitness parameters as measured by tests for Neck Strength - Flexion Left and Right and Neck Flexibility - Head Rotation are significant indicators of areas of vulnerability to minor neck injury in non-elite level players, although these results from the study
were treated with caution because of statistical concerns and because of unusual and
dangerous game tactics that were allowed in the isolated game when all of these injuries
occurred.

6. The Rugby League clubs, their players, and their coaching and training
personnel demonstrated positive attitudes to this research and this augurs well for further
studies in the sport to the betterment of the game through greater preventive care being
taken of the players.

5.3 Recommendations

On the basis of the study, the following recommendations are made to
professionals and those with a special interest in the field:

1. Similar studies should be considered using more specific upper body fitness
exercises entailing experimental strength performance levels that operate through specific
joint angles and utilise the upper body fitness parameters tested in this study. Emphasis
in the conduct of the experimental program would be placed on consistent reproduction
of closely monitored resistance loads and the angles through which the resistance is
moved during conditioning programs. A procedure for identifying players with high
levels of Behind Neck Press Endurance needs to be implemented as these athletes are
most at risk to serious shoulder injury. There needs to be experimentation to determine
optimal levels of Behind Neck Press Endurance and Behind Neck Press Strength to
afford the elite level adolescent Rugby League player minimal vulnerability to the very
serious shoulder injuries such as those suffered during this study.

2. The effects of high risk game practices such as the “screwing or collapsing
the scrum” to gain tactical advantage should be eliminated by diligent refereeing and rule
changes if necessary.
The following recommendations are made for action:

1. The findings of this study should be communicated to professionals and those with a special interested in the field, particularly to those involved in the football codes where shoulder conditioning and neck conditioning are so crucially important to avoid career-threatening, or even life-threatening, injuries.

2. The nature of the implementation process should be reviewed in light of a projected new openness to research and program development. Openness to new training techniques, to the advisability of precautionary rules changes, and to specific training suited to player positions should be encouraged, especially in view of the knowledge contributed to the field by this study.
Bibliography


150


APPENDIX A

1987 Program - SPORTSAFE -
The Prevention
of
Neck and Head Injuries in Sport
APPENDIX A

1987 Program - SPORTSAFE - The prevention of Neck and Head Injuries in Sport

Background and Context

In 1987 the Minister for Sport and Recreation, Michael Cleary, M.P., introduced the N.S.W. Department of Sport and Recreation's Sportsafe Program in New South Wales. The Sportsafe Program addressed the issue of Prevention of Neck and Head Injuries in Sport, and specifically stressed prevention of head and neck injuries within body contact sports such as the football codes. This initiative was the result of a combined private enterprise efforts from Australian Guarantee Corporation (AGC) and The Sun Newspaper as well as from Government bodies including the N.S.W. Department of Education, N.S.W. Department of Health, and N.S.W. Sporting Injuries Committee. Sporting identities employed by the program included Dr. Peter Malouf of the Australian Sports Medicine Federation who was Club Doctor for the Cronulla Sharks Rugby League Club, Kevin Roberts who was a First Grade Rugby League Referee, Topo Rodriguez an Australian Rugby Union International, Peter Sterling an Australian Rugby League International, and Michael O'Connor an Australian Rugby Union and Rugby League Dual International.

The major component of the Sportsafe Program was a statewide series of seminars launched in Sydney with a one-day seminar at the State Sports Centre. There was a follow-up series of country and suburban seminars organised at the local level by sporting clubs and associations involved in the prevention of injury in sport. A comprehensive kit of back-up material, including brochures, a poster and video, was made available to schools, Sport and Recreation regional offices, sporting associations and clubs. 500,000 brochures, 5,000 posters, and 1,250 copies of a video cassette were issued to the above organisations. The objective of the program was to educate the public but not to create alarm nor to target any particular sporting code.
A major contributing factor to the creation of such a program was the unfortunate case of accidental neck injury sustained by Stephen Watson of Wollongong who was rendered a quadriplegic after a scrum incident in a school football match. Watson, who was injured whilst playing in an unfamiliar position at hooker, successfully sued the N.S.W. Education Department in 1987, being awarded heavy damages. Howell outlines the case as follows;

“He claimed teacher negligence in playing him as hooker between two shorter props, in failing to instruct him in neck strengthening exercises before choosing him in that position, and in failing to instruct him in the technique of scrums. In evidence the boy said that he was looking down and to his left to watch his half-back... when he felt a sharp pain in his neck.” (Howell, 1989, p.163.)

Although the Sportsafe Program of 1987 on the Prevention of Neck and Head Injuries in Sport had the desired impact in 1987, and for a number of years thereafter, the importance attached to this issue has become somewhat diminished.
Appendix A.

SPORTSAFE
THE PREVENTION OF
NECK AND HEAD
INJURIES IN SPORT.

Content:
VIDEO
1. Don't Stick Your Neck Out
2. First Aid Treatment for
   On-Field Injuries
BROCHURES
Prevention of
1. Neck Injuries
2. Head Injuries
3. Knee Injuries
4. Soft Tissue Injuries
5. Conditioning the Athlete
POSTER
Prevention of Neck and Head
Injuries in Sport
REFERENCE
Guide for teachers

NSW DEPARTMENT OF
SPORT AND RECREATION

Australian Guarantee
NSW Department of Education
NSW Department of Health
NSW Sporting Injuries Committee
Preventative Measure
The delicate spinal cord must therefore be protected within the bones of the vertebral column. The bones will only remain strong and secure if the ligaments and muscles are also strong and secure. Tearing of ligaments and muscles predispose the spinal cord to injury. After an injury pain will suggest to you that significant damage has occurred and should be thoroughly investigated. Allow time for ligaments and muscles to heal before returning to the field of play. A torn muscle or ligament will take at least ten days to heal and a further ten days to allow return of elasticity and relatively normal muscle function. Be prepared for the position for which you are chosen. Listen carefully to your coach’s advice. Be thoroughly involved in preparation. Spinal exercises will strengthen you and your game. Because the bones in the neck are so small they are particularly susceptible to damage, sometimes causing serious and permanent paralysis of arms, body and legs. So please, add these simple exercises to your training programme. Just a few minutes each session will help develop your neck muscles and avoid doing yourself damage during the game. First, do a programme of static exercises — no movement, just equal and opposite force from head and hands. FIGS. 3, 4. After a week, do dynamic exercises — where the head slowly wins the battle against the pressure of the hands. Follow the illustrations FIGS. 5, 6, try the following sequence: commence with a static exercise, doing the first group for two sessions a day. After one week commence the second group, dynamic exercises, and keep these exercises going right through the season and all year round.

Things to Avoid
Avoid illegal play. You or your friends can suffer serious and permanent disability! Remember, no still arm tackles; avoid collapsing scrums, no spear-head tackles. FIG. 7.
Remember some of us are not as heavily built as others. Consider your build and posture. Do not play in the front row, if you know that your build is unsuitable. There are other positions and other enjoyable sports activities.

Australian Guarantee
This brochure has been printed by A.G.C. Supply as a contribution to the N.S.W. Government’s Sportsafe Programme.
Prevention of Neck Injuries in Sport

Basic Anatomy of the Neck and Spine
The spinal cord contains millions of nerves running to and from the brain and inter-connecting various parts of our body. The spinal cord is no thicker than our little finger and lies within the bones of the vertebral column. It is held in position by three coverings attached to the base of the skull, to our sacrum or tail-bone and to the sides of the spinal canal where the nerves are emerging. The spinal cord occupies approximately 50% of the space within this bony canal. On top of our tail-bones (sacrum and coccyx) are twenty-four vertebrae; seven smaller cervical vertebrae in the neck, twelve thoracic vertebrae with ribs attached and five larger lumbar vertebrae. These vertebrae are held together with discs, ligaments and muscles. Some of the ligaments and muscles run over short distances; others cover almost the entire length of the spine. Although the bones interlock, these ligaments and muscles are essential to keep the spine intact. FIG. 1.

How Damage Can Occur
Sharp and severe contact with the spine can produce tearing of muscle and rupture of ligaments. The bones of the spine then become unstable and if they move they crush the spinal cord within the bony canal. If the bones break the damage is usually more severe. The spinal cord is a very delicate structure and even a slight blow can cause loss of nerve function. Patients can lose normal feeling and the ability to move muscles because a nerve is temporarily "concussed". If the injury is more severe, bruising with bleeding within the spinal cord may cause permanent loss of sensation and movement below the level of the injury. FIG. 2. In the most severe injury the spinal cord can actually be ruptured and the nerves, when severed, will not heal together.
APPENDIX B

The Experimental Treatment
Avoid Spinal Injuries in Football

These spinal exercises will strengthen you and your game.

Most training programmes do wonders for every part of the body except the most vulnerable part - the neck. Remember, whereas a broken arm or leg can put you out for a season, a neck injury can put you in a wheelchair.

So, please, add these simple exercises to your training programme. In just a few minutes each session they'll develop your neck muscles and help avoid doing yourself damage during a game.

For the first week, do this programme as "static" exercises (no movement, just equal and opposite force from the head and hands).
After a week, do them as "dynamic" exercises (where the head slowly wins the battle against the pressure of the hands).

Then, when you're in a game, the best way to avoid head and neck injuries is to simply stick to the rules - and that means no stiff arm tackles, no spear tackles and no collapsing the scrums.

FIG. 1 STATIC
Press head firmly forwards (A), backwards (B) and to each side (as C) tennin for 5 secs each time and increasing to 10 secs during course. 10 repetitions in each of the 4 directions.

FIG. 2 DYNAMIC
Through a full range, against resistance, flex the head forwards (A), extend backwards (B), flex sideways (as C) and rotate to each side (as U). Suitable resistance can be provided by your own hands, those of another person or an exercise machine. Also, shoulder shrugging (not shown). 10 repetitions of each.

For more information please contact:

Awareness and Prevention Team

Spinal Unit
Royal North Shore Hospital
St Leonards NSW 2065

Telephone (02) 438 8785
EXPERIMENTAL GROUP
SPECIFIED UPPER BODY EXERCISES

1) EXERCISES FOR THE NECK -

See static and dynamic neck exercise sheet attached. Always warm up properly first. Include in your warm-up a flexibility component; i.e. apply gentle pressure to head at angle of most flexibility forwards, backwards, sideways, and rotated. With the actual neck strength conditioning exercises, you provide your own resistance by pushing against your head with your own hand. Exercises only to be performed at training under supervision. Actions include flexion, extension, and rotation of neck. Sets of 6 - 8.

2) EXERCISES FOR THE SHOULDER GIRDLE -

a) Seated spine twist (see diagram attached).

b) Deep push-ups - hands on seats or benches so that you can lower yourself past your hands.

c) Inclined push-ups - feet elevated on other player’s back. Gradually sneak hands out further away from you along the ground, above your head.

d) Handstand push-ups using support partner or wall.

e) Try to touch hands behind your back, one hand coming down from over shoulder, other hand coming up from lower back.

Don’t be put off by it if it looks complicated, after a couple of run-throughs it will just be another quick warm-up routine, and the benefits in your fitness is what this research is all about.

SEATED SPINE TWIST

Thanks,

Peter Ritchie.
APPENDIX C

The Test Instrument Measuring Neck Fitness
Appendix C. Test Instrument cont’d. - Neck Strength Testing Apparatus.

Apparatus utilised for Tests # 7a, 7b, 8ab above.

Photos above and left:
Neck Strength Testing Apparatus
Constructed at University of Wollongong;
- portable
- durable
- variable resistance
- lo-tech and built to last.
Baseboard unbolted from weights / pulley stand
Above -  Head sling;

Left -  Weights sling;

Below -  heavy duty yacht rigging pulley and cable.
APPENDIX D

Diagrams of At-risk Upper Body Articulations
Appendix D - Part 1

The Atlas

(Drawing by D. Manks, 1994.
Adapted from - Norkin, C. & Levangie, P., (1992). Joint structure and
Appendix D - Part 2

The Axis

(Drawing by D. Manks, 1994.
Appendix D - Part 3

Typical Cervical Vertebra

(Drawing by D. Manks, 1994.
Slight flexion of neck producing a segmented column.

Appendix D - Part 5

Extreme flexion applied to head - restraint of head against opponent or ground, with continued movement of trunk.

(Drawing by D. Manks, 1994.
Appendix D - Part 6

The shoulder girdle.

1. glenohumeral joint; 2. coracoacromial arch; 3. acromioclavicular joint;
4. scapulothoracic articulation; 5. sternoclavicular joint;
6. first costosternal joint; 7. first costovertebral articulation.

(Drawing by D. Manks, 1994.
Mobility of the shoulder girdle

(Drawing by D. Manks, 1994.
New York: Churchill Livingstone. p. 897.)
Appendix D - Part 8

The shoulder joint - the large head of the humerus and the small glenoid fossa.

The glenoid labrum. As either a fibro-cartilage structure or as a redundant capsular fold, the labrum deepens the glenoid fossa.

APPENDIX E

Injury Data Gathering Forms;
Medical History
and
Team Injury Reports
Injury Data Gathering Forms;

Medical History Proforma

Surname: ___________________________ Christian names: ___________________________

Your Address: ____________________________________________________________

Phone: ____________________________

Parents' Home Address: _______________________________________________________

Phone: ____________________________

1. Have any members of your family had a "heart attack", "heart problems", or died before age 50?  □ Yes □ No

2. Have you ever been told that you have a heart murmur, high blood pressure, "extra heart beats", or a heart abnormality?  □ Yes □ No

3. Are you currently taking any medications, or are you under the care of a physician/doctor at present?  □ Yes □ No

4. Do you have any allergies to medicine?  □ Yes □ No

5. Do you wear glasses or contact lenses?  □ Yes □ No

6. Have you ever "passed out" or been "knocked out"?  □ Yes □ No

7. Have you ever had an illness, condition, or injury that:

   a. Required you to go to the hospital either as a patient overnight or in Casualty / Emergency?  □ Yes □ No

   b. Required an operation?  □ Yes □ No

   c. Lasted longer than a week?  □ Yes □ No

   d. Caused you to miss a game or practice?  □ Yes □ No

   e. Required you to have X-rays taken?  □ Yes □ No

Please explain all "Yes" answers on reverse side of this sheet.
Injury Data Gathering Forms;
Medical History Proforma - Reverse Side of Sheet

Please explain all “Yes” answers to questions asked overleaf.

eg. Yes to Quest. 7 d. Sprained ankle, missed two games. Completely healed now.

At what age did you commence playing Rugby League?
How many years in total have you played Rugby League?
Since earliest commencement of playing, how many years did you not play at all?

Name and surgery suburb of your family physician:

Your signature: ___________________________ Date: ___/___/199_
Your date of birth: ___/___/199_
Injury Data Gathering Forms;

Team Injury Reports Form

Please fill out on weekly basis during playing season, and on monthly basis during off-season.

1. In-season: week ending _____ / _____ / 199__.
   Off-season: month ending _____ / _____ / 199__.

2. Please complete the following report:

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<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Player injured</strong></td>
<td>Injured in game, or when/where?</td>
<td>Body part injured</td>
<td>Type of injury and seriousness</td>
<td>Completed match or unable to continue</td>
<td>Attended doctor or hospitalised?</td>
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<td>11</td>
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</tbody>
</table>

181
APPENDIX F

Player Survey Forms - Experimental and Control
Player Name: ___________________________ Club: = Experimental Group Club

Please fill out all answers on both sides of this sheet.

Question 1. Number of games participated in:
Your draw for the season was versus: eg. M, N1, N2, P1, C1, ST, C2, W, C2, E, P2, I, S, Semifinal, Final. (Each team was furnished their own game draw for the season here).

1.1 How many of the above games did you play in?
1.2 What was your average time on the field per game?
   (eg. 60 minutes, 55 minutes, 20 minutes, 10 minutes?)

Question 2. Training Sessions attended?
Your scheduled training sessions were on Mondays, Wednesdays and Thursdays (3 per week). Including 3 weeks of the preseason, this gives approximately 48 training sessions for the season since I started my study.

2.1 How many of these training sessions did you attend?

Question 3. Neck and Shoulder Exercises at Training:
My study involved completing the specific neck and shoulder exercises at training.

3.1 Of the training sessions attended, at how many did you do the prescribed neck and shoulder exercises?
3.2 When these exercises were done, on average how many minutes were devoted to them?
3.3 Approximately how many game day warm-ups used the neck and shoulder exercises?

Question 4. Were you doing any extra weight training programs or exercise regimens that would have affected your upper body fitness separate from my experimental upper body exercises? (Tick one)
Yes / No

If YES, please elaborate on reverse side of this sheet. (Quest. 7).
Question 5.
5.1 How many extra games did you play for your school?
5.2 On average, how much on-field time did you get during these school games?
5.3 How many extra training sessions did you attend for your school?
5.4 How many games of Representative Football did you play?
5.5 On average, how much on-field time did you get during these Representative Games?

Question 6. In your own opinion (tick in the box on the scale below) how effective were the prescribed neck and shoulder exercises? :-.
6.1 In increasing upper body fitness?

<table>
<thead>
<tr>
<th>Very Beneficial</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>No Benefit</th>
<th>1</th>
</tr>
</thead>
</table>

6.2 In increasing your resistance to upper body injuries?

<table>
<thead>
<tr>
<th>Very Beneficial</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>No Benefit</th>
<th>1</th>
</tr>
</thead>
</table>

Question 7. (Answer only if “Yes” in Question 4). If you answered “Yes” that you were doing extra weight training programs or exercise regimens that would have affected your upper body fitness separate from my experimental upper body exercises; please explain and describe these:

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
Question 8. The time taken in doing the prescribed neck and shoulder exercises of Peter Ritchie's study could have been more usefully put into other training. (Tick the box of your choice in the scale below).

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Unsure</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Suggest other more useful training

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Question 9. Please specify any injuries incurred during 1995 season. State whether you had to leave the field of play, and the time you had off playing and/or training due to each injury.

eg. bruised shoulder, taken from field, missed 3 training sessions and one game.

•
________________________________________________________________________________________
________________________________________________________________________________________

•
________________________________________________________________________________________

•
________________________________________________________________________________________

Thank you for your participation in 1995.
APPENDIX F CONT’D
Player Survey Forms - Control Players

Player Name: ________________________  Club: = Control Group Club

Please fill out all answers on both sides of this sheet.

Question 1. Number of games participated in:
Your draw for the season was versus: eg. M, N1, N2, P1, C1, ST, C2, W, C2, E, P2, I, S, Semifinal, Final. (Each club furnished their own competition game draw here).
1.1 How many of the above games did you play in?
1.2 What was your average time on the field per game?
   (eg. 60 minutes, 55 minutes, 20 minutes, 10 minutes?)

Question 2. Training Sessions attended?
Your scheduled training sessions were on Tuesdays and Thursdays (3 per week). Including 3 weeks of the preseason, this gives approximately 48 training sessions for the season since I started my study.
2.1 How many of these training sessions did you attend?

Question 3. Were you doing any extra weight training programs or exercise regimens that would have affected your upper body fitness separate from your normal team training? (Tick one)
   Yes / No
If YES, please elaborate on reverse side of this sheet. (Quest. 7).

Question 4.
4.1 How many extra games did you play for your school?
4.2 On average, how much on-field time did you get during these school games?

4.3 How many extra training sessions did you attend for your school?
4.4 How many games of Representative Football did you play?
4.5 On average, how much on-field time did you get during these Representative Games?
Question 5. During 1995 Peter Ritchie was conducting parallel studies with other football teams using specific upper body exercises. Were you aware of these other studies & exercises? [Yes] [No]

5.1 If "Yes", did you modify any of your training? If so, please describe in detail:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Question 6. Did you find the influence of the Ritchie study beneficial?

(Please tick in the box of your choice below)

<table>
<thead>
<tr>
<th>Very Beneficial</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>No Benefit</th>
</tr>
</thead>
</table>

Please explain __________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Question 7. How did Peter Ritchie's role or input influence your 1995 SG Ball year?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Please see overleaf for Question 8.
Question 8. (To cross check my injury stats:) Please specify any injuries incurred during 1995 season. State whether you had to leave the field of play, and the time you had off playing and/or training due to each injury.

e.g. bruised shoulder, taken from field, missed 3 training sessions and one game.

•

•

•

Thank you for your participation in 1995.
APPENDIX G

Standard Format:
Coach and Trainer Interview
APPENDIX G

Interview:

Coach and Trainer

Surname:________________________ Christian names:________________________

Position held at club:______________________________

Questions:

1) Years of experience in your position held?

2) Have you noticed any recent important trends in patterns of injury to players?

3) Specific to upper body injuries; have you noticed any recent trends in patterns of injury, incidence of injury?

4) What specific conditioning techniques and practices have you been implementing to cater specifically to upper body conditioning?

5) Do you see any areas where extra caution should be employed with a view to the changing demands of Rugby League?

6) With regards to upper body injuries; in which specific areas can you suggest changes to conditioning practices, and changes to the conduct of the actual game situation?

7) After examining my methodology for my research, can you make suggestions to improve my methods, or suggest any areas where I might find similar research to aid me in my pursuits?

8) After a player has sustained upper body injury, what periods of resting from the playing field do you suggest for: a) Concussion b) Neck injury c) Shoulder dislocation?
APPENDIX H

Subject Participant Consent Forms

1. Experimental Groups Informed Consent Forms:
   
a) Participant Consent Form

b) Parent / Guardian Consent Form

c) Neck Exercises Consent Form

2. Control Groups Informed Consent Forms:

a) Participant & Parent / Guardian Consent Form
Research Consent Forms:

1. Experimental Groups Informed Consent Forms

a) Participant Consent Form

University of Wollongong
Faculty of Education
Human Research Ethics Committee

Participant Consent Form

Research Title: Injuries in Rugby League - Preventive Exercise Systems.

Researcher's Name: Peter Ritchie

This research project is being conducted as part of an Education Doctorate (Physical and Health Education) supervised by Dr. Paul Webb and Dr. E. Booth, of the Faculty of Education in conjunction with Dr. G. Ward of the Faculty of Health and Behavioural Sciences at the University of Wollongong.

The study will involve you taking part in an exercise program over about the next three years. The exercises would be done during the normal training that you would undergo playing and training for your club. This set of exercises will be taught by qualified personnel in conjunction with your football club, and you will need to undertake three sessions of the exercises per week at official training. It is envisaged that this extra training will prove more than worthwhile in that it should better prepare you for your sport. You won't need to buy any special expensive equipment. A team of people under our supervision will use a series of tests to determine your fitness profile before your first season commences and then again at the end of each season throughout.
the program. before his first season commences, and then again at the end of each season until the completion of the program. Medical records will be kept and any injuries that may occur during the period of the study will be recorded by the team management and collected by me to collate. Such medical records and records of injury will be kept as a permanent record. We will assign you a number to preserve your anonymity, and all results collected by us will be strictly confidential.

If you do not participate you will not be discriminated against in any way. If you do participate you will be free to withdraw from the research at anytime without penalty.

If you have any enquiries regarding the conduct of the research please contact:
The Secretary,
University of Wollongong Human Research Ethics Committee Phone (042) 214457.
OR
Associate Professor, John Patterson,
Dean of Education, Phone (042) 213 961.

I understand that the data collected will be used for the promotion of injury reduction efforts in Rugby League and I consent for the data to be used in that manner.

If you wish to take part in this research please sign below:

Signed:...................................................... Date: ........../....../......
Research Consent Forms Cont’d:

1. Experimental Groups Informed Consent Forms

b) Parent / Guardian Consent Form

University of Wollongong
Faculty of Education
Human Research Ethics Committee

Consent Form- Parent/Guardian

Research Title: Specialised Exercise Systems for Injury Risk Reduction in Adolescent Rugby League Players.
Researcher’s Name: Peter Ritchie

This research project is being conducted as part of an Education Doctorate (Physical and Health Education) supervised by Dr. Paul Webb and Dr. E. Booth, of the Faculty of Education in conjunction with Dr. G. Ward of the Faculty of Health and Behavioural Sciences at the University of Wollongong.

The study will involve your son taking part in an exercise program over about the next three years. The exercises would be done during the normal official training sessions he would undergo playing and training for his club. This set of exercises will be taught by qualified personnel in conjunction with his football club, and he will need to undertake about three sessions of the exercises per week at official training. It is envisaged that this training will prove more than worthwhile in that it should better prepare your son for his sport. You won’t need to buy any special expensive equipment.
A team of people under my supervision will use a series of tests to determine his fitness profile before his first season commences, and then again at the end of each season until the completion of the program. Medical records will be kept and any injuries that may occur during the period of the study will be recorded by the team management and collected by me to collate. Such medical records and records of injury will be kept as a permanent record. We will assign your son a number to preserve his anonymity, and all results collected by us will be strictly confidential.

If your son does not participate he will not be discriminated against in any way. If your son does participate he is free to withdraw from the research at anytime without penalty.

If you have any enquiries regarding the conduct of the research please contact:
The Secretary,
University of Wollongong Human Research Ethics Committee on (042) 214457.

OR

Associate Professor, John Patterson
Dean of Education, Phone (042) 213 961.

I understand that the data collected will be used for the promotion of injury reduction efforts in Rugby League and I consent for the data to be used in that manner.

If you wish to take part in this research please sign below:

Signed:........................................... Date: ............../......./.....

(Parent / Guardian)
Research Consent Forms Cont’d:

1. Experimental Groups Informed Consent Forms

c) Neck Exercises Consent Form

Faculty of Education & Faculty of Health & Behavioural Sciences.

Neck Exercise Consent Form.

I, __________________________________________ agree to participate in a program designed to increase my neck muscle strength and flexibility. I understand that this program involves a series of strengthening exercises performed three times per week at official team training sessions, and evaluation of my neck strength and flexibility will be carried out before and after the training program. All exercises will be done under strict supervision.

Physiological measurements that I will be asked to participate in include:

1) Measurement of height, weight, circumference of neck, and thickness of skinfolds (including; abdominal, suprailiac, triceps, biceps and subscapular).

2) Measurement of neck strength using testing apparatus constructed at the University of Wollongong, Department of Biomedical Science.

3) Measurement of neck flexibility using a clinical goniometer.

4) Answering a questionnaire regarding personal history.

The nature of the training program has been explained to me. I understand that I will be requested to undertake the neck training program at only team training sessions, three times per week in-season, and whenever training sessions take place out-of-season. Each training session will consist of approximately 10 - 15 minutes of specific neck and shoulder exercises, including warm-up and warm-down exercises.

I also know that I can withdraw from the study at any time without penalty or without being discriminated against.

I understand that all tests will be performed by only suitably qualified personnel.
I further understand that the results of the tests and questionnaires will be held in confidence by the University of Wollongong (Faculty of Education and Faculty of Health & Behavioural Sciences) with individual results available only to the researchers and myself. I realise that the results of the study may be published in appropriate publications.

I have read the above, understand it and any questions that I have asked have been answered to my satisfaction. I know that I may also ask any questions concerning the study at any time throughout the study.

My consent is given voluntarily and under free power of choice. I have been informed that I may withdraw from the program (or any part of it) at any time, or ask any additional questions.

Signature of volunteer: ________________________________
Witnessed: __________________________
Investigator: __________________________ Supervisor: __________________________
Dated this ____________ 1995.
Research Consent Forms Cont’d:

1. Control Groups Informed Consent Forms

a) Participant and Parent/Guardian Consent Form

Faculty of Education & Faculty of Health & Behavioural Sciences.
Upper Body Injuries in Rugby League Research Consent Form.

I, __________________________ agree to participate in a program designed to measure changes in upper body fitness and to monitor injuries that may be incurred in this time. I understand that there will be evaluation of my neck strength and flexibility both at the commencement of this season and at the end of the season.

Physiological measurements that I will be asked to participate in include:

1) Measurement of height, weight, circumference of neck, and thickness of skinfolds (including abdominal, suprailiac, triceps, biceps and subscapular).
2) Measurement of neck strength using testing apparatus constructed at the University of Wollongong, Department of Biomedical Science.
3) Measurement of neck flexibility using a clinical goniometer.
4) Answering a questionnaire regarding personal history.

I understand that all tests will be performed by only suitably qualified personnel.
I understand that I also can withdraw from the study at any time without penalty or without being discriminated against.

I further understand that the results of the tests and questionnaires will be held in confidence by the University of Wollongong (Faculty of Education and Faculty of Health & Behavioural Sciences) with individual results available only to the researchers and myself. I realise that the results of the study may be published in appropriate publications.
I have read the above, understand it and any questions that I have asked have been answered to my satisfaction. I know that I may also ask any questions concerning the study at any time throughout the study.

My consent is given voluntarily and under free power of choice.

Signature of volunteer: ________________________________

Signature of Parent / Guardian: ________________________________

Witnessed: ________________________________

Investigator: ________________________________ Supervisor: ________________________________

Dated this ________________________________ 1995.
APPENDIX I

Coach and Trainer Interviews Report
APPENDIX I

Coach and Trainer Interview Report

Coach and trainer interviews were conducted following prior notification of interview content themes by means of written advice of the questions (Appendix G - Coach & Trainer Interview Standard Format). These interviews were recorded on studio quality audiotape cassette for later coding. Key informant responses were treated on a question-by-question basis and important responses were quoted verbatim. There were four coaches from the elite teams interviewed and four coaches from the non-elite teams, representing one coach per team. The elite teams provided four trainers for interview, one from each elite team, but only two non-elite trainers could be interviewed as two non-elite teams had no formal trainers, with the coaches fulfilling the role of trainer as well as coach. A summary of the question-by-question coach and trainer interviews follows and this data is supported when appropriate by researcher observations made during the study.

Question 1. Years of experience in position held.

The coaches of all teams were proficient with an average of 9.5 years of coaching experience. Coaches were all holders of a Level 1 Coaching Certificate as required by the Australian Rugby League, and one coach held the Level 2 Coaching Certificate. There was no admission of lack of experience or feeling of lack of confidence by the coaches during the study. Informal observations by the researcher during the study confirmed this self perception.

The trainers were also of proficient experience, with an average of 8.25 years of training. Trainers admitted to feelings of confidence in their level of experience, and this general opinion of their abilities was confirmed by the researcher from field observations during the season.
Question 2. Recent trends in patterns of injury, specifically of the upper body.

90% of the training staff, coaches and trainers, identified a definite and recent trend toward more shoulder injuries, with the remaining 10% admitting to lack of years of experience preventing them from identifying recent trends in upper body injury. However, the observation of the main types of shoulder injuries varied, with 70% of the training personnel identifying gleno-humeral joint shoulder dislocations as the main injury type, 10% identifying rotator cuff injuries, 10% identifying AC joint dislocations, and the remainder citing collarbone fracture as the major concern. There were 20% of the training personnel who felt that injuries to the chest and sternum had also increased dramatically.

The consensus of the training personnel was that this injury trend was brought about mainly with the change on emphasis in the tackling objective of defenders. They identified the recent trend of the concentration on the tackler “wrapping up the ball” or for the tackler to complete the “ball-and-all” tackle in order that the player in possession of the ball might not pass the ball on to continue play as increasing the incidence of upper body injury.

Question 3. Conditioning techniques and practices used for upper body conditioning.

The coaches believed in upper body conditioning for their players, but offered little interference in the training methods employed by their trainers. Each coach had selected his own trainer in whom that coach could place full confidence, and as a result the 1995 trainers were largely responsible for the player conditioning during the season. However, the coaches were all definite about the benefits of weight training and the age at which initial weight training should occur, that age being once the player’s body (particularly the player’s growth plate development) had reached a necessary level of maturity. The age of general agreement was age 16 years for commencement of initial weight training, although this initial weight training was to be limited to a program of high repetitions and low weight resistance for at least the first year.
An elite level team coach reported; “We were all round stronger than most of the other teams, and we didn’t have any injuries to the shoulders and neck because of that.” This statement was made by the coach of the “strongest” team in the study (which was a randomly selected experimental team). The researcher took note of the pretest and posttest sessions for this particular team, and indeed more weight was required for the tests, and more repetitions performed at set weights etc, but the results of this elite experimental team alone were insufficient to skew the results on pretest and posttest.

An elite level team coach who believed in weight training, but was thwarted in its use by lack of club support, reported; “We weren’t even allowed in the weights room. They always said that the First Grade were using the gym, but they wouldn’t be there when we could have used it and we still couldn’t use it. I really believe in weights at this level, but we couldn’t get near them, and I reckon that if we’d have done weights we wouldn’t have had all those shoulder injuries we had. But what can you do?” This report was from the coach of the elite level control team with by far the greatest number of Very Serious shoulder injuries, surgical correction being required for at least one unfortunate player.

The trainers had used a variety of upper body conditioning methods at training varying from scientific weight training programs in the gymnasium to partner activities requiring isometric resistance as well as dynamic competitive activities. There was consensus that weight training was effective, but lack of facilities largely impeded general implementation of these programs. Most trainers used push-ups extensively and considered this exercise as their major upper body conditioner, although there was agreement that weight training utilising the bench press and “clean and jerk” techniques was desirable. One trainer utilised neck and arm stretching in his programs (but this was not reflected in associated fitness test results for his non-elite level control group players).
Question 4. Periods of resting from the playing field suggested after a player has sustained:

a) Concussion - The coaches stated that a minimum of one week's rest from competition was enforced when a player had suffered concussion. If a player was knocked unconscious all coaches required a medical clearance before they would allow the player to play again. In the case of the elite level clubs, all clubs had a club doctor to whom the players were sent, and clearance for all concussions was required from the club doctor before the player could recommence competition.

The trainers were of the same opinions as the coaches and they too stressed that medical clearance was almost becoming essential in the modern game before a player who had suffered concussion could be allowed to recommence competition.

b) Neck injuries - The coaches and trainers all indicated that any incidence of neck injury was to be treated with major concern. The coaches and trainers were very much aware that they were unqualified to judge severity or recovery rate from neck injury. Therefore they stated that they would invariably exclude their player from both training and playing until medical clearance was obtained.

c) Shoulder dislocation - The coaches and trainers differed in their opinions as to rehabilitation times for a shoulder dislocation injury. Over half of the training personnel were of the opinion that they could enforce a rehabilitation program for shoulder dislocation without need to resort to back-up medical advice. The general agreement was for the injured player to require at least five to six weeks cessation of competition matches, with restoration of complete range of joint motion being the guiding factor for when to recommence strengthening programs for the injured shoulder joint. At the elite level, mainly because of ready access to club doctors, a number of training personnel stated that they would seek medical advice to reinforce their own opinions, but at the non-elite level there was more of a tendency to proceed without recourse to medical back-up.
Question 5. Areas where extra caution should be employed with :- a) Training?... and what are your suggestions? b) Rules of the game?... and what are your suggestions?

Question 6. Suggested specific changes to conditioning practices and to the conduct of the actual game situation?

Questions 5 and 6 were treated together because the coaches and trainers interviewed preferred this.

a) Conditioning practices - All coaches and trainers agreed that very few upper body injuries occurred at training because there was a less competitive and less physical approach to training than that needed on the playing field on game day proper. There was a perceived need for greater utilisation of more thorough warm-up exercises at the commencement of each training session and this was indeed being changed accordingly. A small proportion of trainers (10%) suggested that greater use of low weight resistance training warm-ups could be beneficially employed at commencement of each training session.

b) Rules of the game - Coaches and trainers unanimously agreed that the scrum was an area of major concern. 80% of the training personnel stated that scrums could be “depowered”. They suggested rule changes to enforce a formation whereby players reduced the power used to push against the opposition in the scrum. One coach at the non-elite level even suggested excluding the scrum from the game altogether.

“I believe that we could do without scrums altogether. I think they are a farce. I think it’s just a way of producing a situation where so many players are locked up in the scrum, producing the chance that only eight players are attacking against eight players defending. They are becoming predictable, we know that the team feeding the scrum will probably win it. Scrum are producing injuries. I think they should be restarting with a tap kick instead”.

This statement emanated from the non-elite level experimental team coach whose players had suffered a number of minor neck injuries in their final (Grand Final) club game of the 1995 season, as a result of dubious tactics by the opposition team to “screw” and collapse the scrum to their (the opposition’s) advantage.
The spear tackle was also implicated as a technique that was in need of greater attention from the rules of the game to ensure that it was left out of the game altogether. One trainer also stated his belief that the “bomb” or high kick should be eliminated from the game because it put the player in the receiving position at risk from the approaching opposition who were quite often out to injure the player receiving the “bomb” so that he would spill the catch or not want to take the “bomb” receipt the next time it was used. 10% of coaches and trainers perceived a need for greater screening of players for builds (particularly neck types) and their suitability to various player positions, and these training personnel stated that they would pursue this in future years.

Question 7. Value of the study to the players and training personnel.

The coaches of all of the experimental and control teams found their involvement with the study to be of overall benefit. The time involved in the upper body fitness parameter testing phases for both experimental and control players was sometimes seen as detracting from the overall benefit of the study. Also, the experimental teams were called upon to invest more time in the sustained implementation of the experimental exercises. However, even although this was seen as the only “down side”, it was agreed that there was no alternative available to obtain the data necessary in testing the research in question.

One elite level experimental team coach reflected; “We couldn’t do the exercises all the time. There just wasn’t enough time to fit everything in. I found the concepts involved to be of good value, and we didn’t have any injuries in particular so it might have been helpful there”. Indeed, the possibility of wavering support from this particular club team precipitated the formulation and implementation of the player survey for all players involved in the research. The data from this survey yielded information providing affirmation that the exercise system was implemented consistently throughout the season, as well as providing valuable indication of the players’ attitudes to, and appraisal of, the experimental exercise program and the research overall.
There was unanimous support from the coaches that the study had been beneficial for themselves, and that its benefits were readily observable in the positive motivational effects of the study on everyone involved. Coaches were also unanimous in expressing their opinions that the study was also beneficial in the professionalism with which it was carried out. Of course it must be remembered that there were two different levels of researcher interaction experienced by the players and their training personnel according to whether the team was an experimental or control team. The experimental players were exposed to the experimental exercise program, whilst these exercises were not revealed to the control players.

The trainers were also unanimous in their support of the study. They stated that their own understanding of the purpose and effects of the research had increased their openness to future studies and that the observed effect on the motivation and evolving professionalism of the players was very positive. The trainers also expressed unanimous support for the benefits of the professionalism with which the study was carried out.

The experimental teams trainers found the experimental exercises to be innovative and useful. One elite level experimental team trainer, a person with whom the researcher shared an affinity, and probably the most innovative and knowledgeable of the training personnel involved in the study stated;

"I can see how we need to be a bit more scientific in how we prepare the boys. We hadn't seen anything like those exercises before, and although the boys were a bit slow to take to it at first they started to really enjoy competing against each other to see who could do the most of each lot".

The control teams trainers also found the study to be of benefit to themselves and to the players and coaches. However, since the control teams only perceived the researcher as a data gatherer their perceptions of the influence of the study differed from those of the experimental teams who were required to consistently practice the experimental exercises.

"Having you do the study was really good for the boys. It made them keener to get fitter. Hearing them talking about how many times they could lift the heavy
weights, and how strong they were at pressing in on that arm dynamometer gave them a whole new language and they felt more professional because of what you did. So the study was a good thing that we all got a lot out of... No. No down side.”

This was a report indicative of the form of reception afforded the study by the greater proportion of the control teams coaches and trainers, at both the elite and non-elite levels.
APPENDIX J.
Pilot Study Summary of Results Leading To Fitness Testing Modifications.

The pilot study of 17 high school Opens grade Rugby League footballers was undertaken in 1994 using participants from a high school Open Division Rugby League team coached by the researcher. There were a number of items within the initial upper body fitness test battery that were either omitted or revised. The final test battery was refined from the original tested pilot study.

The Pilot Study included barbell Bench Press tests for strength and endurance of the arms. The Pilot Study also included the usual trial and error method to ascertain a 1RM weight for each subject for the strength tests for Bench Press, Military Press Strength, and Behind The Neck Press Strength. The time taken to implement all testing as per the Pilot Study proved prohibitive, considering that the subjects of the study were allowing the research to be undertaken providing that it did not interfere unduly in their normal training programs. Indeed, one prospective team for the study declined to participate after learning of the possible interruption to their normal training program, despite indicating enthusiasm to participate in the formative stages of the study. Thus the testing procedures for the study proper needed to be streamlined to be workable given the time constraints to be met in the field.

It was decided to delete the Bench Press Strength and Endurance tests altogether, since the angles of arm action used to perform this activity were not considered critical in identifying areas of weakness to anterior superior arm actions that were the cause of many of the shoulder injuries under study. It was also decided to minimise the changing of weight loads in strength testing for Military Press Strength and Behind Neck Press Strength by utilising calculations based on relevant literature in the field.

The work of Brzycki (1993) was used to predict a One-Repetition Maximum weight for each subject based on their Repetitions-to-Fatigue weight load. This
particular protocol was used because it allowed greater leeway for assessment without needing to be constantly changing weights to evaluate by trial and error the One-Repetition Maximum of each subject as per the normal testing procedure. Logistical and time constraints were of major concern when dealing with a large number of athletes in one testing session at a time (often 20 + subjects), working within the confines of their home training grounds and the interruptions to their normal training routine.
APPENDIX K

Data Files for Tables and Figures -
(Data stored on enclosed computer floppy disc)
Appendix K.
Data for Tables & Figures
Apple Macintosh Computer
Claris 2.0 Software.