

**ATTACKING THE GOAL OF
NETBALL INJURY PREVENTION:
A REVIEW OF THE LITERATURE**

by

**Alicia C. McGrath
Joan Ozanne-Smith**

May, 1998

Report No. 130



MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE
REPORT DOCUMENTATION PAGE

Report No.	Date	ISBN	Pages
130	May 1998	0 7326 0710 8	123

Title and sub-title:

Attacking the Goal of Netball Injury Prevention: A Review of the Literature

Author(s)

McGrath AC
Ozanne-Smith J

Type of Report & Period Covered:

Critical review 1985-1997

Sponsoring Organisation(s):

Sport and Recreation Victoria

Abstract:

Netball is the most popular team based sport in Australia, played predominantly by females of all ages and skill levels although male and mixed competitions are becoming increasingly popular. Netball has been described as a game reliant on rapid acceleration to “break free” from an opponent, sudden and rapid changes in direction in combination with leaps to receive a pass, intercept a ball or rebound after attempting to goal (Steele and Milburn, 1987b). Taking these characteristics into consideration, injuries can result in a number of ways. Despite the large participation numbers and the controversy surrounding netball which is often defined as “a game prone to ankle and knee injuries” (Steele, 1990), there is a notable lack of formal, controlled evaluations of the effectiveness of injury prevention countermeasures. The overall aim of this report is to critically review both the formal literature and informal sources that describe injury prevention measures, or countermeasures, for netball. In doing so, it provides an evaluation of the extent to which these countermeasures have been demonstrated to be effective. This report discusses a range of countermeasures for preventing netball injuries including: warm-up and stretching, correction of training errors, attention to the netball environment, correction of netball technique, footwear, use of orthotics, adequate treatment and rehabilitation. Specific factors associated with children’s netball injuries are also discussed. Recommendations for further countermeasure research, development and implementation include additional research into the biomechanics of netball and the mechanisms of injury; improved epidemiological studies to identify risk factors; further controlled evaluation of the effectiveness of countermeasures; professional fitting of shoes; professional testing for biomechanical abnormalities and the fitting of orthotic devices.

Key Words:

netball, injury prevention, overuse injuries, countermeasures, evaluation

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CONTENTS

ACKNOWLEDGMENTS	ix
EXECUTIVE SUMMARY	xi
1. INTRODUCTION	1
2. AIMS	1
3. METHODOLOGY	2
4. AN OVERVIEW OF THE PARTICIPATION RATES AND EPIDEMIOLOGY OF NETBALL INJURIES	4
4.1 PARTICIPATION RATES	4
4.2 GENERAL EPIDEMIOLOGICAL NETBALL INJURY DATA	5
4.2.1 Published emergency department presentation data	5
4.2.2 General sports population studies	6
4.2.3 Netball specific population injury rates	7
4.2.4 Combined netball and basketball studies	7
4.2.5 Various netball injury database sources, including insurance claims	7
4.3 VISS EMERGENCY DEPARTMENT PRESENTATIONS	8
4.3.1 Formal Netball	9
4.3.1.1 Children	9
4.3.1.2 Adults	10
4.3.2 Informal netball	10
4.3.2.1 Children	10
4.3.2.2 Adults	11
4.4 CONCLUSIONS	11
5. AN OVERVIEW OF INJURY COUNTERMEASURES FOR NETBALL	13
5.1 PRIMARY, SECONDARY AND TERTIARY PREVENTION	13
5.2 INTRINSIC AND EXTRINSIC FACTORS	14
6. DETAILED REVIEW OF NETBALL INJURY COUNTERMEASURES	16
6.1 LANDING AND ASSOCIATED FACTORS IN RELATION TO NETBALL INJURIES	16
6.1.1 Ground reaction forces (vertical and braking)	16
6.1.2 Extra step	17
6.1.3 Passing height	17
6.1.4 Combined pass height and extra step	18
6.1.5 Speed	18
6.1.6 Netball surface	19
6.1.7 Footwear	20
6.1.8 Landing technique	21
6.1.8.1 Landing technique and footfall pattern	21
6.1.8.2 Landing technique and anthropometrics	22
6.1.8.3 Landing technique and balance	22
6.1.8.4 Landing technique and knee alignment	23
6.1.8.5 Landing technique and fatigue	23
6.1.8.6 Recommended landing techniques	23
6.1.8.7 Conclusion	24

6.1.9	Recommendations for further research, development and implementation.....	25
6.2	TRAINING AND TECHNIQUE.....	25
6.2.1	Warm-Up, Stretching and Cool Down	25
6.2.1.1	<i>Recommendations for further research, development and implementation.....</i>	26
6.2.2	Correction of Training Errors.....	26
6.2.2.1	<i>Recommendations for further research, development and implementation.....</i>	28
6.2.3	Anthropometrics and Injury	29
6.2.3.1	<i>Recommendations for further research, development and implementation.....</i>	29
6.2.4	Pre-Participation Screening.....	30
6.2.4.1	<i>Recommendations for further research, development and implementation.....</i>	30
6.2.5	Education and Training	30
6.2.5.1	<i>Coaches</i>	30
6.2.5.2	<i>Trainers</i>	32
6.2.5.3	<i>Recommendations for further research, development and implementation.....</i>	32
6.2.6	Correction of Netball Styles.....	33
6.2.6.1	<i>Recommendations for further research, development and implementation.....</i>	33
6.2.7	Preventing Overuse Injuries.....	34
6.2.7.1	<i>Recommendations for further research, development and implementation.....</i>	34
6.3	NETBALL ENVIRONMENT.....	35
6.3.1	Netball surface.....	35
6.3.2	Temperature	35
6.3.3	Goal posts	36
6.3.4	Recommendations for further research, development and implementation.....	36
6.4	NETBALL FOOTWEAR.....	37
6.4.1	Netball shoe design.....	37
6.4.1.1	<i>High-topped shoes</i>	38
6.4.2	Orthotics	38
6.4.3	Socks	40
6.4.4	Recommendations for further research, development and implementation.....	41
6.5	MOUTHGUARDS	41
6.5.1	Recommendations for further research, development and implementation.....	42
6.6	PERSONAL HYGIENE.....	42
6.6.1	Recommendations for further research, development and implementation.....	42
6.7	TREATMENT AND REHABILITATION	42
6.7.2	Sports first aid	42
6.7.3	Taping and bracing.....	44
6.7.3.1	<i>Ankles</i>	44
6.7.3.2	<i>Knee</i>	44
6.7.4	Rehabilitation	45
6.7.5	Recommendations for further research, development and implementation.....	46
6.8	CODES OF CONDUCT.....	47
6.8.1	Substitutions/Rules	47
6.8.1.1	<i>Recommendations for further research, development and implementation.....</i>	47
6.8.2	Blood.....	47
6.8.2.1	<i>Recommendations for further research, development and implementation.....</i>	48
6.8.3	Risk Management	48
6.8.3.1	<i>Recommendations for further research, development and implementation.....</i>	49
6.8.4	Standards.....	49
6.8.4.1	<i>Recommendations for further research, development and implementation.....</i>	50
6.9	SPECIFIC POPULATIONS	50
6.9.1	Children	50
6.9.1.1	<i>Recommendations for further research, development and implementation.....</i>	52

6.9.2	Masters	52
6.9.2.1	<i>Recommendations for further research, development and implementation</i>	52
6.9.3	Women	52
6.9.3.1	<i>Anaemia</i>	53
6.9.3.2	<i>Amenorrhoea</i>	53
6.9.3.3	<i>Recommendations for further research, development and implementation</i>	53
6.9.4	Pregnancy.....	53
6.9.4.1	<i>Recommendations for further research development and implementation</i>	55
7.	NETBALL INJURY PREVENTION PROGRAMS	56
7.1	“Your Body - Your Choice”	56
7.2	Injury Prevention Strategy Research.....	57
7.3	Recommendations for Further Research Development and Implementation	57
8.	VARIATIONS OF TRADITIONAL NETBALL	58
8.1	Recommendations for Further Research Development and Implementation	58
9.	SUMMARY AND ADDITIONAL RECOMMENDATIONS	59
10.	REFERENCES	60

Figures

Figure 1	Grading scale for assessing the extent to which countermeasures have been fully evaluated.....	2
Figure 2	Netball Victoria registration 1981-1996.....	4
Figure 3	All Australian Netball Association registration.....	5
Figure 4	A sports injury pyramid.....	6
Figure 5	Countermeasure opportunities in the injury chain.....	13

Tables

Table 1	1995 and 1996 Netball Victoria insurance claims.....	8
Table 2	Netball injury emergency department presentations by age and nature of play	8
Table 3	Netball Injury Presentations.....	9
Table 4	Epidemiology of netball injuries.....	11
Table 5	Netball injury countermeasures	14
Table 6	Intrinsic and extrinsic factors associated with netball injuries	14
Table 7	Aspects of netball prevention programs currently in use by netball coaches in New Zealand.....	31
Table 8	The type of injury prevention research requested by New Zealand netball coaches.....	31
Table 9	Risk management plans at club, sport and facility level	48
Table 10	Analysis of “Your Body: Your Choice” prevention program.....	56

Appendices

Appendix 1	Netball injury data: literature review	70
Appendix 2	Ground reaction forces reported in various studies	77
Appendix 3	Technique and common faults - Produced by Netball Victoria	81
Appendix 4	Example of netball insurance coverage	84
Appendix 5	Risk management: examples from Netball Victoria.....	87

ACKNOWLEDGMENTS

This study was funded by Sport and Recreation Victoria.

The authors would also like to particularly thank Julie Steele (University of Wollongong), Patria Hume (University of Auckland), Diana Hopper (Curtin University), Leonie Otago (University of Ballarat) and Netball Victoria for providing information included in this review and comments on the draft report. Prof Peter Vulcan (Monash University Accident Research Centre) is also thanked for his valuable comments on the draft report.

Karen Ashby is thanked for her contribution towards preparing the Netball Fact Sheet.

Netball New Zealand is thanked for its kind permission to reproduce the training pyramid from, "Netball - Your body: Your choice".

Netball Victoria is also acknowledged for permission to reproduce documents referred to in the appendices.

The illustration on the title page was produced by Debbie Mourtziou.

EXECUTIVE SUMMARY

Netball is the most popular team based sport in Australia, played predominantly by females of all ages and skill levels, although male and mixed competitions are becoming increasingly popular. Netball has been described as a game reliant on rapid acceleration to “break free” from an opponent, sudden and rapid changes in direction in combination with leaps to receive a pass, intercept a ball or rebound after attempting to goal (Steele and Milburn, 1987b).

Taking these characteristics into consideration, injuries can result in numerous ways. Despite the large participation numbers and the controversy surrounding netball, which is often defined as “a game prone to ankle and knee injuries” (Steele, 1990), there is a notable lack of formal, controlled evaluations of the effectiveness of injury prevention countermeasures. Studies to date have tended to focus on the incidence and nature of injuries occurring in netball in an attempt to identify causative mechanisms (Steele, 1990).

Injury prevention is of prime importance because, as well as affecting a player’s sporting capabilities, it can also affect their work resulting in forced absenteeism and consequent socioeconomic problems in the home (The National Coaching Director and Coaching Development Committee, 1990). The benefits of participating in sport need to be weighed up against the risk of incurring a moderate to severe injury (Finch et al., 1995; Nicholl et al., 1991). Nevertheless, sport as a behavioural past time is more likely to be beneficial than the absence of physical activity (Togt, 1988; Finch et al., 1995). Consequently, ways need to be found to manage the risk of injury, which is inherent to physical activity (Backx, 1991).

The aim of this report is to move towards prevention of injuries in netball, through critical review of both the formal literature and informal sources that describe injury prevention measures for netball. Unlike other reports of netball injuries, this report does not focus specifically on the epidemiology of these injuries. Rather, it presents a detailed examination of the range of countermeasures promoted to prevent such injuries. Nevertheless, a brief overview of the epidemiology of netball injuries, particularly from an Australian perspective, is given to set the scene for the subsequent discussion of countermeasures.

Countermeasures for preventing netball injuries can be primary secondary or tertiary and include: factors associated with landing; safe playing environments; stretching; conditioning and technique programs before commencing play; education and training; footwear; mouthguards; taping and bracing; adequate rehabilitation; prompt treatment of injuries and enforced codes of conduct.

This report reviews a range of activities for preventing netball injuries. Recommendations for further countermeasure research, development and implementation have been based on the review as well as discussions with experts acknowledged in this report. Many of the recommended countermeasures have yet to be proven to be effective and more attention to controlled studies “in the field” are needed. More effort directed to basic scientific studies to better understand the biomechanics of netball, the mechanisms of injury and the role of various risk factors in causation are also required. Indeed, the evidence for the effectiveness of certain countermeasures such as warm-up, taping and bracing and landing technique remains equivocal.

INJURY DATA

In a 1997 Australian Bureau of Statistics (ABS) report, netball was rated the fourth most popular sports activity in Australia after aerobics, golf and tennis for persons aged 15 years

and over, with 2.4% of total participation or 328,600 participants. Netball was the third most common sporting activity for children aged 5-14 years, in both school and club organised activities. This followed swimming and basketball. It was estimated that 10.2% of children participated in netball. Similarly, in Victoria, netball was the fourth most popular sport with 2.5% of the population participating (ABS, 1997). Netball Victoria reported that in 1997 there were 112,000 registered members allocated to 22 regions throughout Victoria and 275 affiliated Associations and Associates. The proportion of total female sporting participation represented by netball would be considerably higher than for the whole population.

Emergency department presentation data collected by the Victorian Injury Surveillance System (VISS) indicates that netball injuries amongst both adults (15+) and children (<15) who present to emergency departments in Victoria, account for 9% of all sporting injury cases. Eighty three percent of adult and 70% of child netball injuries occurred during formal competition. Of total formal match presentations 3% of child and 4% of adult cases were sufficiently severe to require hospital admission, similar results also occurred in informal netball.

Adults in formal play were predominantly injured as a result of a collision (26%), while children were injured due to falling (23%). Sprains and strains were the dominant injury for both child and adult injury in formal play (42% and 56%, respectively). Lower limbs were the main body region injured in formal adult netball (62%). A higher frequency of upper limb injuries were reported in formal child netball (58%). This is likely to be a result of incorrect technique and a lack of coordination, in which the child falls and uses their outstretched hands to stop them from falling heavily onto their body.

The incidence of injury in terms of body region and nature of injury reported from VISS data correlates to a large extent with the literature reviewed. Although, one notable factor, is the high proportion of fractures and less sprains and strains in children. This is likely to be attributable to emergency department injuries being more severe than those that occur in other population studies. Comparison of the data must be made with caution, given the presentation of data gathered with different study populations, data collection methods and injury definitions.

RECOMMENDATIONS FOR FURTHER COUNTERMEASURE IMPLEMENTATION, RESEARCH AND DEVELOPMENT

Landing and associated factors in relation to netball injuries

- Given the inconclusive results, to date, of the complex inter-relationship between playing surface, footwear and injury it is recommended that controlled epidemiological studies be undertaken to identify risk or protective factors.
- Further biomechanical and EMG studies of landing need to take into account age, skill, gender, anthropometric characteristics and other factors known to affect landing and should be conducted within normal playing conditions.
- Adequately trained controls are required for future studies of the stepping rule.

Warm-up, stretching and cool-down

- More netball specific research into the effectiveness of warm-up, stretching and cool-down as an injury prevention measure is needed, including the benefits of different types

of warm-up, cooling-down and stretching practices and optimal duration, frequency and intensity of each component.

- The specific needs of the injured netballer, versus the non-injured netballer, should be considered when setting up a warm-up program. Injured netball players should seek professional advice (eg. a physiotherapist) about appropriate exercises.
- Information about warm-up, cool-down and stretching techniques should continue to be developed and widely promoted to improve specific knowledge of techniques.
- Research into the maintenance and effectiveness of warm-up during the start-stop nature of netball games and tournament competitions should be conducted.

Correction of training errors

- Simple fitness testing should be conducted prior to competition to ensure fitness.
- Players should undergo graduated netball skills and fitness progression, guided by initial fitness testing results.
- More research is needed to determine the threshold levels of the various training factors under which netball players are likely to remain injury free.
- A campaign aimed at increasing netball players' awareness of the injury consequences of training errors should be developed and promoted.
- Appropriate fitness programmes should be undertaken to develop strength, co-ordination, and flexibility, especially of muscles involving the ankle and foot (Steele, 1990a).
- Proprioceptive and skill training should be implemented, focussing particularly on activities to enhance body balance and control in landing, moving forwards, and catching passes (Steele, 1990a).
- Players should participate in physical training programmes specific to netball on a regular basis prior to competing in all-day tournaments (Steele, 1990a).
- Evaluation studies should be conducted to determine the effectiveness of the above 'best practice' recommendations on injury prevention and control.

Anthropometrics and injury

- Further anthropometric research is required on a wide range of netball players (age and skill variation) to establish a screening and intervention system.

Education and training

- Coaches, Umpires and Trainers should undertake appropriate training courses specific to the requirements of netball players.
- All netball teams should have at least one qualified Trainer or Coach on hand at both training and competition to aid in injury prevention and treatment of injury.
- Coaches and Trainers should regularly update their qualifications.

- Systematic evaluations of the effectiveness of education and training programs should be conducted.

Correction of netball styles

- Research is required to identify the relationship between netball style imperfections and injury risk.
- Correction of netball style needs to be evaluated in terms of injury reduction.
- Sporting organisations should continue to promote and teach correct netball techniques.
- Coaches should be guided by current Netball Victoria and Netball Australia recommendations until further evaluation is conducted.

Preventing overuse injuries

- Further research is necessary to gain a greater understanding of biomechanics of netball play and the associated overuse injuries.
- Players with potential biomechanical abnormalities (eg. leg length discrepancies) should have these assessed by a professional who can recommend corrective actions.
- Players should be educated about the risk and the severity of the consequences of overuse injuries.

Netball environment

- More research into the role of netball playing surfaces is required to assess the impact on injury risk.
- Netball surfaces should be regularly checked for hazards such as potholes, rubbish etc. and frequently maintained.
- Netball should not be played on slippery surfaces.
- Netball events should not be planned for times when there is a likelihood of extreme weather conditions. Whenever possible, such events should be postponed if such weather conditions eventuate.
- If netball players are planning to play in events likely to be conducted when it is hot or humid, they should undergo a process of acclimatisation and should monitor their fluid loss and replace as needed.
- Broad spectrum sunscreen should be provided at netball events, where appropriate.
- Drinking water should be provided at all netball events.
- Investigations should be conducted on the use of specialised materials for elite level players, which allow evaporating cooling.
- Biomechanical studies of optimal goal post padding need to be conducted.

- Goal posts should be firmly fixed into the ground with no parts of the post base protruding onto the court surface or providing a trip.
- Consistent surface types should be provided within a tournament for a given level of play.
- Surrounding equipment or advertising should be kept away from the court boundaries.

Netball footwear

- Netball players should choose their shoes carefully, preferably with professional advice.
- Future research must account for confounding factors such as previous injury when looking at the relationship between shoe design and injury.
- Development of shoes to overcome the relatively short life of their impact absorption and sole, should be investigated.
- Further research should be conducted on the design and benefits of high versus low top shoes.
- Further development and refinement of orthotic devices specific to the demands of netball is required.
- The effectiveness of orthoses in netball should be determined by well designed controlled studies of sufficient sample size to provide definitive results.

Mouthguards

- Research should be conducted to determine the incidence of dental injuries in netball and the protective effort of mouthguards.
- The use of mouthguards in netball should be strongly promoted until further evidence of effectiveness is available.

Personal hygiene

- Players should maintain an appropriate level of nutrition (if possible).
- Players should use individual drink bottles.
- Players should not share personal items.
- Blood rules should be implemented to minimise the risk of blood borne infections.

Treatment and rehabilitation

- Organisers should ensure that there are qualified first aid personnel at all events.
- Netball players should seek prompt attention to their netball injuries from a person with appropriate medical qualifications for the level of injury.
- Injured netball players should undertake adequate rehabilitation before returning to their pre-injury level of activity.

- Pre-screening testing should be undertaken prior to play and after an injury before recommencing play.
- Taping or bracing of joints should be considered by professionals in their management of injuries.
- Wobble board exercises and similar rehabilitation exercises should be considered in the rehabilitation of injured ankles and as a preventative measure.
- Evaluation of rehabilitation programs for netball players is required.
- Controlled research into the effectiveness of prophylactic and rehabilitative ankle and knee bracing specifically for the repetitive, fast turning and landing actions of the netballer should be undertaken.

Substitutions/rules

- Rules should be strictly observed by players and enforced by umpires.
- Modified rules should be utilised for appropriate participants ie. juniors, masters, disabled

Blood

- Clubs/organisations and facility management should develop and enforce Hepatitis B vaccination regulations.
- Information on the risks and precautions relevant to bloodborne pathogens should be provided.
- First aid personnel should be aware of bloodborne pathogens and therefore take precautions when treating an injured player (ie. use of gloves).
- The blood rules should be strictly adhered to.

Risk management

- Clubs/organisations should be guided by established risk management plans.
- Performance indicators should be established and progress reviewed.
- Clubs/organisations should ensure they take out adequate insurance.

Standards

- Netball clubs/organisations and facility managers should seek information regarding standards and ensure their facilities meet the requirements.

Children

- Safety regulations and adequate training programs specifically for children need to be supported and widely implemented.
- Fun Net and Netta netball should be supported and widely implemented

- School netball programs should include more information about injury prevention.

Masters

- Masters participants should be educated about appropriate age related training and competitive practices from available literature.
- Older players should be aware of their body's capabilities
- Older players should undertake appropriate training prior to competing in social and other competitions

Women

- More research into the role of menstrual disturbances and the risk of overuse injuries needs to be undertaken. In particular, the exact relationship between menstrual health, bone health and stress fractures is yet to be elucidated.
- The impact of dietary behaviours and habits on the incidence of injuries, particularly in women, needs to be determined.

Pregnancy

- Pregnant women should be provided with educational material regarding physical wellbeing, pregnancy and sport.
- Further research findings on the effects of sports participation and training on pregnancy should be monitored and relevant findings incorporated into risk management plans.

Netball injury prevention program

- A program based on the New Zealand model should be developed, implemented and evaluated in Australia.
- Further investigate how to encourage players to adopt injury prevention strategies

Variations of traditional netball

- Research should be conducted into the incidence and cause of injuries in mixed games and netball played in indoor cricket centers in comparison to traditional forms of netball.

Other

- Improved standardised data collection for netball injuries and their associated factors needs to be developed and maintained for both formal and recreational play.
- Data collections should conform to national guidelines for sports injury surveillance.
- Ideally, data should be maintained on all players at least at senior levels, including participation details in competition and training and a record kept of all injuries.
- Information about preventing netball injuries should be disseminated widely through points of sale (eg. shoes), netball magazines and more general magazines.

- Guidelines for minimum safety requirements for netball events (including the need for mobile phones, telephone contacts, first aid kits, etc) should be further developed and more widely disseminated.
- Guidelines for netball specific risk management plans should be made available to netball clubs and associations at all levels and to schools and facility managers.
- Data about netball policy compliance should be collected and evaluated.
- Data collected on children's injuries should include the type of program they are participant in at the time of injury ie. FunNet, Netta, Competitive.
- A cost of sports injury study is required to determine overall and relative costs of sports injuries in order to attract commensurate levels of research and prevention funds.

1. INTRODUCTION

In Australia, numerous people participate in sport and recreational activities for a variety of social and physical reasons. One such sport is netball. Netball developed from basketball, initially with no standard rules and both nine and five-a-side versions emerged (IFNA, 1997). The game was brought to Australia by English school teachers, with records of interschool games being played as early as 1913 (Otago, 1991). Standardised rules did not develop until 1957 after which the International Federation of Women's Basketball and Netball was established in 1960 (IFNA, 1997). Netball has progressed a long way in a short time, with recognition as an Olympic sport in 1995, to be played for the first time at the 1998 Commonwealth Games.

Today netball is the most popular team based sport in Australia, played predominantly by females of all ages and skill level although male and mixed competitions are becoming increasingly popular. Netball has been described as a game reliant on rapid acceleration to "break free" from an opponent, sudden and rapid changes in direction in combination with leaps to receive a pass, intercept a ball or rebound after attempting to goal (Steele and Milburn, 1987b).

Taking these characteristics into consideration, injuries can result in a number of ways. Despite the large participation numbers and the controversy surrounding netball which is often defined as "a game prone to ankle and knee injuries" (Steele, 1990), there is a notable lack of formal, controlled evaluations of the effectiveness of injury prevention countermeasures. Studies to date have tended to focus on the incidence and nature of injuries occurring in netball in an attempt to identify causative mechanisms (Steele, 1990).

Injury prevention is of prime importance because, as well as affecting players' sporting capabilities it can also affect their work, resulting in forced absenteeism and consequent socioeconomic problems in the home (The National Coaching Director and Coaching Development Committee, 1990). Thus, the benefits of participating in sport need to be weighed up against the risk of incurring a moderate to severe injury (Finch et al., 1995; Nicholl et al., 1991). Nevertheless, sport as a behavioural pastime is more likely to be beneficial than the absence of physical activity (Togt, 1988; Finch, 1995). Consequently we have to find ways to manage the risk of becoming injured which is inherent to physical activity (Backx, 1991).

2. AIMS

The aim of this report is to move towards prevention of injuries in netball, through a critical review of both the formal literature and informal sources that describe injury prevention measures, or countermeasures, for netball. In doing so, the report provides an evaluation of the extent to which these countermeasures have been demonstrated to be effective. The full range of countermeasures widely promoted to prevent netball injuries is discussed.

Unlike other literature describing netball injuries, this report does not focus only on the epidemiology of netball injuries and neither does it provide a detailed description of their aetiology. Rather, this report presents a detailed examination of the range of countermeasures promoted to prevent netball injuries. Nevertheless, a brief overview of the epidemiology of netball injuries, particularly from an Australian perspective, is given to set the scene for the subsequent discussion of countermeasures.

3. METHODOLOGY

The sources of information used to compile this report were:

- Medline CD-ROM search for published medical literature (1985-1997)
- Sport discus CD-ROM search for published sports literature (1985-1997)
- injury conference proceedings scans
- discussions with key Australian researchers and sporting organisations
- correspondence with relevant state and national sporting organisations
- correspondence with relevant researchers
- scanning of other Internet and world wide web sites.

The literature gathered for this review was critically assessed to determine the extent to which the various countermeasures had been fully evaluated and demonstrated to be effective in preventing injuries. A scale of the strength of the evidence presented in the identified literature was developed (Watt & Finch, 1996) and is shown in Figure 1.

Figure 1 Grading scale for assessing the extent to which countermeasures have been fully evaluated

STRENGTH OF THE SCIENTIFIC EVIDENCE	TYPE OF SCIENTIFIC EVIDENCE
least	anecdotal or informed/expert opinion
↑	
	laboratory-based/equipment testing
	data-based evidence (uncontrolled)
↓	
most	controlled evaluations

This scale reflects an epidemiological and rigorous scientific approach to injury prevention that considers demonstration by controlled studies of the effectiveness of a countermeasure's performance in the field to be the highest level of 'proof'. This is particularly important for netball injury countermeasures where any change to the nature of netball is an important factor to be considered. In general, changes to factors such as how netball is played or undertaken, the behaviour of the participants and the level of enjoyment can only be measured during "in-the-field" evaluations.

At the lowest level of proof (ie. the "least" evidence end of the scale) are anecdotal reports of injuries and their prevention and comments based on informed or expert opinion. This category would include, for example, statements like "I treated five cases of Achilles tendinitis during last year and all would have been prevented if they had adequately warmed-up" or "none of the children I treated

last year were wearing shock absorbing footwear”. Some expert/informed opinion may carry more weight than other opinion particularly when it is based on a critical review of available information.

Laboratory-based evidence is a very important source of information about netball injury countermeasures. This category includes reports that have explored equipment design and testing, development of standard testing procedures and biomechanical research, including that performed on animals, cadavers and simulated body tissue such as crash-test dummies. Such information provides detail about the extent to which countermeasures such as protective equipment and properly designed netball shoes perform under certain stress and/or impact conditions. This research is generally performed under laboratory conditions which are often controlled. However, such conditions may not be a good representation of actual field or playing conditions.

Data-based evidence can take a number of forms. Routine injury surveillance activities document the incidence of new injury cases over periods of time. Patterns in data can be examined over time to draw conclusions about the impact that countermeasures may have on injury rates. Cross-sectional epidemiological studies provide some information about injury prevalence at a given point of time but are unable to assess the influence of countermeasures on injury rates. Quasi-experimental studies enable a comparison of pre-intervention with post-intervention data and sometimes includes controls or comparison groups to examine the effects of countermeasures.

Controlled evaluations provide the most definitive evidence for the impact of countermeasures. Case-control studies and longitudinal (cohort) studies are common forms of controlled studies. Neither study type involves random assignment of people (or injuries) to test and control groups, though they are examples of natural experiments. A randomised controlled trial is considered to provide the best evidence. In such studies, the units of interest (ie netballer, surface, type of shoe, etc) are randomly assigned to test and control groups.

Another important aspect of countermeasure implementation is the extent to which they are accepted or adopted by the users for whom they were intended. Countermeasures should be acceptable to those they were designed to protect. Community consultation and awareness programs must therefore be considered in any implementation process. It is also important to assess barriers towards use of injury countermeasures. An examination of attitudes, knowledge and behaviours is crucial to this. Studies of these factors are generally conducted after implementation of a countermeasure and can highlight the need for behavioural or educational change at either the individual or organisational level. Because of the importance of this sort of research, the literature describing these studies is also included in this review.

Another measure of the success of countermeasures is a demonstration of their cost/benefit ratios. This information is often needed by regulatory bodies and those involved in policy or rule making, to inform their decisions about countermeasures. Unfortunately, there have been no studies of the economic benefits of netball injury countermeasures to date.

In the following sections the relevant literature for the effectiveness of each countermeasure is critically reviewed. Based on the studies reviewed, available injury data and discussion with the experts acknowledged in this report, recommendations are made for future countermeasure research, development and implementation.

4. AN OVERVIEW OF THE PARTICIPATION RATES AND EPIDEMIOLOGY OF NETBALL INJURIES

4.1 PARTICIPATION RATES

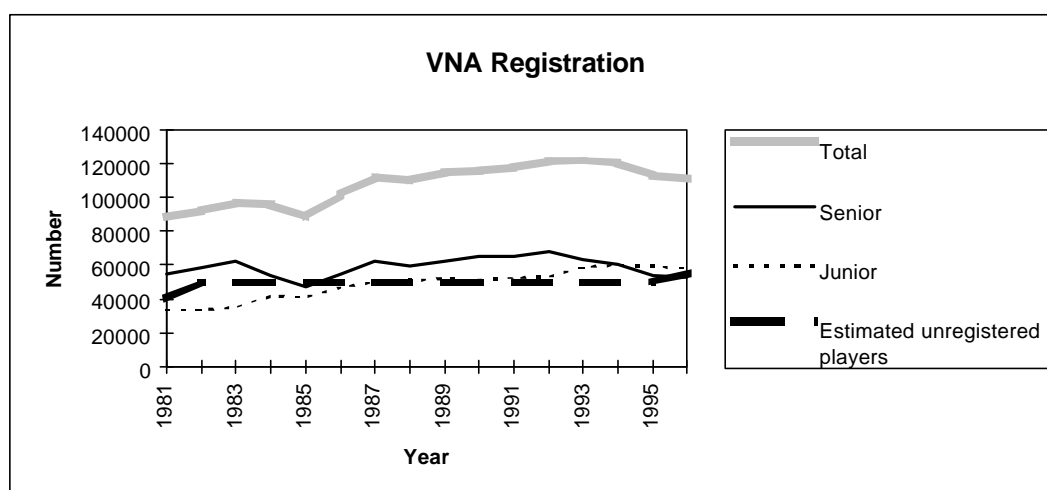
It has been estimated from a randomised household survey of 1509 people in six capital cities that 10% of Australians over the age of 16 participated in netball between 1992 and 1996 (Brian Sweeny and Associates, 1997). It was further stipulated that around 560,000 Australians between the ages of 16 and 65 years (8% of population) participated in netball in 1996. These surveys have also concluded that 87.5% of netball players were female and 12.5% were male. A limitation of these population estimates is that they were based on small sample sizes. Although under 15 year olds are likely to make up a large proportion of all those participating in netball, this data sources did not collect information about this population.

In a 1997 Australian Bureau of Statistics (ABS) report, netball was rated the fourth most popular sports activity in Australia after aerobics, golf and tennis for persons aged 15 years and over, with 2.4% or 328600 participants. Netball was the third most common sporting activity for children aged 5-14 years, in both school and club organised activities. This followed swimming and basketball. It was estimated that 10.2% of children participated in netball. The majority of these children (285,882 or 87%) were female, ranking it the second most popular sporting activity for females following aerobics. These population estimates were again based on small sample sizes and therefore limited.

Similarly, in Victoria, netball was the fourth most popular sport with 2.5% of the population participating (ABS, 1997). The average cost (membership, transport, equipment and clothing etc.) per participant per season was \$241, rating it one of the cheapest participation sports in Victoria.

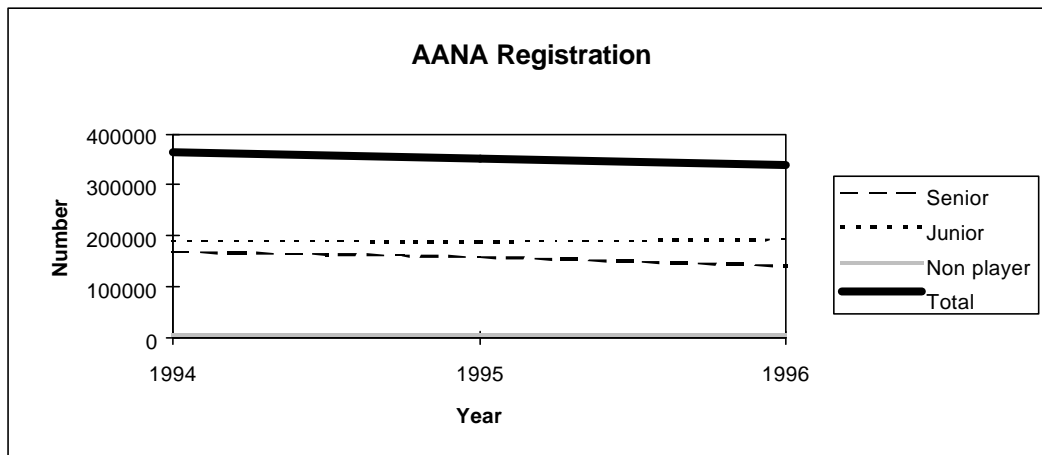
Netball Victoria reported that in 1997 there were 112,000 registered members allocated to 22 regions throughout Victoria and 275 affiliated Associations and Associates. Figure 2 shows the increasing popularity of netball in Victoria since 1981. In 1996 there were 110,769 registered players (52,872 seniors, 57,897 juniors). It was further estimated that there were 55,000 unregistered players (Netball Victoria, 1997).

Figure 2 Netball Victoria registration 1981-1996



National registrations from 1994-1996 are shown in Figure 3. The number of senior registered players nationally is well below that established by the ABS report (141,031 versus 328,600) indicating the possibility of a large unregistered or other registered base. As for Victoria no growth in number of participants was evident in this period.

Figure 3 All Australian Netball Association registration



Unfortunately, an increased level of participation in sport and recreational activities such as netball since the early 1980's has also increased the exposure to the hazards and risk factors associated with sports injuries (Finch et al., 1995).

4.2 GENERAL EPIDEMIOLOGICAL NETBALL INJURY DATA

Despite the highly publicised and controversial recognition of injury resulting from netball, only limited well conducted studies have documented the incidence and nature of netball injuries. Netball is essentially a British Commonwealth nation sport and given the limited number of countries involved, little international data exists focusing on the epidemiology of injury. Therefore, this overview will focus predominantly on the limited available Australian and New Zealand epidemiological data.

4.2.1 Published emergency department presentation data

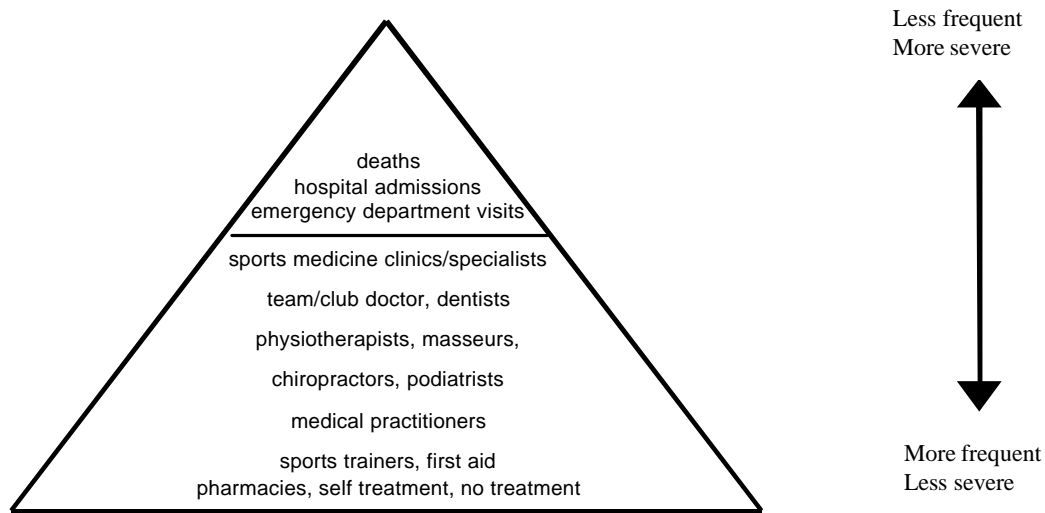
Finch et al. (1995) reported that netball injuries amongst adults (>15 years) who presented to emergency departments in Australia accounted for 6.6% of all sporting injury cases. This ranked netball injuries as the seventh greatest source of sports-related emergency department presentations. This followed Australian Rules Football, Bicycling, Soccer, Rugby, Cricket and Basketball. At the time of injury, 99.2% of injured cases were involved in netball as a formal sporting activity (organised competition or practice: 94.8%; informal netball: 1.2%; unspecified: 3.2%). The remaining 0.8% of netball injuries presenting to emergency departments occurred during recreational netball activities. This study also provided information about the body regions injured whilst participating in netball. The lower extremity was the most commonly injured body region (63.9%), followed by the upper extremities (27.5%) and head injuries (4.9%). The injuries recorded were predominantly sprains/strains (45.7%), fractures (18.3%) and bruising (11.1%).

Amongst children, netball injuries contributed to 3.7% of all sports-related injuries, ranking it the eighth most common cause of sports-related injuries leading to child emergency department presentation (Finch et al., 1995). Amongst this group formal sporting activities contributed 97.7% of all netball injuries (organised competition or practice: 85.5%; informal sport: 5.0%; unspecified: 7.2%). Recreational netball accounted for 2.3% of all injuries. Upper extremity injuries were the most common injury (54.4%), followed by lower extremity injuries (37.3%). If ranking's were given separately by gender, netball would be expected to rank high for females due to the gender specificity of the sport.

The range of possible settings for sports injury treatment, limits this study's representativeness of sports injury data collections as it is based on just one source of data from a particular place of

treatment (Finch et al., 1995). As is shown in Figure 4, emergency department presentations represent injuries at the less frequent, more severe end of the scale. It is likely that most netball injuries, particularly overuse ones, would be treated from sources towards the “more frequent, less severe” end of the pyramid. Unfortunately, there is less data available for these sources of treatment.

Figure 4 A sports injury pyramid



Source: Finch et al., 1995 (modified)

Similar findings, with the same limitations, were reported by Routley and Valuri (1993). In Victoria, it was found that netball contributed to 9% of all sporting injuries presenting to hospital emergency departments and 6% of all sports-related admissions following emergency department presentations. Females were the predominant group injured representing 85% of cases, as were those aged 20-24 years (33%). The causes of injury were strain/overexertion (43%) and a hit against something (35%). The most frequently injured body region was the ankle (41%). This proportion of ankle injuries is higher than that for any other sport according to the Victorian Injury Surveillance System (VISS) data (Routley and Valuri, 1993). Injuries to the knees accounted for a further 14%, the hand 13%, and the elbow, wrist, forearm resulted in 11%.

The Victorian Injury Surveillance System (1991) also reported that netball was responsible for 7% of sporting injuries sustained by children (Routley, 1991). Of these, 90% of cases were female. The upper extremities were the most frequently injured site followed by the feet and ankles. Most injuries resulted from a fall (35%) or being hit by the ball to the fingers and hand. Children are believed to have a higher incidence of upper extremity injuries due to a lack of skills, whereby the child falls landing on outstretched hands or has difficulty in catching passes.

4.2.2 General sports population studies

While the above studies provide a good overview of the more severe acute injuries, they do not take into consideration the number of injuries in relation to the number of participants. Cunningham and Cunningham (1996) took this factor into consideration when investigating the incidence of injury at the 1994 Australian University Games. Netball was reported to have a 30.1% incidence of injury in relation to the total number of participants registered in netball competitions throughout the games. Netball ranked as the fourth highest cause of sport related injury, following Tae kwondo, hockey and softball. Sprains contributed towards 28% of these injuries, followed closely by bruising (26%) and muscle-tendon injuries (21%).

4.2.3 Netball specific population injury rates

In a netball specific population, Hopper (1986) investigated 3108 Western Australian players of various age and competition levels over a fourteen week winter season in 1983 for the incidence and related conditions of netball injuries. A total of 158 injuries were recorded, indicating that 5.2% of the total population sustained an injury. Both senior and junior A-grade teams demonstrated the highest incidence of injury. Injuries predominantly occurred to the ankles (58.2%), followed by the knees (15.2%), the hands (13.3%) and other regions (13.3%).

This investigation was repeated for the years 1985-1989, with approximately 11,228 participants studied using the same methodology (Hopper et al., 1995b). The overall incidence rate during competition was 5.4%. Again injuries were most frequent in A-grade levels of play. Ankle injuries (84.0%) were by far the most frequent, with knee injuries contributing to only 8.3% of injuries, the hand (2.8%) and other areas (4.6%). The direct probability of a netball player's risk of injury was 0.054 per person per match, which implied that netball was a relatively safe game (Hopper et al., 1995b).

However, as training time was not included in this analysis, it raises the issue of whether higher injury rates among A-grade players is related to higher training time and therefore a higher incidence of overuse injuries. Furthermore, if elite players' risk of injury had been calculated per hour played (training and competition), perhaps the elite players would not have been injured more frequently than other players (Macera, 1996).

In a veteran population, only 45 (4.3%) players of 1053 competing in the 1987 Elastoplast-Nivea Classic suffered an injury severe enough to seek medical treatment (Steele, 1990a). Of these 27.3% were ligamentous, 25.0% were muscular and 15.9% were abrasions, bruises and contusions. Most injuries occurred to the ankles (29.6%) and fingers/hands/wrist (22.8%).

The incidence of injury presented in the above studies ranging from 1.73% - 5.4%, is somewhat lower than Egger's (1991) estimate of a 10% risk of injury if playing for one season. Egger derived this estimate as a median figure from three studies reviewed.

4.2.4 Combined netball and basketball studies

A prospective and reliable method of injury surveillance was implemented to document a comprehensive injury profile in female basketball and netball players in Victoria (McKay et al., 1996). Looking specifically at the netball component of this study, 9,190 players participated. The injury rate was observed to be 17.30 per 1,000 participants during competition. In netball, the injuries were largely to three body parts: the ankle (30.2%), hand (20.9%) and knees (17.8%). The most frequent causes of injury are hits by the ball (18.2%), incorrect landing (15.1%) and collisions with another player (13.9%).

Purdam (1987) surveyed netball and basketball players in relation to training programmes and preventative measures undertaken at the Australian Institute of Sport. One hundred and five injuries occurred in the 20 netball participants over a nine month period. The average number of injuries per player per year was found to be 5.25. This study, however, included minor injuries such as aches after exercise.

4.2.5 Various netball injury database sources, including insurance claims

In an attempt to look at various data sources, an injury surveillance study was conducted in New Zealand by Hume (1993) of netball injuries presenting to a hospital emergency department and a sports medicine clinic along with monitoring insurance claims. It was reported that netball injuries contributed to 3.1% of all sports injuries requiring hospitalisation, 7.7% of all sports emergency

department presentations, 5.3% of all sports claims and between 21.7% and 26.5% of presentations to a sports injury clinic.

Detailed data from the Netball Victoria insurance scheme indicating the claims in 1995 and 1996 is presented in Table 1.

Table 1 1995 and 1996 Netball Victoria insurance claims

Netball Victoria	No. of claims finalised	No. of ongoing claims	No. of outstanding claims*
1995	662	43	1290
1996	568	94	1632

Source: Spyrou Pty Ltd (undated)

* not yet processed

Of the 1996 claims, 43% were ankle related, 41% knee, 6% back, 5% finger, 2% shoulder, 2% wrist and 1% archilles (Spyrou, undated). However, despite the higher incidence of ankle claims, only \$18,789.92 was paid out in comparison to \$72,394.05 on knee claims. This supports Eggers (1991) suggestion, that knee injuries were the most costly sports injury.

In New Zealand there were 1,397 new netball claims, costing \$1,864,000, in a 12 month period from July 1995 to June 1996. This ranks netball, in New Zealand as the second highest source of new claims following rugby and the third highest cost following rugby and snow skiing (ACC, 1996).

4.3 VISS EMERGENCY DEPARTMENT PRESENTATIONS

The Victorian Injury Surveillance System (VISS) collects detailed information from emergency department presentations to Victorian public hospitals. The collection began in 1988 with data collected from 7 campuses of 5 Victorian public hospitals. Since October 1995 this collection has been extended progressively to 25 hospitals, 23 of which have contributed data to this study.

Over these data collection periods, VISS has recorded a total of 24,800 sporting injuries, of which 9% (n=1700) relate to netball.

More than two thirds of netball injuries to both children and adults occurred during formal competition compared to less than one-third during play of an informal or unspecified nature (Table 2).

Table 2 Netball injury emergency department presentations by age and nature of play

Netball type	Adult		Children		Total	
	n	%	n	%	n	%
Formal outdoor	892	83	446	70	1338	79
Informal/not specified outdoor	178	17	184	30	362	21
Total	1070	100	630	100	1700	100

An overview of the major outcomes associated with all types of child and adult netball injuries are shown in Table 3.

Table 3 Netball Injury Presentations

	< 15 years		> 15 years	
	Informal	Formal	Formal	Informal
	%	%	%	%
Body region				
- upper limb	58	55	27	29
- lower limb	33	35	62	57
- head and face	9	5	7	10
Nature of injury				
- fracture	23	20	13	16
- superficial	28	27	17	16
- strain/sprain	4	42	56	48
Admission to hospital	4	3	4	2

Source: Victorian Injury Surveillance System, Emergency Department Presentations 1988 to 1996

4.3.1 Formal Netball

Eighty three percent of adult and 17% of child netball injuries occurred during formal competition (Table 2). The circumstances surrounding these cases is considered below.

4.3.1.1 Children

Of the 446 cases of child injuries resulting from formal netball, most players (89%) were aged 10 to 14 years and 96% were female.

Over one-third of cases occurred at netball courts or sporting areas (68%). A further quarter of injuries occurred in areas of education (24%), during regular school hours. The remaining cases occurred at parks and recreational areas (4%).

Forty three percent of injuries were caused when a player fell (including 6% who fell over another player). Other common causes of formal netball injuries to children included being hit by a netball (18% of total cases), 14% collisions and 6% due to over exertion.

Three percent of the children's formal netball injuries were so severe that they required hospital admission. A further 48% of players required significant further treatment, ie. review or referral, particularly to a general practitioner (20% of total cases), a review in the emergency department (17%) or referral to an outpatients department (8%). The remaining 49% of players required minor, or no treatment.

There were a total of 462 separate injuries sustained by the 446 injured players. Twenty-four percent of total injuries were to the hand, including the fingers. This included strained hands (10% of total) and superficial hand injuries (8%). A further 23% of injuries were to the ankles, particularly fractures (18% of total ankle injuries) and a further 10% were wrist injuries.

4.3.1.2 Adults

Eighty-nine percent of the 892 adult players injured while playing formal netball were female. Nearly one third of players were aged 15-19 years (31%) and 20-24 years (31%). A further 17% were aged 25-29 years and 11% were aged 30-34 years of age.

Twenty-three percent of injuries occurred when a player fell. Other common causes of formal netball injuries to adults included collisions with another player (15%), over exertion or over-use injuries (14%), collisions with the ball (10%) and awkward landing (6%).

The admission rate following an emergency department presentation for formal adult netball injuries was 4%. A further 61% of players required significant treatments. That is, review or referral, particularly to a general practitioner (27% of total cases), a review in the emergency department (20%) or referral to an outpatients' department (13%). The remaining 35% of players required minor or no treatment.

VISS recorded a total of 932 separate injuries sustained by the 892 injured formal adult players. Injuries were most common to the ankle (41% of the total injuries sustained), particularly strained ankles (32% of total) and superficial ankle injuries (4%). Hand injuries accounted for a further 15% of total injuries sustained.

4.3.2 Informal netball

In addition to the formal netball injuries listed above, there were a further 184 child and 178 adult injuries which related to informal netball activities. These cases represent one third of all child netball injuries recorded by VISS and 17% of adult netball injuries.

4.3.2.1 Children

Seventy-five percent of the injured children were aged 10-14 years and 91% of injured participants were female.

The most common location for children's informal netball injuries was the school (55%). Other common locations were areas for sport (12%), home (6%), parks/recreational areas (4%) and the road (2%). Twenty percent of cases did not specify the injury location.

The most common circumstances surrounding these injuries included falls (39% of total cases, including 6% who fell over another player); hit by the ball (26%); collisions with another player (9%) and over-exertion (9%).

Four percent of these informal netball injuries to children were severe enough to require hospital admission. Almost half of the injured children required significant treatment, including referral to an outpatient department (15% of total), to a general practitioner (16%) and a review in the emergency department (13%). A further 34% of injured players received only minor treatment and 16% no treatment, following assessment.

VISS recorded 196 separate injuries for these 184 cases. The hand and wrist (43% of total) and the ankle (16%) were the most common body regions injured. Strained or sprained ankles (14%), strain/sprain hands (11%), superficial finger injuries (11%) and finger fractures (9%) were the most common injuries sustained.

4.3.2.2 Adults

Eighty-eight percent of the 178 adult informal netball injury cases were to females. Half of the adult informal injured players were aged less than 25 years.

Thirty-seven percent of injured players did not specify the location where the injury occurred. Of the cases for which a location was specified 33% were at areas for sport, 17% parks and recreational areas, 9% at schools and 3% at residential locations.

One quarter of injuries occurred when the player fell. Another 16% of players sustained overexertion or overuse injuries, 11% collided with another person and 8% were injured by the ball.

The admission rate for adults sustaining informal netball injuries was 2%. Most players (72%) required significant treatment, 14% were referred to an outpatient department, 49% to a general practitioner and 14% required a review in the emergency department. Another 21% required only minor treatment.

Of the 182 separate injuries sustained, 56% were to the lower limbs, particularly ankle sprains/strains (29% of total injuries sustained).

4.4 CONCLUSIONS

Injury data from a collection of cases from Victorian hospital emergency departments is reasonably consistent with that described in the literature.

Table 4 Epidemiology of netball injuries

	CHILD		ADULT	
	VISS data	Literature range	VISS data	Literature range
Body region				
upper limb	58	43-59	27	3-28
lower limb	33	32-70	62	32-93
head & face	9	2-6	7	2-5
Nature of injury				
fracture	23	9-18	13	2-15
superficial	28	2-35	17	10-26
sprain/strain	4	43-70	56	49-63

Assessing the level of agreement between studies is difficult, given the varying presentation of the data and differences in the study populations. Summary details of site of injury, type of injury and cause of injury are presented in Appendix 1.

However, irrespective of age and level of player. It can be concluded that:

- females predominate for all injury types
- ankle injuries are the most common followed by hand/finger and knee injuries for adults, while upper extremity injuries are more common in children

- the most common types of injuries are predominantly sprains and strains for adults
- between 2 and 4% of emergency department presentations require hospital admission

Egger (1991) stated that 25% of all direct injury costs were related to knee injuries, and that ankle injuries (6%) accounted for substantially less. Similar findings were also reported in Hopper's (1986) earlier study.

A comprehensive cost of sports injury study is required, based on high quality epidemiological data, to identify relative costs of sports injuries by sport and body region and nature of injury. This information would assist in targeting scarce research and prevention resources.

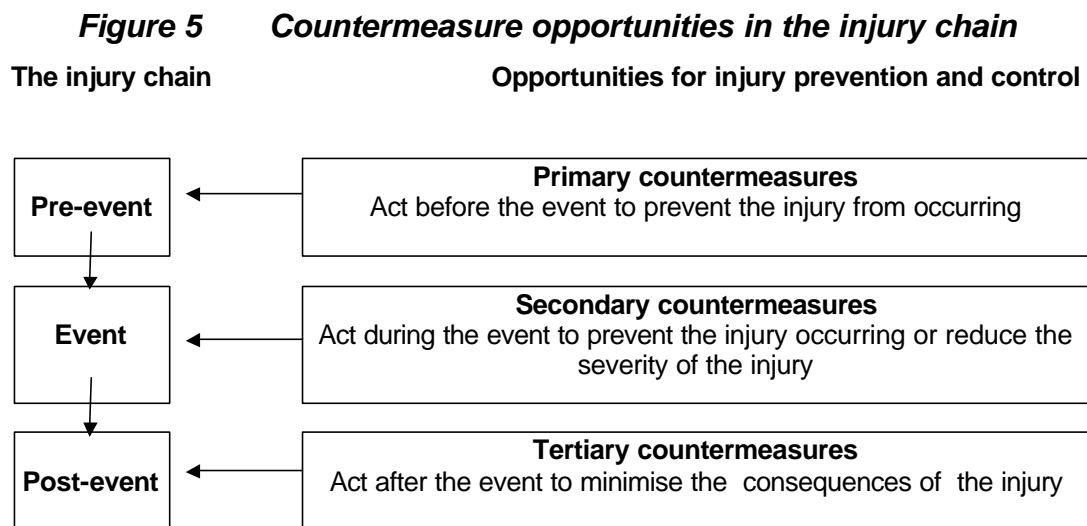
Variations in the incidence levels in many studies has been attributed by Hume (1993) to the variations in the physical preparation and skill levels of players, and to weather conditions. Other considerations are the level of severity of injury, the amount of training and whether injury data includes both training and competition. Injury is obviously not the desired outcome for a netballer and may affect more than their playing ability. Consequently injury prevention countermeasures must be reviewed.

5. AN OVERVIEW OF INJURY COUNTERMEASURES FOR NETBALL

Injuries are considered to result from the culmination of a set of circumstances and pre-existing conditions that may best be understood as a chain of events: pre-event, event and post-event (Robertson, 1983). Injury countermeasures are measures that can “counter”, that is, prevent or reduce, the risk of injury. A number of researchers have described how countermeasures should be targeted at the different links in the chain of events leading to injury (Haddon, 1972; Ozanne-Smith & Vulcan, 1990; Watt & Finch, 1996).

5.1 PRIMARY, SECONDARY AND TERTIARY PREVENTION

Such injury countermeasures can be equated with primary (pre-event), secondary (event) and tertiary (post-event) prevention in the chain of events associated with injury (Figure 5). Primary countermeasures act before an event or incident that could potentially lead to injury to prevent the event from occurring in the first place. Secondary countermeasures act during the event or incident to prevent the injury occurring or to reduce the severity of the injury. The third level of countermeasures act after the chain of events/incidents leading to injury and help to minimise the consequences of injury.



Source: Watt & Finch (1996)

There are a multitude of factors that may contribute to the risk of injury in netball players. Generally, more than one factor is involved in each injury. Consequently, there are numerous countermeasures aimed at the primary, secondary or tertiary levels of prevention which can be used to help prevent these injuries. These are summarised in Table 5.

Table 5 Netball injury countermeasures

Primary	Secondary	Tertiary
training	environment	rehabilitation
pre-season conditioning	surface	availability of first aid equipment
warm-up	footwear	rest, ice, compression, elevation, referral
technique	orthotics	strapping/bracing
footwear	appropriate level of program/competition	orthotics
orthotics		return to play only when fit
surface		transfer
nutrition		evaluation and referral
environment		
strapping/bracing		
adequate water intake		
pre existing medical condition		
rules of the game		

5.2 INTRINSIC AND EXTRINSIC FACTORS

Sports injury risk factors can also be described as intrinsic and extrinsic (Kannus, 1993). Intrinsic or internal factors are related to the physical and mental health of the athlete. Extrinsic or external factors are those which impinge externally on the athletes' performance (eg. injured when fell over due to a uneven surface). Different countermeasures are used to address the intrinsic and extrinsic risk factors. Table 6 describes which of the netball countermeasures given in Table 5 address the intrinsic and extrinsic factors respectively. Typically, the intrinsic factors are addressed by primary prevention activities, while extrinsic factors involve prevention at the primary, secondary and tertiary levels.

Table 6 Intrinsic and extrinsic factors associated with netball injuries

Intrinsic factors	Extrinsic factors
pre-season conditioning	training
technique	warm-up
nutrition	footwear
strapping/bracing	surface
orthotics	environment
rehabilitation	strapping/bracing
return to play when fit	orthotics
pre-existing medical conditions	rehabilitation
	adequate water intake
	first aid
	rules of the game
	rest, ice, compression, elevation, referral

The literature assessing the effectiveness of the various countermeasures listed in Tables 5 and 6, for the prevention of netball injuries, is reviewed in the following sections. For each countermeasure, the rationale for its use as a safety measure is presented followed by a critical review of the extent to which it has been evaluated.

6. DETAILED REVIEW OF NETBALL INJURY COUNTERMEASURES

6.1 LANDING AND ASSOCIATED FACTORS IN RELATION TO NETBALL INJURIES

Epidemiological evidence presented in this report indicates that most netball related injuries particularly in adults occur to the lower extremities, predominantly to the ankles and knees and as a result of inadequate landing or falling. Given this association it is critical to look at factors which impinge on the landing technique. The technique a player uses to land after receiving a pass in netball is influenced by several factors including: the type of pass to be caught, the speed of the player's approach to the pass, positioning of opposition players, movements required following the landing action, the material properties of the court surface, and the footwear worn by the player (Steele and Lafortune, 1989).

6.1.1 Ground reaction forces (vertical and braking)

The process of catching a pass in netball generally involves running to meet the pass and suddenly stopping on either one or two feet. The speed at which these actions occur can affect the range of joint motion, muscle activity and ground reaction forces (Ting, 1991). Ground reaction forces consist of vertical and horizontal (braking) components. The magnitude of these forces, along with their repetitive nature, may contribute to the relatively high incidence of lower extremity injuries in netball players (Neal and Sydney-Smith, 1992).

Fifteen skilled centre court netball players (mean age = 18.6 years) were studied by Steele and Milburn (1987b) using a Kistler force platform to quantify ground reaction forces demonstrated at landing on one foot after performing a typical attacking movement under four different footwear conditions. For the four conditions the mean vertical ground reaction force (VGRF) ranged from 3.9 to 4.3 times bodyweight (BW). Horizontal ground reaction force, often referred to as braking force (BF) were reported to range from 4.2 to 4.6 BW. The timing of the mean peak VGRF ranged from 18-32 msec after initial foot-ground contact.

Steele and Milburn (1988b) repeated this study with 10 skilled netball players as subjects. The players were again required to perform a typical attacking netball movement landing on one foot on a Kistler Force platform. To simulate playing conditions each player was defended by a matched player and wore standardised shoes. Under standard netball conditions the average peak VGRF was 3.83 BW and the BF averaged 4.02 BW, thus supporting the earlier findings of Steele (1987a).

The effect of different synthetic sport surfaces on ground reaction forces of 10 skilled netball players at landing in netball produced a mean peak VGRF of 3.71-3.91 BW. Braking forces ranged from 2.98 to 3.8BW. Their braking forces were slightly lower than other reports possibly due to the surfaces being tested and different approach speeds.

These impact forces are higher than those reported for running (jogging), which ranged from 2-3BW vertically and 0.4 to 0.8BW horizontally (braking) (Knutzen and Hart, 1996). Impact forces must be distributed by the body, and it is speculated that these forces contribute to the occurrence of netball injuries. Steele (1986) claimed that excessive braking forces, such as those occurring in netball, subject ligaments to undue stress, especially at the knee joint, thereby increasing the potential for injury. Epidemiological evidence has indicated that 34%-93% of netball injuries are located from the knee downwards. The logical approach to prevent these injuries would, therefore, be to attenuate the impact forces. In order to minimise the potential for injury, frictional forces have to be low enough to ensure loads acting on the body are not beyond the physiological limits of the musculoskeletal system (Steele and Milburn, 1988b). However, they must be significant enough to enable players to stop and start movements (Steele, 1998)

Steele and Milburn (1987b) also recognised that although a player may be able to withstand these high stresses if their musculoskeletal system is properly aligned, any individual with a skeletal malalignment or unusual foot placement at landing may risk potential injury.

Appendix 2 outlines ground reaction forces reported in a number of studies under differing circumstances. Further investigation and comparison could be conducted on whether these studies identified one versus two step landings.

6.1.2 Extra step

The footwork rules in netball greatly influence a player's landing technique. The current netball footwork rules permit a player in possession of the ball to land on either one or both feet and take a maximum of one and a half steps in any direction. Technically the landed foot can not be re-grounded. A player in possession of the ball is also allowed to pivot about the landing foot, but, must not re-ground the 'grounded' landing foot. Consequently the player must brake quickly in order to maintain footwork rules and retain possession of the ball.

It has been claimed by a number of netball authorities along with Steele and Milburn (1987b), that the high braking forces required to stop abruptly from a rapid approach may subject ligaments of the lower limb, especially at the knee joint, to undue stress. It has often been postulated that, in order to reduce associated stresses and decrease the magnitude of braking forces at landing, players should be allowed an extra step in order to decelerate.

This proposal was tested by Steele and Milburn (1987b). Ten skilled netball players were analysed performing a typical attacking netball movement and forces generated at landing recorded. Results of the investigation showed that, when an additional step was taken (after a period of familiarisation) in comparison to normal footwork rules, together with the effect of raising pass height on landing forces. No significant difference were reported between VGRF generated, time to peak, or initial peak VGRF when landing. Therefore the authors indicated that taking an additional step on landing did not influence cushioning of the VGRF experienced by landing on the limb. Although taking an additional step on landing reduced the braking forces, it did not significantly alter the time to peak braking forces. Thus the authors suggested that alterations to passing height may be more effective in attenuating GRF.

The hypothesis was further tested by Otago (1997) who conducted a case control experiment of 20 female netball players of State or State Under 21 levels. The subjects performed a legal pivot, extra step pivot, a legal run on and an illegal extra step run on. Two pass heights (above head, chest) and two directions (frontal, 45% angle behind) of pass were used. The motor pattern developed for the legal landings made the illegal landings difficult, thus, a skill familiarisation period was used to test the true mechanical differences for the extra step. Results showed that taking an extra step did not significantly alter the body or knee forces and that the extra step actually placed more stress on the second leg than did a normal landing. Run on landings were the least stressful to the body, two foot landings were slightly more stressful than the run on landings and the pivot landings (the most common technique in netball) produced the highest forces. Therefore, these studies indicate little benefit in changing the rules to allow an extra step, though it has been suggested that the study should be repeated using longer skill familiarisation periods to learn currently illegal techniques.

6.1.3 Passing height

It was further proposed that braking forces could be reduced by throwing higher passes, requiring the receiver to jump upward to catch the ball (Steele, 1986). This proposal was based on the notion that jumping upward on the move would enable conversion of some of a player's horizontal momentum

to vertical momentum, thus decreasing the horizontal distance the player travelled and, in turn, decreasing the braking forces (Lees, 1984).

The proposal was tested on 10 skilled netball players selected from the 1987 netball scholarship holders at the Australian Institute of Sport by Steele (1988). This study found that an increased passing height significantly decreased the braking forces and therefore decreased the horizontal load on the lower extremities. However, higher passes significantly increased the vertical forces at landing. Passing height also influenced the landing technique. Players tended to land on the forefoot more than the heel after receiving a high pass. Alterations to pass height also significantly influenced the orientation of the lower extremities. Steele (1988) concluded that changes to pass height without consideration for landing technique, may not help to reduce ground reaction forces generated at landing.

The effect of passing height on ground reaction forces in netball was also examined by Neal and Sydney-Smith (1992) within a group of six elite netball players aged 19-27 years, under three separate conditions: chest pass with heel landing, chest pass with forefoot landing and high pass with forefoot landing. The change in pass height did not affect the magnitude of either the peak VGRF, initial impact force or BF recorded in the forefoot landing trials. Neither did the change to passing height affect the times to peak VGRF, peak vertical impact force or peak BF. Neal and Sydney-Smith (1992) reported that these findings are contradictory to previous reports which show significant differences in one or more of these parameters (Steele, 1988; Steele and Milburn 1988a; Steele and Milburn, 1989).

6.1.4 Combined pass height and extra step

Steele and Milburn (1988b) showed that when an additional step was permitted and passing height increased, braking forces were significantly lower (mean 2.98BW and 3.04BW respectively) in comparison to the normal footwork rule and chest high passes (mean 4.02BW). The time to peak braking forces or the magnitude of VGRF, however, was not significantly different (Refer appendix 2). After receiving a high pass in comparison to a standard pass or taking an extra step, there was a significantly longer time to peak VGRF and thus a reduced rate of force loading. There was also a significantly lower initial peak VGRF after receiving a high pass compared to a standard pass when an extra step was allowed. Steele and Milburn (1988b) therefore concluded that a high pass could decrease initial peak VGRF and thus reduce the stress on the musculoskeletal system. However, taking an extra step did not produce the same benefits. Thus changes to current passing techniques could potentially decrease injury to a greater extent than alterations to footwork rules.

6.1.5 Speed

Vertical and horizontal ground reaction forces are modulated by approach speed, with faster speeds generating greater forces (Roy, 1992). However, as pointed out by Neal and Sydney-Smith (1992) previous studies in netball have not controlled for the effect of speed. Neal and Sydney-Smith (1992), stated that the decision not to control approach speed either statistically or experimentally may have introduced greater variability in previous studies and thus contributed to the equivocal findings.

In a sample of six elite netball players Neal and Sydney-Smith (1992) found that approach speed and high passes with forefoot landing condition correlated strongly with both peak VGRF and peak braking forces and was significantly slower than for the chest passes with forefoot landing and chest passes with heel landing conditions (Neal and Sydney-Smith, 1992). This implies that the reported modulating effect of a high pass on the ground reaction forces (as shown in this study and others previously reported) is related to lower approach speed and is not inherent to the high pass. When receiving a chest pass alteration of the footfall pattern from a heel to a forefoot landing may reduce

the vertical force loading on the leg without affecting a players speed (Neal and Sydney-Smith, 1992).

6.1.6 Netball surface

Most sports, as with netball, developed from participation in a natural outdoor environment, using natural turf as a surface. However, in order to eliminate external influences such as weather and to reduce maintenance time and costs, special man-made surfaces such as bitumen and rubber were introduced. Today netball is played on a variety of surfaces from natural turfs to concrete, bitumen, synthetic grass, timber and variations of synthetic rubber. Despite the development of an extensive range of synthetic surfaces available to sporting associations, there is a paucity of information relating to the suitability of playing characteristics of various surfaces for individual sports (Standards Association of Australia, 1986; Steele and Milburn, 1988c). However, these new surfaces had effects which were neither expected nor planned (Nigg and Yeadon, 1987). Concern that a surface may be a source of injuries began to develop as far back as the late 1960s with the use of synthetic surfaces for track and field (Nigg and Yeadon, 1987).

As the foot-surface impact forces associated with repetitive running and landing can be quite large, it is generally believed that playing netball on hard surfaces increases mechanical shock thereby overloading joints and tendons.

Information on the forces generated at landing was obtained for 10 skilled netball players after performing a typical netball movement (Steele and Milburn, 1987b). The purpose of this study was, in part, to examine the influence of changes to playing surface on the forces experienced at landing. Subjects were required to land on bitumen, concrete, 3 synthetic grass samples and 7 rubber samples. Three representative trials per condition were selected for analysis. Results indicated that peak braking forces were significantly higher and time to peak VGRF shortest when landing on bitumen and concrete. Time to maximum peak VGRF and initial peak VGRF were significantly longer when landing on synthetic grass, while time to peak braking forces were significantly shorter when landing on synthetic grass compared to other surfaces. This shortened time may increase the likelihood of injury due to an increased rate of loading of these forces. Traditional "all weather" courts of bitumen and concrete therefore appear to have the greatest potential for injury in comparison to other synthetic surfaces tested in the present study. The authors, concluded that the rubber surfaces tested were the most suitable playing surfaces and demonstrated the best potential for injury minimisation. However, whilst GRF may be reduced by construction of more pliable court surfaces, the financial outlay required for this modification of equipment restricts this option to a few selected venues (Neal and Sydney-Smith, 1992).

Steele (1990a) studied players aged over 30 years who presented to the injury clinic operating during the Elastoplast-Nivea Netball Classic held in New South Wales in 1987. A total of 45 players of approximately 1053 players at the tournament completed the injury survey. Less injuries were found to occur on the synthetic surfaces compared to bitumen or natural grass. However, when the expected frequencies of injuries were adjusted by the number of games played on each court type throughout the tournament, there was no significant difference in the injury rate (Steele, 1990a).

Hopper (1986) showed that there was a significant association between surface type and body part injured, although ankle injuries occurred most frequently despite surface type. Natural grass surfaces resulted in more hand injuries, bitumen led to more knee injuries and more 'other' injuries were reported on synthetic surfaces. However, when adjusted for exposure there was no significant association between how the injury occurred and the playing surface (Hopper, 1986).

In review Nigg and Yeadon (1987) concluded that:

- There is a distinct difference between material tests and subject tests. Results from material test often cannot be related to results in situations where actual movements are performed by subjects.
- Tests using subjects show that changes in playing surfaces frequently produce changes in movement patterns of athletes. A thorough understanding of the loading and/or performance aspect of a surface can, therefore, only be gained if material tests are complemented with tests using subjects.
- Point elastic surfaces, used particularly in track and field running, are widely studied. At the time of reporting, area elastic surfaces (eg. suspended wood floors) had received little attention, and questions of energy losses on sport surfaces had rarely been studied scientifically. Further research is needed to understand these issues.

Steele (1990) recommended that, due to the conflicts in the literature, the relationship between court surface type and the nature and frequency of injury be further investigated.

Further, the surface must provide sufficient friction to enable the player to perform the typical movements of netball without slipping or sliding (Steele, 1990). Since frictional properties of surface depend on the interaction of the material and structural pattern of the surface and the sole of the shoe worn by players, continued work is required on the stability of various surface types, interacting with netball shoes, with regard to the demands of the game (Steele and Milburn, 1988c)

6.1.7 Footwear

With increasing participation and recognition of the potential importance of footwear in both the prevention of injury and benefit to performance, more netball specific shoe designs have reached the marketplace. Nevertheless, many netballers wear running type shoes, which are designed primarily for movement in a straight line and do not provide significant cushioning for the forces of netball. Netball shoes must be designed taking into account the input conditions experienced by the players during a typical netball movement, the activities performed, the playing surface, and the stresses imposed on the body (Hopper, 1986; Steele and Milburn, 1987b). In addition to cosmetic appearance and comfort, factors such as shock attenuation, lateral stability and the optimal friction characteristics between playing surfaces and tread patterns, must be considered in design (Hopper, 1986).

The manufacture and marketing of a safer netball shoe is hindered by both company and player financial considerations as well as a lack of effective research in shoe design specific to the requirements of netball.

It seems evident that a training shoe providing cushioning, support and stability can play a role in shock absorption, and as a consequence injury prevention (Cook et al. 1990). However, there is also evidence that modern athletic shoes provide poor protection from some injuries and may cause chronic overloading (Robbins and Gouw, 1990).

In review, Robbins and Gouw (1991) reported that modern athletic footwear makes the durable barefoot vulnerable to injury. This is supported by: Robbins & Hanna (1987) who showed that running related injuries were uncommon in barefoot populations; also in support Robbins et al., (1988b) showed that modern athletic footwear produces sensory illusions, while Robbins et al., (1988a) demonstrated that diminished impact-moderating behaviour with the modern footwear compared with barefoot conditions. In review Robbins and Gouw (1991) concluded that modern running shoes are not superior, and are sometimes worse, than the unadapted barefoot in attenuating shock during running (Robbins & Gouw, 1991). These details are included, given the high use of running shoes and running itself, in netball.

The question still remains, therefore, as to the effect of netball shoes on the risk of injury.

Steele and Milburn (1987a) also investigated kinematic analysis of netball landing techniques on 21 centre court representative netball players (mean age 18.2 years). Subjects were required to carry out a typical netball movement pattern under four footwear types (netball shoe, running shoe, an ankle support plus netball shoe and barefoot). When landing barefoot, subjects altered the alignment of the landing limb compared to when wearing shoes. Greater flexion at the knee, greater angular velocity of the leg but less horizontal velocity of the lateral malleolus of the landing leg was also experienced when landing barefoot in comparison to landing with footwear. The authors concluded that while improvements in shoe design can decrease injury potential, a shoe offering maximum shock absorption properties, compared to a poorly designed shoe, does not necessarily ensure that less force is transmitted to the player's body (Steele & Milburn, 1987a). Rather the effectiveness of the shoe will be influenced by the way the shoe is used, or more specifically, the mechanics of landing technique. A player who lands with the lower limb completely rigid and appropriate footwear, is more likely to impart jarring to their body than a player who wears inappropriate footwear but flexes the leg at the knee (Steele & Milburn, 1987a).

6.1.8 Landing technique

Landing is a fundamental component of most netball skills and movements, such as rebounding after an attempt to goal, leaping to catch a pass, or to steady the body after a defensive deflection (Steele, 1990). Despite the fundamental nature of landing, coaching manuals contain limited guidance.

Changes to footwork rules and to the material properties of court surfaces and footwear could reduce stress placed on the musculoskeletal system. However, Steele suggests that the factor which influences musculoskeletal stress to the greatest extent is a player's landing technique (Steele, 1990).

6.1.8.1 Landing technique and footfall pattern

The footfall patterns at landing also influence the rate of landing of the GRF. A kinematic analysis of the netball landing techniques of 21 centre court representative netball players (mean age 18.2 years) was conducted by Steele and Milburn (1987a), although only 13 players were considered suitable for analysis. Players were excluded due to the exact position required by the two dimensional experimental procedures. To prevent such a loss of data, it was recommended that three-dimensional analysis procedures be used in future studies. In all trials most subjects used a leap approach to receive a pass (75.9%) in combination with a heel strike footfall pattern (83.6%) and a vertical positioning of the trunk at landing. Significant differences were reported between landing on the dominant and non-dominant limb. Their research indicated that to land efficiently, a player should: flex at the knee of the landing limb to absorb the impact forces over a greater time period and thus reduce the jarring effects at landing, thereby lowering the body's centre of gravity and enhancing stability. Empirical evidence also suggested that players maintain an upright position of the trunk at landing in order to enhance stability and ensure the centre of gravity of the body remains within the base of support.

Further support for these findings was documented by Steele and Milburn (1988c), who found that in a sample of 357 landing trials on different playing surfaces, initial foot-ground contact was made with the heel in 95.8% of cases. However, Steele and Milburn (1989) reported that after receiving a high pass, seven of ten subjects made initial contact with the forefoot. Forefoot landings significantly lowered initial peak VGRF and braking force, while producing a longer time to peak VGRF, therefore potentially decreasing the risk of injury.

In a follow-up study by Steele and Lafortune (1989), contradictory results were produced. That is, no significant differences were found in the magnitude or timing of the peak or initial peak VGRF or of

the peak resultant forces when landing on either the heel or forefoot. However, braking forces were again found to be significantly lower when landing with the forefoot, which could decrease the stress on the lower extremity musculoskeletal system.

Six elite netball players were measured for the GRF generation at landing after performing a typical netball move (Neal and Sydney-Smith, 1992). The peak VGRF was significantly lower with a forefoot landing than with a heel landing in the chest pass conditions and thus the rate of force loading was 30% less with a forefoot landing. When normalised for body weight, the peak braking force with forefoot landing trials in the high passes was significantly less than in the chest passes with forefoot landing condition. However when momentum was normalised no difference was found.

Further, no significant difference was reported between injured and uninjured players for different landing techniques (heel, forefoot) following various types of passes in a study of 228 participants of the 1988 Australian netball championships (Hopper and Elliott, 1993). Irrespective of injury region, players preferred to land on the ball of the foot for all different passes. Hopper and Elliott (1993) did indicate that more than 25% of players were unaware of the type of foot placements for various passes. They further suggested that this lack of kinaesthetic sense may be a contributing factor to lower limb injuries.

6.1.8.2 Landing technique and anthropometrics

The relationship between selected anthropometric characteristics, lower extremity strength, flexibility and alignment with landing technique in netball was conducted by Steele and Milburn (1988a) for 21 skilled netball players from NSW State League and district representative teams. No significant correlations were reported between anthropometric measures (height, weight), lower extremity characteristics (strength alignment, flexibility) and kinematic variables demonstrated during landing. The only results found to be statistically significant were peak VGRF with ankle flexibility and body weight with peak braking forces. However, both these results were obtained for trials where the subject landed on the non-dominant lower extremity. On the basis of these results it was recommended that players with limited mobility at the ankle undertake appropriate flexibility exercises to increase their range of motion and therefore potentially decrease VGRF at landing. Heavier players were recommended to pay attention to developing landing skills, particularly for the non-dominant side.

6.1.8.3 Landing technique and balance

Uncontrolled balance at landing is obviously a risk factor associated with lower limb netball injuries. Hume et al. (undated) investigated 62 Australian netball players representing a range of skill levels. Single-limb balance time was measured as the subjects balanced on hard and foam surfaces, for both lower limbs of each player, with their eyes open then closed, their head straight then tilted backwards. Floor balance tests between left and right lower limbs showed no significant differences nor did static limb stance with eyes open, as all players completed the maximal 30 seconds of balance. Tests conducted on foam with the head tilted back resulted in shorter balance times. The purpose of this study was to identify appropriate tools for coaches to use in detecting balance problems by comparing the balance ability using an electronic method of assessing balance, the Kinaesthetic Ability Trainer (KAT) (a portable static balance (SB) and dynamic balance (DB) tool) compared to traditional timed static balance tests. It was concluded that when assessing netball players both static balance and dynamic balance should be measured using tests sensitive enough to detect balance deficits. The KAT was recommended when a more sensitive SB method was required, and to assess DB, if not available. Static floor tests including a foam and a head tilted back condition can be conducted to detect the level of balance. Detecting imbalances prior to injury, allows a programme to be developed to improve balance and reduce the likelihood of injury.

6.1.8.4 Landing technique and knee alignment

Landing with incorrect knee alignment and single leg support was reported to stress the ligamentous structures of the knee and the surrounding musculature and therefore could predispose a player to lower extremity overuse injuries (Hume et al., 1996). Previous support for this statement was reported by Downey (1986) who stated that knee recurvatum or knee hyperextension was often observed with ankle equinus deformity (Hopper and Elliott, 1993).

Hume et al. (1996) investigated this theory by studying 62 netball players (mean age = 18.8 years) representing a range of skill levels. Players were assessed for ranges in Q-angle during several dynamic landing tasks. (The quadriceps femoris muscle group angle (Q-angle) is the angle between the line of pull of the quadriceps muscle group and the line of the patellar tendon and is used for assessment of correct biomechanical alignment of the lower limb). Under the analysis performed, previously injured subjects had significantly larger Q-angles than uninjured subjects. The thigh-to-shank angles and shank-to-ground angles were also larger in non-injured than the injured players. However, the subjects did not reach the theoretical normal Q-angle of 10 deg. Thus, the authors concluded that either the study underestimated the true Q-angle, or the group of players had small Q-angles compared to previous studies (Hume et al., 1996).

Results of a study of 228, 1988 Australian netball championship players indicated that knee recurvatum was significantly different between injured and uninjured for the right and left ankle regions (normal 5°) (Evans, 1986). However, both the injured and uninjured exceeded the normal range of movement with the injured recording a range between 13 and 15° (Hopper and Elliott, 1993).

Steele (1990) concluded that a player who wears appropriate footwear and competes on a suitable surface, but lands with the lower limb completely rigid is more likely to impart jarring to their body than a player who lands wearing poorly designed shoes but flexes the at the knee.

6.1.8.5 Landing technique and fatigue

Fatigue has often been associated with injury. During the stance phase at landing, shock absorption is achieved through muscle stiffness, bony deformation, joint motion, and cartilage compression (Nyland et al., 1994). When muscle is not present, the stabilising influence is lost and inert internal muscle become vulnerable to the increased forces, resulting in injury (Nyland et al., 1994). This may also explain some of the lower extremity injuries among netballers. Although not based on a netball population, Nyland et al. (1994) investigated the effect of lower extremity fatigue on GRF production, lower extremity kinematics, and muscle activation during the landing phase of a run and rapid stop among 19 female division 1 collegiate basketball and volleyball players. This study found that run and rapid stop performance following fatigue showed statistically significant trends toward injury.

6.1.8.6 Recommended landing techniques

Although the landing action adopted by the player will be determined by the type of catch attempted (a pass thrown high or low, slow or fast) there are fundamental principles that can be applied in any landing situation (Steele and Milburn, 1987a).

A 3-dimensional cinematographical analysis was performed to evaluate the relationship between kinematic parameters and ground reaction forces at landing by 10 skilled players performing a typical attacking movement (Steele and Lafortune, 1989). Results indicated that in order to possibly decrease both the magnitude and rate of loading of horizontal and vertical components of GRF, at landing and therefore minimise musculoskeletal stress, the player should:

- Land with the foot neutrally aligned thereby eliminating excessive ankle adduction-abduction, internal rotation or dorsiflexion
- Ensure adequate hip and knee flexion
- Eliminating an exaggerated 'striding out' position by reducing the foot-hip displacement.

Netball Australia has produced a one page article indicating the correct landing technique for the netballer. This is distributed Australian wide by each State body. It recommends:

- land with the feet apart to give a firm support base
- land with the body upright
- cushion the land by bending the knees, hips and ankles slightly on impact
- try for a balanced, 'soft' landing
- body weight should be over the feet, with shoulders level
- when landing with two feet simultaneously, weight should be distributed on both feet
- for one foot land, quickly bring the other foot down, to evenly distribute the weight between the two
- allow time for a balanced position to be taken before releasing the ball to a team mate

Netball Victoria has also produced a pamphlet on fault detection and correction. In terms of coaching points for landing, it recommends:

- leap out to catch the ball (Note: this is in direct opposition to recommendations of Steele (1988), Steele (1998).
- land
 - right foot first
 - left foot first
 - two feet simultaneously
- ground the other foot quickly about shoulder width distance apart to give a steady base
- ankles, knees and hips flex (bend) to cushion land
- shoulders should be level
- weight should be level
- when landing from a sideways motion, weight should be over the outside leg - land on outside foot - other leg comes down quickly on the inside

These recommendation are made to allow internal forces to be absorbed over a longer period of time and prevent the jarring felt with sudden stopping (Wilson and Hume, 1993).

6.1.8.7 Conclusion

The problem with the studies presented is that the samples are small and also consist of various standard netball players. Studies are predominantly conducted in an artificial environment and often ask the player to perform movements unnatural to their playing ability and often involve only one netball attacking movement pattern. Subjects are female. As the game increases in popularity, however, male and child populations also need to be included in investigations. Further examinations need to take place with subjects of various skill, age, and anthropometric characteristics in order to be representative. The gathering of this wide ranging data would enable the establishment of a screening

system. Such a system could be used to ensure players demonstrating lower extremity malpostures or instability receive appropriate rehabilitation to achieve functional efficiency prior to participation in the game and thus minimise potential for injury (Steele and Milburn, 1988a). A further consideration is the age of the studies reviewed, techniques and biomechanical testing methods will have changed over this time (Steele, 1998)

6.1.9 Recommendations for further research, development and implementation

- Given the inconclusive results, to date, of the complex inter-relationship between playing surface, footwear and injury it is recommended that controlled epidemiological studies be undertaken to identify risk or protective factors.
- Further biomechanical and EMG studies of landing should take into account age, skill, gender and anthropometric characteristics and other factors known to affect landing and should be conducted within normal playing conditions.
- Adequately trained controls are required for future studies of the current stepping rule.

6.2 TRAINING AND TECHNIQUE

6.2.1 Warm-Up, Stretching and Cool Down

Netball often involves short bursts of speed and sharp movements. It is widely accepted that warm-ups and stretching reduce musculoskeletal injury because they improve the range of motion of the joints and improve muscle elasticity, thereby removing some of the physical stresses associated with netball, along with increasing mental and skill preparation. Warm-ups can be active or passive and affect not only a particular area, but the whole body.

All national accredited coaching courses for netball advise and provide examples of warm-ups. These courses also outline recommendations appropriate to age group. The level one coaching book states that:

“Physical warm-up raises body temperature, increases blood supply to the muscles, helps to avoid injuries and prepares the nervous system to the performance of complicated skills. In addition, where performance depends on endurance, the warm-up brings the body close to the desired steady state where oxygen intake and consumption are level. Controversy exists as to the duration and the intensity of the warm-up, which varies considerably between individuals and different types of activities (training, competition) and which must not induce fatigue” (The National Coaching Director and Coaching Development Committee, 1990).

A typical description and rationale follows: warm ups should be carried out for 10-20 minutes prior to play and completed prior to stretching exercises, with limited lag time between warm-up and play. As a player may be stationary when play is occurring, continued movement around and stretching is recommended to prevent the body from cooling and to stay alert for future play. Cool down although often forgotten about is just as important as it removes excess fluid and waste products from muscles preventing delayed muscle soreness and stiffness and gradually returning the body to a resting state (unknown, 1991).

Netball Victoria and the Netball Australia has produced a large number of pamphlets and reports within their magazines regarding the importance of warm-ups and the appropriate activities to be carried out in order to warm-up.

Despite the lack of evidence for the benefits of warm-up, a five year study of Western Australian netball players reported that 90% of injured players warmed up prior to competition (Hopper et al., 1995b). Specifically 97% of A grade players in comparison to 80% of lower grade players warmed up.

While warm-up, stretching and cool down are highly recommended, sound epidemiological and experimental evidence for the preventive effect of warm-up in netball is scarce and inconclusive.

Many netballers play for social reasons and therefore maintain the attitude that they are only there for fun and do not need to train or warm-up. Perhaps the lack of research into the role of fitness and netball performance, along with inadequate enforcement, is a major reason for this attitude.

Laboratory studies have demonstrated that the mechanical properties of connective tissues can be altered in response to loading and temperature variations which can bring about changes in joint range of motion (Woo et al., 1990). In reviewing the literature, Best and Garrett (1993) concluded that warm-up prior to exercise, particularly before exhaustive exercise, will help to reduce the incidence and severity of musculoskeletal injuries.

Anecdotal evidence suggests that stretching and warm-up should occur before the start of training or match play, and be repeated after long breaks in play or during matches, particularly in cold weather (Hlobil and van Mechelen, 1988). In order for this to occur a good training and pre-participation program needs to be designed and implemented by coaches.

6.2.1.1 Recommendations for further research, development and implementation

Taken together these studies suggest some areas requiring further attention:

- More netball specific research into the effectiveness of warm-up, stretching and cool-down as an injury prevention measure in netball is needed including the benefits of different types of warm-up, cooling-down and stretching practices and the optimal duration, frequency of each component.
- The specific needs of the injured netballer versus the non-injured netballer should be considered when setting up a warm-up program. Injured netball players should seek professional advice, from a physiotherapist for example, about the appropriate exercises.
- Information about warm-up, cool-down and stretching techniques should continue to be developed and widely promoted to improve specific knowledge of techniques.
- Research into the maintenance and effectiveness of warm-up during the start-stop nature of netball should be conducted.

6.2.2 Correction of Training Errors

There is no doubt that a major contribution to athletic injury is inadequately designed training programs, in which what is commonly known as training errors occur (Best & Garrett, 1993). Training errors include a range of factors such as persistent high intensity training without sufficient recovery; sudden increases in training volume and/or intensity; a single severe training or competitive session, and inadequate warm-up (ASIPT, 1997).

Adequate physical, physiological and psychological preparation is essential prior to participation in sport. Without these components athletes have decreased skill and mental performances which can lead to injury. Conditioning programs should involve exercises that develop flexibility, endurance and strength. Flexibility (stretching) will help players to avoid painful pulls to muscles such as the hamstrings, endurance will help players to last through games without becoming exhausted and

straining out-of-shape muscles, and strengthening in the off and regular seasons will help players' bodies cope with playing in all games during the season (Croce, 1987), by stabilising the joint against large or sudden forces (Wilson and Hume, 1993). Agility, balance and proprioception also need to be included in training. Agility helps to avoid collisions, balance reduces the likelihood of awkward positioning leading to injury, while proprioception allows the player to be aware of their body position again reducing the possibility of injury (Wilson and Hume, 1993). A training program is required, which will prepare the participant for sporting events and will not in itself constitute a high risk of injury to the participant (Vicenzino and Vicenzino, 1995).

Hopper et al. (1995b), in a five year study of 11,228 various level netball players, found that 80% trained at least once a week. There was also a significant relationship between the duration of training and the level of competition. Hopper (1986) reported similar levels, with 70% of players training at least once a week. Steele (1990a) studied players aged over 30 years who presented to the injury clinic operating during the Elastoplast-Nivea Netball Classic held in New South Wales in 1987. A total 45 players completed the injury survey of approximately 1053 players at the tournament. Of these injured players, 54.5% indicated that they were not involved in any regular netball training prior to the event, although 77.3% reported being regularly involved in other activities. However, Steele (1990a) recommended that all players be encouraged to participate in physical training programmes specific to netball.

A fundamental pre-requisite for developing a training programme specific to the requirements of any sport is an understanding of the physiological demands placed on each individual team member during a game (Steele and Chad, 1991).

Chad and Steele (1990) identified that there was a lack of specific information pertaining to skill and fitness training of the netballer. Further, they stated that in terms of both the muscle groups involved in netball, and the energy sources required, similarity should exist between training and match play and that training activities should be tailored to suit the needs of particular positions on the court (Steele and Chad, 1991). By closely monitoring the movement patterns of netball players during match play, what players have to practice can be established thereby ensuring training activities are designed to be specific to the demands of the player. Consequently they investigated players from three New South Wales State League Netball teams and players from one team from the Illawarra Academy of Sport (mean age = 19.7 years). The aims of the project were to evaluate the physical capacities of skilled netball players in relation to playing position; to evaluate the energy requirements of positional play during match play and training; to evaluate the movement patterns demonstrated during match and training in relation to playing position and to develop recommendations for individualised training programs, specific to netball.

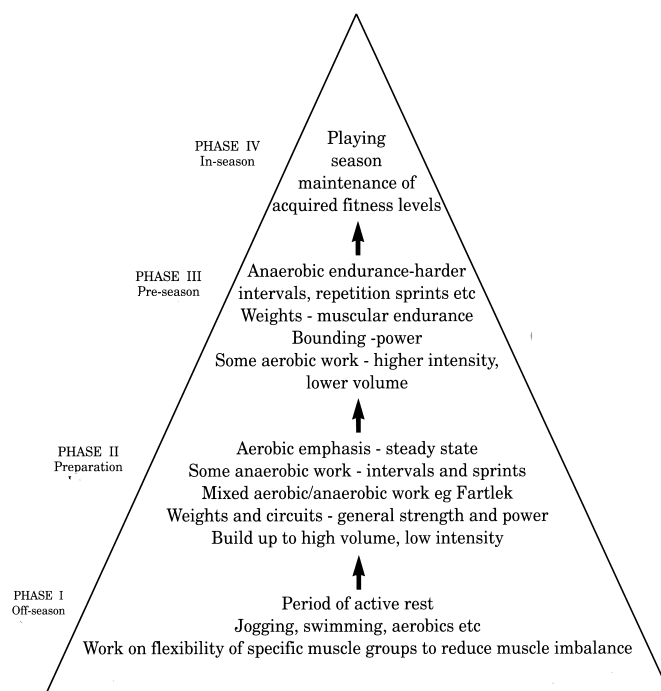
A limitations of this study was that data analysis took place for only one match and two training sessions and although netball matches were organised to closely duplicate competition conditions, the players' movement patterns and physiological responses may differ under arranged matches in comparison to those demonstrated in an actual competition game (Chad and Steele, 1990). Despite this limitation a long list of training recommendations were made respective to player position. These can be found in the document by Chad and Steele (1990).

Netball Victoria has also produced guidelines on training for netball, covering areas such as training principles (warm-up and cool down, progression, training regularity), weekly netball training schedule and flexibility exercises. Many documents including the netball coaching manuals emphasise the need for complete physical fitness. Thus pre-season training and continual training is highly recommended. The basis for this is that a player who is physically fit is less likely to sustain a soft tissue injury because these tissues will be more able to withstand the stresses and strains to which they are subjected (The National Coaching Director and Coaching Development Committee, 1990).

According to Elam (1986) an ideal training programme includes a period of warm-up and stretching, gradual increases and variation in training intensity, frequency and duration, drills specific to the sport, a time for cool-down and stretching after exercise, and adequate rest and recovery periods. This programme should be flexible to take into account off-season, pre-season and in-season training needs. Training programs should enable athletes to peak when appropriate and maintain a high standard of fitness for the duration of the competition season (Best and Garrett, 1993). Such a training programme requires advanced planning and good knowledge of the requirements of the sport and the player's body. It is again for these reasons that coaches should be adequately qualified to undertake such activities.

Wilson and Hume (1993) indicated that training should go from the general to the specific with early increases in volume rather than intensity. As the main season is entered, volume should decline while intensity increases, reflecting the change in emphasis from quantity to quality (Wilson and Hume, 1993).

Basic physical fitness is of the utmost importance in avoiding sports injuries, especially when a period of immobilisation caused by illness, injury or a break in training requires a gradual progression in training to rebuild a basic level of physical fitness (Peterson & Renström, 1986 in Backx, 1991). A gradual progression is required to ensure physical and mental adaptation occurs without injury. Wilson and Hume (1993) have developed a training pyramid, taking the above factors into consideration. The pyramid consists of four phases. As yet, the effects of this training pyramid on injury rates have not been evaluated.



Source: Wilson and Hume (1993)

Other training errors include the wearing of inadequate shoes, poor netball surface, climatic conditions and inadequate rehabilitation. These factors, are discussed separately in later sections of this report.

6.2.2.1 Recommendations for further research, development and implementation

Taken together these studies suggest the following areas requiring further attention:

- Netball players should undergo a graduated netball progression, guided by initial fitness testing results.
- Simple fitness testing should be conducted prior to netball competition to ensure fitness for competition.
- More research is needed to determine the threshold levels of the various training factors under which netball players are likely to remain injury free.
- A campaign aimed at increasing netball players' awareness of the injury consequences of training errors should be developed and promoted.
- Appropriate fitness programmes should be undertaken to develop strength, co-ordination, and flexibility, especially of muscles involving the ankle and foot (Steel, 1990a)
- Proprioceptive and skill training should be implemented focussing particularly on activities to enhance body balance and control in landing, moving forwards, and catching passes (Steele, 1990a)
- Players should participate in physical training programmes specific to netball on a regular basis prior to competing in all-day tournaments (Steele, 1990a)
- Evaluation studies should be conducted to determine the effectiveness of the above 'best practice' recommendations on injury prevention and control.

6.2.3 Anthropometrics and Injury

Hopper et al. (1995a) investigated kinanthropometric and performance variable in relation to injury. Seventy-two, A grade players were measured for hypermobility, somatype, static balance, jumping abilities and anaerobic fitness. A total of 22 injuries were reported in 22 players. Of the total sample, players were more likely to have had an injury if they had better anaerobic fitness, jumping ability and were low on the endomorphy somatype scale. Jumping ability alone was the best predictor of injury. However, jumping ability may be associated with landing technique, surface, footwear or a number of other factors. More specific risk factors need to be identified in order to implement appropriate countermeasures.

Macera (1996) critically examined many aspects of this study raising the question as to whether the higher injury rate among younger and high-performance netball players may be related to the overall playing time. If their superior abilities were a result of extra practice time, the overall time they were at risk of injury may have been longer than for less competitive players. If injury rates had been calculated per hours played including training and competition, perhaps the elite players would not have been injured at a lower rate than other players (Macera, 1996). Macera (1996) further indicated that the A grade players in this study compared to other reports appear to be taller, weigh more, and have increased leg power, therefore raising the questions of recruiting sample representativeness, particularly because the process of selecting 72 volunteers, their similarity to those not included, and the fact that the number eligible for participation were not discussed.

The further development of anthropometric data collection is required in controlled studies to identify both protective and risk factors. This data would enable the establishment of screening systems, whereby people with a higher injury risk could be instructed on better techniques or protective equipment use to prevent injuries.

6.2.3.1 Recommendations for further research, development and implementation

- Further research is required on a wide range of netball players (age and skill variation) to establish a screening and intervention system.

6.2.4 Pre-Participation Screening

As indicated, anthropometric measurements and technique may be factors associated with the risk of injury. Therefore pre-participation screening could identify conditions that may predispose a person to injury. An injury screening examination is designed to detect characteristics of the musculoskeletal system that predispose an athlete to injury or identify incomplete rehabilitation from a previous injury by locating diminished motion, diminished strength, diminished flexibility or increased instability (Hersham, 1984, Backx, 1991). Screening tests evaluate a person's posture, joint integrity and muscular strength (ASIPT, 1997). It is therefore intended as a primary prevention method, although secondary and tertiary aspects are also included (van Mechelen, 1987).

Netball Victoria reported that a pre-participation screening program specific to netball players has recently been developed through the Victorian Institute of Sport.

6.2.4.1 Recommendations for further research, development and implementation

- Conduct further research into anthropometric, technique and other variables on which to base pre-participation screening.
- Collect data for normal calculations and assess the risk of injury

6.2.5 Education and Training

6.2.5.1 Coaches

Coaches are responsible for designing safe and effective training programmes. Thus, coaches must be educated in the general principles of sport and fitness, and understand the specific sport and its potential risks (Weaver et al., 1996).

Netball coaches have a responsibility to their players to provide the best advice and assistance possible. Coaches must recognise and reduce potentially risky situations. As far as possible they should match players and prevent players from attempting skill or competition levels for which skill, maturity and strength, or similar requirements are inadequate. Coaches can be seen as an educator, psychologist, first aid personnel, friend and role model.

In order to establish what injury prevention programs netball coaches used and what type of further information netball coaches would like, Hume (1993) distributed questionnaires to 45 coaches. Twenty-seven coaches returned the form, a 60% response rate. The level of coaching is not indicated. The results from this study are presented in tables 5 and 6.

Table 7 Aspects of netball prevention programs currently in use by netball coaches in New Zealand

Strategies for injury prevention	No. of coaches who used the strategy for injury prevention (n=27)
fitness training program	14 (52%)
stretching	10 (37%)
pre-season preparation	9 (33%)
warm-up	9 (33%)
technique/skills	8 (30%)
seminars/lectures/advice	8 (30%)
taping/strapping	6 (22%)
checks by physiotherapist at beginning of season	6 (22%)
cool down	4 (15%)
use of physiotherapist during season	3 (11%)
no injury prevention strategies	3 (11%)
monitoring of players during season	2 (7%)
treatment for injury	2 (7%)
footwear	2 (7%)
other methods of prevention	2 (7%)

Source: Hume (1993)

Table 8 The type of injury prevention research requested by New Zealand netball coaches

Type of research requested	No. of coaches who requested the research (n=27)
footwear	10 (37%)
shin splints	9 (33%)
specific injuries	6 (22%)
fitness programme	6 (22%)
treatment of injuries	6 (22%)
skill programme	5 (19%)
prevention programmes in general	4 (15%)
other	3 (11%)
types, nature and cause of injuries	3 (11%)
effects of injuries	2 (7%)
warm-up programme	2 (7%)
stretching programmes	1 (4%)

Source: Hume (1993)

The use of three open-ended questions to gather detail is a further limitation. Within this format many coaches may not have indicated strategies in use, believing they weren't relevant or simply not thinking of them at the time. Recruitment of subjects at a coaching training seminar, potentially introduces a number of biases. Participation in itself may indicate above average awareness that may result in higher response rates for variables, than in the general coaching population.

Despite a limited body of knowledge, it is highly recommended that in order to perform the role of a coach and have a understanding of netball and its potential risks accredited coaching courses should be undertaken. Netball coaches can undergo a variety of training levels. Firstly there is the orientation to coaching course, which looks at the basic rule and development skills of netball, including components on the coach's code of behaviour, warm-up, modified games and other safety considerations.

Secondly, Level I national accredited coaching courses aim to develop a broader background in the skills of coaching and player requirements. Again Level I coaching courses include education of basic safety procedures, injury prevention and common sense first aid.

The Level II accreditation courses run for approximately 70 hours, of which 30 hours involves general principles of coaching, 30 hours is netball specific and 10 hours is mentoring. The final level is the Level III course, developed for coaches who intend to or are coaching teams at an elite level. This course takes approximately 100 hours to complete.

In order to maintain an up to date approach and knowledge, it is important that coaches undertake regular updates in injury prevention, recognition, first aid and rehabilitation principles (Weaver et al., 1996).

6.2.5.2 Trainers

Sports trainers are also essential to the smooth operation and prevention of injuries in netball. Sports trainers, along with coaches need to be well qualified to deal efficiently in the prevention, immediate treatment and rehabilitation of an injury. Sports Medicine Australia (SMA) conducts a number of progressive courses: Sports Medicine Awareness Course, Sports First aid, and Level 1 and 2 Sports Trainers Courses, which offer accreditation and the option of personal liability insurance. Trainers receive education on the prevention of sports injury, assessment and immediate management of sports injuries, CPR, warm-up, stretching and cool down, taping and nutrition (ASIPTF, 1997).

The overwhelming majority of experts interviewed by Egger (1990) rated education, particularly of coaches and trainers, as a major factor in preventing injury. Egger (1990) further estimated that a \$300,000 investment towards education of coaches and trainers, would save \$100 million dollars over three years. This estimation is based on a estimation of the number of coaches/trainers needed at a cost of \$100 each for training. There is no estimated indication of how many injuries would be saved per person trained.

However, as indicated in the Australian Sports Injury Prevention Taskforce document "Sportsafe Australia", education lies not only with coaches, officials and trainers but also with administrators and facility managers/operators, who are often in charge of the overall management plan for sport. Evaluation of coaching and training courses in terms of injury prevention is required.

6.2.5.3 Recommendations for further research, development and implementation

- Coaches, Umpires and Trainers should undertake appropriate training courses specific to the requirements of netball players

- All netball teams should have at least one qualified Trainer or Coach on hand at both, training and games to aid in injury prevention and treatment of injury.
- Coaches and Trainers should regularly update their qualifications.
- Systematic evaluations of the effectiveness of education and training programs should be conducted.

6.2.6 Correction of Netball Styles

Incorrect technique with unsound movements places unnecessary stresses on the body, possibly resulting in injury.

In training, the coach should demonstrate and teach correct and safe skills identified as “critical” to success and enjoyment. Although “repetition is the mother of learning”, overuse must be carefully avoided by employing variable training routines, doing cross training, limiting practice length and/or frequency and, where appropriate, using mental drills or performance imaging to substitute for repetitive performance (Weaver et al., 1996).

Corrections of netball style may include: landing, throwing, catching and general movement techniques. The importance of correct landing technique has been discussed in section 6.1.

While the lower extremities are the site of a large proportion of injuries (discussed in terms of landing technique), finger and hand injuries also account for a large proportion of injuries, particularly to junior netballers. Hand injuries are often painful and cause an inability to train and compete as well as painful limitations in the netballer’s work and home activities (Bohan, 1995). Hand injuries usually comprise of sprains or dislocations to the finger joints or thumbs as a result of hand-ball collisions. These injuries usually result from the large forces that must be absorbed by the fingers and arms along with incorrect technique. It is therefore critical that netballers, particularly juniors, are taught the correct way to catch a pass. Wilson and Hume (1993) indicate that in order to reduce these forces the fingers should be spread to increase the area over which the force acts and the arms extended in a relaxed manner, with a small amount of flexion retained at the elbow to cushion the impact. Movement techniques are also important allowing the players to move easily and to dodge players rather than colliding. Netball Victoria, has produced specific guidelines in terms of fault detection and correction (refer Appendix 3).

Each netballer has their own netball style, based on both natural and acquired habits. Given the large number of elements involved in netball, it is obvious that each person’s netball style is different. Sometimes a netballer’s style will change to protect a previous injury site from further damage. Correction of style is a complex matter which needs to be treated on an individual basis. Problems of malalignment (ie. leg length differences) may be an underlying cause of poor style and orthoses are required to correct this. An orthoses is a device, inserted into the shoe to support, align, prevent or correct deformities/malalignments or to improve walking or netball function. The use of orthotics are discussed in more detail in Section 6.4.2

Despite the obvious association between correction of technique and injury reduction only limited netball specific studies have focused on this area. These studies are primarily in terms of landing as discussed earlier. With improved technique, however, not only will the risk of injury be reduced, but higher levels of skill and playing ability will eventually be attained (Bryant, 1997).

6.2.6.1 Recommendations for further research, development and implementation

There has been little research into the role of correcting netball styles in injury prevention other than with regard to landing technique (discussed earlier). Suggested areas requiring further attention are:

- Research is required to identify the relationship between netball style imperfections and injury risk.
- Correction of netball style needs to be evaluated in terms of injury reduction.
- Sporting organisations should continue to promote and teach correct netball techniques.
- Coaches should be guided by current Netball Victoria and Netball Australia recommendations until further evaluation is conducted

6.2.7 Preventing Overuse Injuries

Netballers are expected to train harder and longer, and to commence at an earlier age to succeed. Consequently there is an increasing number of overuse injuries. An overuse injury results from an accumulation of stress to the involved tissues - bone, ligaments or tendons. The tissues and anatomic sites of overuse injuries may vary but according to one study, the cause is the same: repetitive episodes of trauma overwhelming the body's ability to repair itself (Herring & Nilson, 1987). This may be associated with the forces and repetitive nature of the gait cycle. Alternatively, an overuse injury could be the result of a previous injury for which the body compensates, by increasing the stress on another part of the body, eventually leading to tissue breakdown and overt injury at the vulnerable site.

Overuse injuries in netball players usually begin with pain and stiffness. Depending on the severity, the netballer will suffer pain and stiffness at the beginning, during or after play, or a combination of these. Continuous pain and stiffness will eventually lead to a cessation of play. Once an overuse injury develops, the condition remains until physiological equilibrium is re-established between the stresses of athletic activity and the body's healing ability (Ting, 1991). Due to the range of factors contributing to overuse injuries, reference also needs to be made to all the countermeasures reviewed in other sections of this report.

Overuse injuries were responsible for 32 injuries presented by 20 Australian Institute of Sport Scholarship netball players over a nine month period (Purdam, 1987). The author reported a high incidence of calf and shin problems, which were attributed to a combination of aerobics on board surfaces and running on polygrass. Hopper and Elliott (1993) reported that among 228 players participating in the 1988 Australian netball championship, more than a quarter of players had overuse type injuries (24% retropatellar pain, 38% shin soreness) and 33% complained of back problems during their careers.

6.2.7.1 Recommendations for further research, development and implementation

Based on the above studies the following set of recommendations for future research, development and implementation can be made:

- Further research is necessary to gain a greater understanding of biomechanics of netball play and the associated overuse injuries.
- Players with potential biomechanical abnormalities (eg. leg length discrepancies) should have these assessed by a professional who can recommend corrective actions.
- Players should be educated about the risk and the severity of the consequences of overuse injuries.

6.3 NETBALL ENVIRONMENT

Netball often takes place in an outdoor environment. It is not surprising, therefore, that the netballer is influenced by factors such as netball surface, weather and surrounding equipment.

6.3.1 Netball surface

As indicated early, netball is played on a variety of surfaces ranging from natural turf to concrete, synthetic grass and variations of rubber. Evaluation of the effects of the surface type or injury rates is warranted.

Steele (1990a) studied players aged over 30 years who presented to the injury clinic operating during the Elastoplast-Nivea Netball Classic held in New South Wales in 1987. A total of 45 of approximately 1053 players at the tournament required treatment at the injuries clinic. Less injuries were found to occur on the synthetic surfaces compared to bitumen or grass. However, when the expected frequencies of injuries were adjusted to be proportional to the number of games played on each court type throughout the tournament, there was no significant difference in the injury rate related to court surface type (Steele, 1990a).

Hopper (1986) in a 14 week study of 3108 Western Australian players of various age and competition level showed that there was a significant association between surface type and body part injured.

Netball Victoria insurance claims in 1995 indicated that play occurred indoor in 51% of cases, 21% occurred on asphalt, 7% on other surfaces and 21% were unknown. Again this data does not take exposure into account.

Small sample sizes and lack of control data in some of the above studies indicate the need for further work in the area of surface related injuries. Care needs to be taken to ensure a netball surface remains free of potholes, tree roots and stones. All grounds, particularly the surfaces, should be checked for dangerous items such as glass and rubbish, prior to each event. Obstacles around the perimeter of the playing field should also be checked as they may induce collisions with sports participants (Stanitski, 1989). There are regulations for checking the surface of the netball area for objects which may lead to injury. There are specifications for netball facilities. Within these specifications they indicate that:

- The minimum space between the side and base line and any obstacle shall be 10 feet.
- The minimum space between the courts shall be 20 feet
- There is however some flexibility within these regulations

All outside surfaces should be of a permanently firm nature and should be: smooth and level; slip resistant both dry or wet (including paint used for marking lines); well drained; and preferably with a degree of shock absorbency (IFNA, 1997).

6.3.2 Temperature

The weather is a pertinent factor in the risk of injury. Temperature affects both bodily function and environmental factors. Netball in a hot environment increases the risk of heat exhaustion, heatstroke, and dehydration (Brodeur et al., 1989; Lee & Bishop., 1990). Likewise, a netballer can experience frostbite or hypothermia if playing in extremely cold temperatures without taking precautionary steps (McGrath & Finch, 1996). Also requiring consideration is the netball surface in different climates. Climatic circumstances such as rain, may lead to more injuries since the netball surfaces may become slippery.

No specific preventive measures related to climate and netball injuries were identified in the literature. Suggestions for injury prevention are based on general recommendations relating to thermoregulation, such as wearing appropriate clothing, using sunscreens, maintaining hydration and undergoing acclimatisation (American College of Sports Medicine, 1987; Ting, 1991; Cross, 1993).

Given the playing environment, it is only possible to supply limited shade when playing outdoors. Players should therefore be instructed to wear a broad spectrum sunscreen, when playing in strong sun. It is also highly advisable that the club have sunscreen on hand for use. Event management has also been stressed and this includes not planning events at times when environmental stresses are most likely to occur or cancelling the event if they do occur. To cover these aspects, a weather policy could be implemented within the club or organisation. This policy would cover things such as time of the day for events, under which climatic conditions the game should be ceased, the provision of sunscreen, uniform alterations or exceptions and the provision of climate shelters.

6.3.3 Goal posts

Although there is no research to indicate the benefits of goal post padding, anecdotal evidence suggests that it aids in preventing collision injuries between person and post in the tight confines of the goal circle, where play is intense.

It is recommended that goal posts be firmly secured into the ground. Free standing round and triangle based goal post produce hazards in a confined area, as the player may land incorrectly or become entangled within them resulting in injury. Further such goal posts can easily be tipped over, and cause further injury to players and spectators.

6.3.4 Recommendations for further research, development and implementation

Based on these studies, and consultation with experts in the field, the following recommendations can be made:

- More research into the role of netball surface is required to assess the impact on injury risk.
- Netball surfaces should be regularly checked for hazards such as potholes, rubbish etc. and frequently maintained.
- Netball should not be played on slippery surfaces.
- Netball events should not be planned for times when there is a likelihood of extreme weather conditions. Whenever possible, such events should be cancelled if such weather conditions eventuate.
- If netball players, are planning to play in events likely to be conducted when it is hot or humid, they should undergo a process of acclimatisation and should monitor their fluid loss and replace as needed.
- Broad spectrum sunscreen should be provided at netball events, where appropriate.
- Drinking water should be provided at all netball events to ensure adequate player fluid intake.
- Investigate the use of specialised materials for elite level players, which allow evaporating cooling.
- Studies of optimal goal post padding need to be conducted.
- Goal posts should be firmly fixed into the ground with no parts protruding onto the court surface or providing a trip.
- Consistent surface types should be provided within a tournament for a given level

- Surrounding equipment or advertising should be kept away from the court boundaries

6.4 NETBALL FOOTWEAR

As discussed previously, the process of netball involves rapid acceleration, explosive changes in direction and repetitive high force landings, all of which involve the lower extremities. Epidemiological evidence has indicated that most netball injuries are located from the knee downwards in adults. One approach to prevent these injuries would, therefore, be to attenuate the impact forces and provide a stable foot position by using specifically designed netball shoes and orthoses.

6.4.1 Netball shoe design

From a general review of the literature on the prevention of injuries in sport, Cross (1993) concluded that correct, suitable and safe footwear plays an important role in injury prevention. Cross (1993) also argued that an athlete's footwear must be able to absorb shock, while maintaining enough stability to prevent excessive pronation (rolling in of the foot). This is achieved in shoe design by including a heel counter (a rigid material within the exterior wrap around the heel) that is firmly connected to the midsole (ie. between the upper and the sole). This wedges the midsole and is made with materials of greater consistency (firmness) than those on the lateral side (away from the midline) (Cross, 1993). The material of the midsole cannot be too heavy or too inflexible, but must still provide much of the shock absorption. It also should not be too thick as this makes the shoe unstable and a player has an increased risk of ankle sprain (Lang, 1994). As a result of these factors, shoes are now designed with gel or air inserts in the midsole in order to provide lighter, yet efficient, shock absorption qualities.

Because netball is played on a hard abrasive surface a hard wearing outsole that is not too grippy is essential. This does not change if playing on boards (Lang, 1994). Sufficient traction with the playing surface to enable the player to accelerate and decelerate in a controlled manner (Wilson and Hume, 1993) in wet and slippery conditions requires a good tread pattern on the outer sole of the shoe. However, excessive traction may cause knee and ankle injuries due to undue stress when the player changes direction (Wilson and Hume, 1993). The inner sole should be comfortable, cupping the normal heel contour (the rigid material within the counter) during landing and supporting the arch of the foot. The toe box of the shoe should leave sufficient room for foot movement, particularly when braking. Blisters, corns, loss of toenails, and so on, can be the result of a too tight fit. It is also important that the material used in manufacturing sports shoes allows the feet to breathe, thus reducing moisture and helping prevent blisters (Cross, 1993). For the serious athlete, this requires a regular update of shoes (every 6-12 months) as supportive features deteriorate with usage (Lang, 1994).

It is generally believed that the potential aetiological factors of impact forces and foot pronation, can be influenced by the sport shoe (Cook & Brinker, 1990). The corollary to this is that shoe design can be used to prevent injury. An understanding that poor shoes may contribute to netball-related injuries has lead manufacturers to design shoes with added stability and motion control, through the use of various components. Fit is especially important and netball shoes should always be fitted by an experienced shoe fitter (Lang, 1994).

Despite a recognition of the need for good supportive footwear, only 63% of netballers studied by Hopper (1986) reported that their footwear was in a satisfactory condition while 32.9% indicated they were partially worn and 4% totally worn. Of those surveyed 45.6% reported problems with their feet (either, blisters, chafing, soreness or other conditions). Consequently 41.8% used some type of foot protection (bandaids, pads, strapping, vaseline), 8.9% attributed their injury to their footwear.

Of 45 players completing the injury survey by Steele (1990a) over half (59.1%) rated their shoes as being in 'good' condition, 22.7% rated them as 'average' while 18.2% indicated that their shoes were worn or bad.

6.4.1.1 High-topped shoes

It is often speculated that high-top shoes will aid the prevention of ankle sprains in multidirectional sports. High-top shoes theoretically provide external mechanical support to the ankle by preventing extremes in range of motion, thereby reducing the risks of injury (Barrett et al., 1993).

A recent prospective, randomised experimental designed study has been conducted among 622 college intramural basketball players (Barrett et al., 1993). Players were stratified by a previous history of ankle sprain to wear a new pair of either high-top, high-top with inflatable air chambers, or low-top basketball shoes during all games for a complete season. During 39,302 minutes of player-time 15 ankle injuries occurred (7 in high-top shoes, 4 in low top shoes, and 4 in high top shoes with inflatable air chambers). However, no significant difference among these three groups was found, leading to the conclusions by the authors, that there is no strong relationship between shoe type and ankle sprains. Given the small number of ankle injuries in this study, it appears that an alternative study design, such as a case control study, may provide more convincing results.

Ottaviani et al. (1995) in a study of 20 healthy adult men, without recent ankle injury, found that shoe height (low or three-quarter top shoes) did not significantly affect an individual's ability to actively resist an eversion moment at any angle of the ankle plantar flexion. However shoe height significantly increased the active resistance to an inversion moment in moderate ankle plantar flexion. These findings apply to a neutral foot position in the frontal plane, an orientation equivalent to the early phase of a potential ankle sprain (Ottaviani et al., 1995).

Lang (1994) reported that there was no evidence to suggest a high cut boot was an advantage. In contrast, Wilson and Hume (1993) reported that shoe height had been shown to significantly affect the lateral stability of ankles in sideways movements, contributing to the control supination in sideways movements and therefore recommended medium to high cut shoes for playing netball.

6.4.2 Orthotics

Court sports, such as netball, require a good deal of side to side, or lateral movements, that place increased stress on the ankle, and transverse tarsal joints. To avoid excessive muscle strain, good medial and lateral support is needed, which can be attained with appropriate court shoes and supportive orthoses (Janisse, 1994).

The term orthosis is currently used to refer to one of a variety of devices that are used inside the shoe to provide support, increase shock absorption, or influence foot position in some way (Janisse, 1994). Orthotics can be pre-made and custom made, ranging from heel cushions, arch supports, to full insoles.

The use of orthotics to balance the feet in unidirectional and multidirectional sports was introduced after it was observed that small imbalances may have a significant effect on the athletes' performance and risk of injury because of the increased forces of netball (Subotnick, 1985). Imbalances often refer to the degree to which one pronates (rolling in of the ankle). Pronation is a necessary part of weight bearing, however, the ankle joint is not designed for excessive pronation and if it occurs may lead to lower limb overuse injuries (Wilson and Hume, 1993).

In assessing foot type and lower limb injuries, Hopper et al. (1994) surveyed 204 elite netball players. The majority (90%) of those surveyed had symmetrical foot types for both feet and had experienced

at least one lower limb injury. The study showed that players with the pronating foot types with rearfoot abnormalities (57%) were the most commonly injured and that rearfoot varus foot type presented the most lower limb injuries for all body sites. These details, suggest the possible use of orthosis to prevent injuries.

However, the scientific basis for the use of biomechanical foot orthoses in the treatment of lower limb sports injuries was reviewed by Kilmartin and Wallace (1994). These authors concluded that biomechanical orthoses will reduce rearfoot movement, but the effect on the knee function is negligible and the clinical significance of excessive rearfoot movement has not yet been proven to positively reduce injury or aid in treatment.

Orthotics or insoles of appropriate material may be of assistance in reducing impact forces associated with running and landing in netball. Eighteen volunteers (10 men, 8 women) were examined by Oakley and Pratt (1988) in order to establish heel and toe strike running styles and the effect of shock attenuating materials in reducing foot/floor contact forces and skeletal shocks. This study found that using a heel strike, the insole materials (PPT, Cleron, Viscolas) were able to reduce the loading rate in some cases by over 40%. Only one material (Viscolas) produced a reduction, although not statistically significant in the magnitude of the skeletal transient during heel striking. Only PPT material significantly changed any parameter when toe striking by reducing the skeletal transient.

D'Amico and Rubin (1986) found a highly significant reduction in Q-angle when orthoses were positioned beneath the feet of 21 standing subjects. A high Q-angle is reported to place undue stress onto the lower extremities and thus possibly result in injury. Unfortunately the repeatability of measuring technique, involving a short-armed goniometer which did not overlie the points of anatomical reference, was not tested or reported, nor were the subjects used in the study knee pain sufferers. So the relevance to the condition remains uncertain (Kilmartin and Wallace, 1994).

The effect of orthoses and the Q-angle was further investigated by Lefebvre and Boucher (1989). In this study a medial wedging of the foot significantly reduced static trials but not dynamic trials, indicating that orthoses reduced the Q-angle of the knee in standing subjects but not on movement.

McGrath and Finch (1996) reviewed several studies which evaluated orthoses in a number of settings relating to running. As running is a key component of netball, reference is made to these studies. Donatelli et al. (1988) studied 81 subjects who had worn orthoses for a period ranging from three months to two years. Fifty-three subjects participated in a questionnaire evaluation of their progress with orthoses. Relief from pain was reported by 96%, while 52% of respondents said they would not leave home without the orthoses in their shoes (Kilmartin, 1994). Axe and Ray (1988), used biomechanical orthoses in the treatment of ten athletes with resistant sesamoiditis (ie. a small bone embedded in a tendon or joint capsule). While eight of the subjects had undergone a variety of previous treatments including cortisone injections, metatarsal padding and below knee casting, symptoms had persisted. Once the biomechanical orthoses were prescribed no further practices or competitions were missed by any of the athletes and at 18 month follow up, eight of the ten subjects had sufficient symptom relief that surgical excision of the sesamoids could be avoided (Kilmartin, 1994).

A sample of 237 randomly selected army recruits fitted with orthotics, and a further 1151 recruits as a control group were investigated by Schweltnus et al. (1990) to determine the prevention of common overuse injuries by the use of shock absorbing insoles. A total of 54 (22.8%) and 237 (31.9%) injuries were reported in the experimental and control groups respectively. Of these injuries the majority were overuse in nature (experimental group 90.7% and control group 86.4%). The mean weekly incidence of total overuse injuries and tibial stress syndrome injuries was significantly lower in the experimental group, however the incidence of stress fractures was not significantly lower in the

experimental group. This suggests that the incidence of total overuse injuries and tibial stress syndrome can be reduced by wearing insoles.

Supporting this finding, Gardner et al. (1988) conducted a twelve week prospective study of 3025 marine recruits. The purpose of the study was to determine the effects of insoles and the age of running shoes on the incidence of stress fractures. No significant findings were reported.

A limitation in these studies is that it is often not evident whether the tested strategies for impact reduction were ineffective because their cushioning was minimal or whether the injuries reported resulted from factors other than the impact forces (McGrath & Finch, 1996).

A further overview of the treatment of lower extremity injuries with orthotic shoe inserts indicated that they are an effective way of providing symptomatic relief of lower extremity complaints in athletes (Gross & Napoli, 1993). Inserts adjust the biomechanical variables associated with netball injuries and are reported to reduce the effect of high stresses produced by netball activities. Successful treatment with orthotic shoe inserts is dependent on careful evaluation of the netballer and formulation of a properly fitted orthosis. When correctly utilised, orthotic shoe inserts are beneficial for a broad range of disorders experienced by netball players. Problems relating to prolonged pronation are most amenable to orthotic treatment. Finally, it needs to be remembered that orthotics are only one facet in the overall treatment plan for injured netball players (Gross & Napoli, 1993).

From these scarce results, the importance of malalignment as a cause of netball injuries is still not clear. However, the hypotheses that structural abnormalities are a risk factor for injuries and that these can be corrected with orthoses warrant testing in well designed controlled studies.

6.4.3 Socks

Blistering of the feet is common among netball players. Sequela of friction blisters of the feet can lead to compromise of individual performance, local infection and can, rarely, progress to septicemia (Richie, 1993).

In a presentation to the 1993 Annual Conference in Sports Medicine, Richie (1993) stated that in order to reduce potentially damaging shearing forces, a protective material must be interfaced between the skin and shoe surface. Moisture (perspiration) is a significant secondary factor contributing to blistering of the feet. A sock can reduce moisture against the surface of the skin by either absorbing or wicking moisture (that is drawing it out eg. by a gauze) from the skin surface and moving the moisture through the fibre framework of the sock to the shoe upper (Richie, 1993; McGrath & Finch, 1996).

No investigations have been conducted into the effects of different thickness and fibre composition of socks used while playing netball. However, Richie (1993) conducted three studies designed to determine the effect of sock fibre composition and density of padding on the formation of friction blister sequelae in running athletes, which may be of relevance to the netball population. The first study reported a significantly reduced severity of blistering when wearing heavily padded socks. The second study showed a significant difference in blistering rate between cotton and acrylic. Acrylic fibre socks were associated with fewer, smaller blisters and less severe blisters when compared to cotton fibre socks. Richie's (1993) third study was conducted on a generic cushioned sole running sock to identify any superiority of acrylic over cotton. No superiority of either cotton or acrylic in terms of reduced blistering frequency or severity was demonstrated. Richie concluded that acrylic fibre socks are superior to cotton fibre socks only when the fibres are arranged in dense padding under the key shearing stress areas of the foot.

Limitations of these studies were outlined by McGrath and Finch (1996). These studies of sock composition are based on relatively small sample groups, which may not be representative of the population as a whole or the netball population. Also of consideration is the fact that no attempt was made in these studies to control for the runners' personal training habits, surface or regime, which are all factors that can contribute to blisters. Shoe fit and condition of the shoes was only controlled to the extent that proper fit and condition of the shoes to be used were confirmed at the time of sock assignment. The studies, also, did not investigate the effect of environmental temperature. They did, however, eliminate runners with intrinsic structural or mechanical problems that may contribute to blister formation. The attempt to replicate these results was also not clear in the outcome and as a result these findings should be considered with caution.

6.4.4 Recommendations for further research, development and implementation

Taken together these studies suggest some areas requiring further attention:

- Netball players should choose their shoes carefully, preferably with professional advice.
- Future research must adjust for confounding factors such as previous injury when looking at the relationship between shoe design and injury.
- Development of shoes to overcome the relatively short life of their impact absorption, should be investigated.
- Further research should be conducted on the design and benefits of high versus low top shoes.
- Further development and refinement of orthotic devices specific to the demands of netball is required.
- The effectiveness of orthoses in netball should be determined by well designed controlled studies of sufficient sample size to provide definitive results.

6.5 MOUTHGUARDS

While mouthguards are not mandatory in netball and rarely used, their worth is indisputable. This is probably as a result of the relatively small risk of facial/dental injuries in netball. There are three types of mouthguards available: custom made, mouth formed and ready made. The custom made mouthguard provides the best protection. Although custom made mouth guards are relatively expensive, their cost should be weighed up against the risk of injury and subsequent dental expenses. It is recommended that mouthguards be correctly fitted and worn during both practice and game. Care and maintenance are also important to the long life and hygiene of the mouthguard. The Dental Health Services of Victoria, have indicated that a properly fitted mouthguard provides protection by:

- decreasing the risk of injury to the front teeth, especially upper front teeth.
- preventing laceration to jaws, lips and cheeks from the sharp edges of teeth
- decreasing the risk of serious injury to back teeth of both jaws when the mouth is forcibly shut by a blow
- reducing the risk of jaw fracture, especially in the area of the temporo-mandibular joint
- reducing the risk of concussion by shock absorption of a blow to the jaw. The plastic mouthguard absorbs and disperses the energy

There is little promotion of mouthguards through Netball Victoria (personal communication), however, it was indicated that some players at state level do wear them. It is strongly, recommended

that netball players consider the use of mouthguards, particularly if playing in the goal area, were competition for rebounds is strong and elbows to the face are possible.

6.5.1 Recommendations for further research, development and implementation

- Research should be conducted to determine the incidence of dental injuries in netball and the protective effects of mouthguards.
- The use of mouthguards in netball should be strongly promoted until further evidence of effectiveness is available.

6.6 PERSONAL HYGIENE

It should be noted that fatigue and consequential injury may result from poor hydration, causing a reduced blood flow, and hence impairing availability of muscle fuels (Burke & Deakin, 1994). Fatigue may also occur because of inadequate nutrition, leading to early muscle glycogen depletion (Burke & Deakin, 1994). Such nutritional deficits are not uncommon in athletes, with players often restricting their diet in order to fit within society's young slim image (Larkins, 1990).

Aspects of good personal health and hygiene also include adequate sleep, a good state of general hygiene, cleanliness and robust state of health (Bryant, 1997). In order to prevent the spread of infection, it is important not to share certain items, this specifically includes water bottles, face washers and towels (Bryant, 1997). Blood rules should also apply to prevent the possible spread of blood borne infections

6.6.1 Recommendations for further research, development and implementation

- Players should maintain an appropriate level of nutrition (if possible)
- Players should use individual drink bottles
- Players should not share personal items
- Blood rules should be implemented to minimise the risk of blood borne infections

6.7 TREATMENT AND REHABILITATION

Despite the best preventative activities, there is, unfortunately, always the chance of an injury when participating in netball. Further, a previously sustained injury is consistently reported as a strong predictor of another injury occurring (van Mechelen, 1992). In other words, many injuries are re-injuries or aggravation of a pre-existing injury. Thus treatment and management of an injury needs to be considered. Treatment may include first aid, rehabilitation or taping and bracing all aimed at protecting the players from further injury.

However, the causes of netball injuries are so multifactorial and diverse that any specific single measure proposed would probably be of help to only a small minority of netball players. Overall, the treatment goals are pain relief, promotion of healing, decreased inflammation, and a return to functional and sports activities as soon as possible (ASMF, 1994).

6.7.2 Sports first aid

The treatment undertaken within the first 48 hours of an acute soft tissue injury is crucial in determining the rate of recovery from that injury (Wilson and Hume, 1993). This process usually involves rest, ice, compression, elevation and referral (RICER), a well known procedure to initially manage a netball injury and thus restrict the possibility of further damage (Knight, 1985; Larkins,

1990). The RICER regime should be repeated every 3 to 4 hours for the first 48 hours. Ice should be applied for 20 minutes for each treatment (Wilson and Hume, 1993). While this procedure is well recognised and widely used, studies indicating the benefits of the procedure, conducted within the last ten years, have been minimal. Nevertheless, it is so widely used and promoted as good first aid practice, that its effectiveness is accepted. Sports Medicine Australia (SMA) in its 'Sports First Aid Course' provides guidance on the RICER technique (National Sports Trainers Scheme, 1994). SMA identifies the benefits to be a reduction in the severity of further injury, haematoma and swelling, a reduction in the amount of tissue damage and finally a reduction in recovery time (National Sports Trainers Scheme, 1994).

Procedural guidelines in coaching courses in the assessment and immediate management of injuries refers to two actions "STOP" and "RICER" .

- S Stop the player from participating
 Stop the game if necessary
- T Talk to the injured player
- O Observe, whilst talking, the players' personality and injury site
- P Prevent further injury by either getting help in a severe injury case, carry out the RICER regime in less severe cases and in minor cases continue play, with a few words of encouragement.

Along with RICER, no 'HARM' has also been recommended referring to no heat, no alcohol, no running and no massage during the first 48-72 hours after an injury.

After the initial period of icing, and not before 72 hours from the time of injury, alternate hot and cold bathing will help decrease bleeding and swelling (3 minutes of each repeated 3 times, once a day) (Cook, 1989). Massaging over the bruised and sore area with a anticoagulant cream, after the bleeding has stopped (48-72 hours after injury) will also aid in rehabilitation (Cook, 1989). Further to this treatment and given the severity of the injury a sports medicine specialist should examine the injury and recommend further treatment and/or rehabilitation.

Medical coverage for netball tournaments and elite events is required. This may include the requirement that sports trainers, physiotherapists and/or doctors be on duty. At the local level, however, these requirements vary. Medical coverage is often left to parents or associates who may or may not be accredited Sports Trainers, St John's First Aid certified, or may be medical practitioners or qualified nurses.

Netball Victoria has produced an information sheet regarding First Aid "Infonet 6: First Aid for netball course and competitions". This sheet states that all committees and organisers in affiliated associations should supply first aid equipment at the courts when a competition or game is in progress. They indicate what should be contained in a first aid kit, the need for a separate kit when blood is present and the need for emergency contact phone numbers at easy access. It is also stated that each injury is to be recorded in a booklet, giving details of the person, time, date, cause of injury, treatment of injury and person treating.

In terms of treatment given, 69% of Western Australian competitive players, irrespective of injury, received treatment with ice, followed by a compression bandage, strapping or splinting, while 31% only required ice or rest, in a five year study by Hopper et al. (1995b). Of those injured in this study, 54% received advice and home programmes, 30% were advised to visit a doctor or physiotherapist and 16% were referred to a hospital casualty department. Specifically for ankle injuries, 58% of the players were given advice and a home programme and only 15% were referred to the hospital. Conversely for the 8.3% of injuries to the knees only 20% of the players received advice and a home

programme, with 54% being referred to a doctor or a physiotherapist, while 27% were referred to a hospital.

6.7.3 Taping and bracing

There has been an increase in taping and bracing over the last decade aimed at preventing injuries and allowing the early return to sports after injury. Taping and bracing of a joint helps to reduce the range of movement possible at that joint. It is therefore believed to help reduce the risk or severity of injury (National Sports Trainers Scheme, 1994). Taping and bracing are often referred to in terms of:

- Prophylactic - designed to prevent or reduce the severity of injury
- Rehabilitative - designed to protect injured joints treated operatively or non-operatively
- Functional - designed to provide stability for unstable joints.

In netball, as with the majority of sports, the two most frequently injured major joints are the knee and ankle and thus most taping studies have focused on these areas, although not specifically looking at netball. The results of these studies are relevant to the issue of taping and bracing for netball players and hence, are presented here.

6.7.3.1 Ankles

The benefits of both ankle taping and bracing have been shown in a number of laboratory and clinical studies (Bunch et al., 1985; Greene and Wright, 1990; Gross et al., 1987; Gross et al., 1991; Rovere et al., 1988). Studies have also often compared the two process, indicating that while both provide good initial restriction of movement, taping often loosens providing only limited protection (Greene and Wright, 1990; Gross et al., 1987; Gross et al., 1991; Rovere et al., 1988).

The prophylactic value of ankle taping has been shown in some studies (Garrick and Requa, 1987; Karlsson and Andreasson, 1992), whilst others have pointed out some negative factors (Grana, 1994).

A study was conducted on semirigid ankle stabilisers to reduce acute ankle injuries in basketball, a sport associated with many characteristics of netball (Sitler et al., 1994). Participants in the study were 1601 United States Military Academy cadets with no pre-participation, clinical, functional or radiographic evidence of ankle instability. Athletic shoe, playing surface, athlete-exposure, ankle injury history and brace assignment were either statistically or experimentally controlled. It was reported that within the 13,430 athlete-exposures, ankle stabilisers significantly reduced the frequency of ankle injuries. Reduction was, however, dependant on the nature of injury (fewer contact injuries occurred among those who wore braces). Injury severity was not significantly reduced.

In netball terms, Purdam (1987) reported from a observational study that ankle braces were quite effective, although they did not provide as much support as good taping, definitely better than poor strapping or wrapping. An advantage of braces is that they are relatively simple to use and do not take a large amount of time to put on, in comparison to tape, which is awkward to self administer, timely, messy and often painful on removal.

6.7.3.2 Knee

Several clinical and epidemiological studies have been conducted into prophylactic knee braces (France et al., 1987; Garrick and Requa, 1987; Grace et al., 1988; Hewson et al., 1986; Paulos et al., 1987; Rovere et al., 1987; Sitler et al., 1990; Taft et al., 1985; Teitz et al., 1987). In a comprehensive review Pinkowski and Paulos (1993) concluded that there was no agreement on the use of

prophylactic bracing, with two studies finding favourable results (Sitler et al., 1990; Taft et al., 1985) and three studies finding unfavourable results (Grace et al., 1988; Rovere et al., 1987; Teitz et al., 1987) and one showing no significant difference (Hewson et al., 1986). After analysing each study carefully, Pinkowski and Paulos (1993) found that multiple variables existed which may invalidate conclusions drawn and that reduction of these variables experimentally or statistically would yield more useful data and conclusions.

In further studies, Baker (1990) suggested that prophylactic bracing not only offered little protection for knee joint ligaments but may cause additional injuries in that area. Strapping and bracing can effectively stabilise joints such as the thumb, elbow and ankle as these joints can normally tolerate small losses in movement without affecting function. On the other hand, they are usually ineffective measures in stabilising the knees and the shoulder for the rigours of competitive sport and limiting the function of these joints.

A biomechanical evaluation of taping and bracing on the knee joint translation and rotation was conducted on five randomly selected cadaver specimens (Anderson et al., 1992). This study found that taping and bracing together produced the greatest reduction in both anterior-posterior translation and internal-external rotation, providing objective evidence of the restraining capabilities of these protective systems that may prove to be beneficial in the clinical setting. However, load levels used to test the knee laxity (weakness of supporting structures of the knee) were much lower than those levels anticipated based on in vivo experience. Furthermore, there was a lack of active muscle tension in the cadaveric model. Under normal conditions, the tension produced by muscles across the joint would be expected to decrease the displacement at a given load. The final limitation of this study was in regard to the loosening and slippage of the tape or brace. This is a common problem encountered during activity, which can decrease effectiveness. This situation was not tested and the results may therefore be overly optimistic when considering their actual clinical effectiveness.

Townsend and Steele (1997) conducted a kinematic and kinetic analysis of the Paterson anterior cruciate support on 12 active volunteers. After standardised warm-up, five successful trials of a dynamic landing task under three conditions was undertaken (unbraced, standard brace, modified brace). It was concluded that the support was able to impose mechanical restraint to the knee extension during both pre-contact and contact phases of a dynamic landing task.

6.7.4 Rehabilitation

Van Mechelen (1992) concluded that the complete rehabilitation of an injured athlete should restrict the athlete from restarting activities too soon. A rehabilitation programme cannot be regarded as having been completed until the athlete is free from pain; muscle strength has returned to about the pre-injury level; and articular mobility (joint union movement) has recovered to pre-injury level.

Often, rehabilitation needs to include the complete cessation of netball for a given period of time for the injury to heal. Alternatively, it may include a reduction in training.

It is recommended by Hess et al. (1987) that range of motion exercises would be beneficial during the acute phase of an injury to reduce swelling and maintain joint mobility during rehabilitation. This could be done within the confines of a compression dressing such as athletic tape or elastic bandages, which protect the injured area without restricting active movement (Hess et al., 1989). This is also dependant on the injury and the severity.

Hunter and Poole (1987) recommended the application of heat or a contrast programme of heat and cold. The rationale is that heat increases the circulation and promotes healing. The contrast treatment, on the other hand increases circulation as well as decreasing swelling.

Specific studies into the effects of rehabilitation programmes with respect to netball could not be found. However, Hopper et al. (1995b) reported that approximately 65% of ankle injuries and 80% of knee injuries were new injuries, indicating either good rehabilitation programs or that players with such injuries withdrew from participation.

Netball players returning to play after an injury may also undergo a wobble board programme. Limited evidence is available on the benefits of this type of rehabilitation or prevention. One identified study included 61 (48 completed) active sports people competing in more than 2 hours a week of sport with a primary ankle sprain, who completed a 12 week wobble board or non-wobble board training programme (Wester et al., 1996). It was found that in the follow up period (mean 230 days), significantly fewer recurrent sprains and significantly fewer patients in the training group had functional instability of the ankle compared with the no training group.

A further recent study was conducted by Sheth et al. (1997) on 20 adults recruited and divided into a control or experimental group. The experimental group underwent 8 weeks of ankle disc training between the pre-training test and post training test. In the pre-training test all four muscles investigated (anterior tibialis, posterior tibialis, peroneus longus and flexor digitorum) started to contract simultaneously; in the post training tests, the contractions of the anterior and posterior tibialis muscles were delayed, favouring the correction of excessive ankle inversion and thereby explaining why wobble board training helps protect against ankle sprains.

Wilson and Hume (1993) reported that the Australian Institute of Sport had successfully incorporated an ankle strengthening programme for its netball players, using the wobble board, resulting in a dramatic decline in ankle injuries.

Wilson and Hume (1993) in the netball prevention kit “Your body; Your choice” indicated that a player can start to play again when they have:

- 90-100% range of pain free motion
- 90-100% return to strength to the injured part
- 90-100% return to muscular and general endurance
- regain functional stability
- absence of pain at rest
- ability to perform the skills needed to play netball
- self confident and psychologically prepared

Netball players should also undergo appropriate pre-screening or fitness testing prior to competing after an injury to ensure these stipulation’s are meet. For example a warm-up period, followed by a slow paced run, jumping, pivoting and dodging exercises, after which ball handling can be incorporated.

6.7.5 Recommendations for further research, development and implementation

Taken together these studies suggest some areas requiring further attention:

- Organisers should ensure that there are qualified first aid personnel at all events.
- Netball players should seek prompt attention to their netball injuries from a person with appropriate medical qualifications for the level of injury.

- Injured netball players should allow enough time for adequate rehabilitation before returning to their pre-injury level of activity.
- Pre-screening testing should be undertaken prior to play and after an injury before recommencing play.
- Taping or bracing should be considered by professionals in their management of injuries.
- Wobble board exercise and similar rehabilitation exercises should be considered in the rehabilitation of injured ankles and as a preventative measure.
- Evaluation of rehabilitation programs for netball players is required.
- Controlled research into the effectiveness of prophylactic and rehabilitative ankle and knee bracing specifically for the repetitive, fast turning and landing actions of the netballer should be undertaken.

6.8 CODES OF CONDUCT

6.8.1 Substitutions/Rules

Rules, and the way they are implemented by officials, are a key approach to injury prevention in sport (Jørgensen, 1993). A number of rules exist in netball which aid the restriction of injuries. Such rules apply penalties for contacts or obstructions. They require the removal of jewellery or dangerous hair clips prior to play, along with the shortening of nail length to prevent scratches. Other measures include the right of the umpire to cease play in extreme weather conditions along with the ability to warn or remove players from the game if they should act in an unsports-like manner.

In the case of an injury the rules allow play to be stopped for up to two minutes or until the umpire indicates otherwise. Should a player be removed from the game due to injury, a substitution is allowed. Until recent changes, only three substitutions were allowed per game. Thus if three substitutions have been made prior to an injury occurring, the injured player may leave the court and not be replaced or feel that they must continue for the benefit of the team, subjecting themselves to the risk of further injury. New rulings taking place in 1998, however, will allow unlimited substitutions from a full squad of up to 12 players permitted at scheduled intervals or for injury

6.8.1.1 Recommendations for further research, development and implementation

- Rules should be strictly observed by players and enforced by umpires
- Modified rules should be utilised for appropriate participants ie. juniors, masters, disabled

6.8.2 Blood

Recent attention has been directed toward the increasing risk of bloodborne pathogens to sports people. Of greatest concern are three bloodborne pathogens; Hepatitis B Virus, Hepatitis C Virus and Human Immune Deficiency Virus (HIV) (ANCA & ASMF, 1994). Although a non-contact sport, contacts do occur in netball and therefore the strict Netball Australia rules need to be enforced regarding bleeding wounds.

Initially time is called and the injury rule applied. Any bleeding must be stopped before the player can continue to play. All blood stained material should be removed.

Each netball organisation or club should develop and/or enforce regulations regarding vaccination against the Hepatitis B virus. This consists of three injections over a six to seven month period, followed by an immunity screening.

While there is no medical or public health justification for testing or screening players for bloodborne pathogens prior to their participation in sporting activities, there is a moral obligation by the player to make players and officials aware of infectious bloodborne pathogens.

6.8.2.1 Recommendations for further research, development and implementation

- Clubs/organisations should develop and enforce Hepatitis B vaccination regulations
- Information on the risks and precautions relevant to bloodborne pathogens should be provided
- First aid personnel should be aware of bloodborne pathogens and therefore take precautions when treating an injured player (ie. use of gloves)
- The blood rule should be strictly adhered to

6.8.3 Risk Management

The All Australian Netball Association and the Netball Victoria have extensive insurance cover for registered members (players, coaches, umpires, scorers etc). Netball Victoria members are covered for public, product and personal liability, professional indemnity, participant injury and personal property when involved in any Netball Victoria authorised activity or event anywhere in Australia (Spyrou, 1996). Netball Victoria in conjunction with Spyrou (Aust) Pty Ltd have produced a brochure entitled “Netball insurance: How does it work?” (Appendix 4). Policy entitlements range from permanent and total disablement \$100,000 to temporary partial disablement for weekly benefits - loss of earnings, - 75% reduction in usual earnings to a maximum of \$75.

In order to make a claim the injured person must notify an official immediately after or during the game or practice session in which the injury occurred. The injured person (claimant) must call the insurance agency for a claim form, which is then submitted and recorded. If the claim is within insurance guidelines a cheque is produced and forwarded to the claimant.

Risk management, is more than just insurance, it provides the basis of a safe sporting environment by incorporating a full range of countermeasures, as discussed in this report. In order to develop a risk management plan, clubs and organisations need to identify assess and manage the risks, implement a plan and finally evaluate and modify the plan. A recent report by the Australian Sports Injury Prevention Taskforce (ASIPT) has outlined that risk management plans can be developed and implemented at both the club/sport and facilities levels.

Table 9 Risk management plans at club, sport and facility level

Sport/club level - attention to:	Facility level - focus on:
<ul style="list-style-type: none"> • the participants and the activities they undertake • the role of coaches and officials • protective and playing equipment use • provision of first aid personnel and equipment • checking for hazards in playing surrounds before play • injury surveillance 	<ul style="list-style-type: none"> • spectators as well as participants • facility design and layout • facilities maintenance and upgrading • equipment provision and maintenance • provision of first aid facilities • injury surveillance

Source: ASIPT (1997)

In 1995 Netball Victoria in conjunction with Spyrou (Aust) Pty Ltd developed and commenced implementation of the document “Taking the risk management initiative and using it’. This document

provides a checklist for Victorian netball members in associations and clubs to use in and around their facilities. (Appendix 5)

Incorporation of a risk management plan also reduces the likelihood of legal action should someone be hurt, given that an organisation or club has attempted to provide a safe sporting environment.

6.8.3.1 Recommendations for further research, development and implementation

- Clubs/organisations and facilities management should be guided by established risk management plans
- Performance indicators should be established and progress reviewed
- Clubs/organisations should ensure they take out adequate insurance

6.8.4 Standards

Standards Australia has produced a variety of standards relevant to netball. Specifically these are:

- **Guide to sports lighting AS 2560**
Sets out general principles and recommendations for lighting, both indoors and outdoors. Takes into account the visual requirements of both players and spectators.

Lighting for multipurpose indoor sports centres AS 2560.2.2-1986

Sets out specific recommendations for the lighting of indoor sports centres in which a number of sports are played within the same space.

Lighting for outdoor netball and basketball AS 2560.2.4-1986

This standard sets out specific recommendations for lighting for netball and basketball where played outdoors. It provides recommendations for recreational or training and competition levels of play, and takes into account spectator viewing requirements

- **Methods for testing synthetic sporting surfaces AS 2983**
This standard sets out test methods to determine the play characteristics of synthetic sporting surfaces.

Determination of rebound resilience AS 2983.1-1988

Determination of rolling resistance AS2983.2-1988

Test for spin AS2983.3-1988

Test for slip resistance AS2983.4-1988

Determination of stiffness AS2983.5-1988

Determination of resistance to indentation AS2983.6-1987

Determination of abrasion resistance AS2983.7-1987

Determination of tear resistance AS2983.8-1987

Determination of scratch resistance AS2983.9-1987

Determination of spike resistance AS2983.10-1987

Determination of resistance to fatigue AS2983.11-1987

Determination of resistance to delimitation AS2983.12-1987

Determination of impact resistance AS2983.13-1987

Determination of withdrawal force of tufts or loops AS2983.14-1987

Determination of heat ageing AS2983.15-1987

Determination of ozone resistance AS2983.16-1987

Determination of water resistance AS2983.17-1987

Determination of water absorption AS2983.18-1987

Determination of low temperature impact resistance AS2983.19-1987

Determination of resistance to staining AS2983.20-1987

Determination of chemical resistance AS2983.21-1987

- **Synthetic sports surfaces AS 3541.1-1988**

Specifies characteristics of different types of synthetic sporting surfaces and base layers for indoor and outdoor applications. Synthetic surfaces are defined, the parameters are measured and basic safety requirements are included.

Synthetic surfaces include concrete, bitumen, timber, composition block and polymeric surfaces.

- **Sports facilities manual SAA HB49.1-1993**

Provides extracts from Australian Standards and AUSFAC (Australian Sport and recreation Facilities Advisory Committee) publications setting out the major requirements for sports lighting. It covers the general principles of sports lighting, specific lighting recommendations for different sports, and a guide to calculating the floodlighting requirements for different sports facilities.

- **Sporting surfaces SAA HB49.2-1993**

Provides extracts from Australian Standards setting out the major requirements for synthetic sports surfaces. It covers the types of synthetic sporting surfaces, the subfloors and surface selection.

6.8.4.1 Recommendations for further research, development and implementation

Netball clubs/organisations and facility managers should seek information regarding standards and ensure their facilities meet the requirements.

6.9 SPECIFIC POPULATIONS

6.9.1 Children

Children are becoming more involved in sport at earlier ages with higher levels of intensity and expectation. When it comes to sports performance, children must not be thought of as little adults (Stanitski, 1988). Significant differences exist between child and adult athletes, and those interested in injury prevention must understand the difference (Meyers, 1993). Growth and maturation rates in children demonstrate marked variability, along with concomitant gains in coordination and strength, flexibility, and endurance (Stanitski, 1988).

Within the same age groups, physical maturity can vary widely (Welford, 1989). The stage of physical maturity is a better predictor of injury than is chronological age. In particular, rapid growth spurts are often associated with diminished strength, agility, coordination and endurance (Backx, 1991).

Because of child developmental issues, injury prevention strategies for children should be considered separately, despite the fact that their injuries may be attributed to many of the factors associated with adult netball players (eg. training, environment, warm-up, technique, footwear).

For these reasons Fun Net, a play based motor skills program for 5 to 7 year olds, was developed by Netball Australia. Fun Net involves a variety of small structured activities and mini games appropriate to the age level. It's emphasis is on the acquisition of the basic motor skills in a fun environment of games and activities (All Australian Netball Association, 1997)

Netta netball, a modified version of netball, was designed for children aged 8 to 11 years. Netta varies from traditional netball in that instead of using a full sized netball, a smaller, size 4 ball is used, the goal posts are only 2.4 meters high and the opponent is not allowed to defend the shooting player, all players defending a pass must be 1.2 meters away from the player in possession of the ball and six seconds can be taken to pass the ball. In Netta Netball children are also allowed to shuffle their feet in order to regain balance after catching a pass. Up to ten players can participate with shorter quarters.

Netta netball aims to:

- improve the quality, quantity and variety of sporting activities available to children
- provide all children with the opportunity to participate and experience a feeling of success from their participation
- reduce the emphasis on 'win at all costs' and promote enjoyment and good competition through participation in sport
- promote the principles of good sporting behaviour
- improve the quality of instruction available to junior netballers (Netball Victoria, undated)

Club development Consultant, Jeff Dry in 'The Netta Netball Starter Kit' reports that inappropriate equipment or playing fields can deter children from sport. For example, a ten year old shooting netball goals using the standard 3.05m goal height would be equivalent to an adult shooting at a 6m goal. Playing sports with appropriately modified equipment and rules enables children to be involved without risk or humiliation (Dry, undated)

In terms of junior players a report by the Netball Australia (1985) indicated that of 60,300 registered under 12 year old players, 81% of the under 10 year olds played 'Netta', while 28% of the under 12 year olds played modified netball. These figures varied between state.

There has been considerable debate regarding the effectiveness of modified rules. A comparison of the effectiveness of modified versus traditional approaches to junior netball has been undertaken by Plaisted (1989) as a thesis project. In the comparison, 142 netball players (7-11 years) were administered a variety of tests both before and at the end of the season. Analysis of covariance revealed that modified players achieved significantly higher levels in two of four fundamental netball skills (shoulder passing and pivoting) compared to the traditional players. However, no difference was found between traditional and modified netball players in terms of self-esteem, self-competence, anxiety or attitude. With regard to coaching behaviours, the hypothesis that modified coaches would exhibit more reinforcing, encouraging and technical instructive behaviours and fewer punitive and controlling behaviours compared to traditional coaches, was not generally supported. There are however, major limitations with this study, given that all subjects were female and that owing to the specifications of modified and traditional netball, there is a difference in age. This could greatly affect the skill development and attitudes of players.

Netball Australia developed a Junior netball policy in 1994. The purpose of the policy is to ensure the provision of opportunity to all young Australians to develop and enrich their lives through the sport of netball (All Australian Netball Association, 1995). This policy also outlines safety guidelines. These guidelines are:

- take into consideration the ways in which the physical and emotional maturity of a child/youth differs from that of an adult (body temperature, nutrition, fluid replacement, weight training, stress, drugs and sport, sun exposure)
- take into account any long or short term medical conditions participants may have

- ensure that junior netball facilities and equipment are appropriate and safe
- ensure that participants are properly prepared for their sporting involvement, especially through quality of teaching and coaching
- ensure coaches/teachers have adequate first aid knowledge

Finally, children should equate sport with happiness without fear of getting hurt (Kennedy & Fitzgerald, undated). Therefore good safety regulations and adequate training programs need to be developed. Fun Net and Netta netball should be recognised as providing much of the progress in this area.

6.9.1.1 Recommendations for further research, development and implementation

- Safety regulations and adequate training programs specifically for children need to be supported and implemented.
- Fun Net and Netta netball should be supported and widely implemented
- School netball programs should include more information about injury prevention.

6.9.2 Masters

The process of aging is an irreversible and inevitable phenomena which results in changes to the structural, functional, and physiological properties of the human body (Steele, 1990a).

Steele (1990a) studied players aged over 30 years who presented to the injury clinic operating during the Elastoplast-Nivea Netball Classic held in New South Wales in 1987. A total 45 players of approximately 1053 at the tournament underwent treatment at the injury clinic. Thus only 4.3% of the players incurred an injury severe enough to seek medical treatment. Two players required hospitalisation and 34.1% were recommended to further treatment. The majority of injuries were ligamentous (27.3%) and muscular (25.0%), followed by abrasions, bruises and contusions (15.9%). The ankle was the most common site of injury (29.6%) followed by the fingers/hand/wrist (22.8%). The position of play did not significantly influence injury.

Despite the fact that these findings are similar to those for other netball populations (Appendix 1), older players should realise the importance of maintaining a regular standard of fitness in order to compete and not excessively exert themselves. Advice on master fitness is available through the Australian Sports Medicine Federation.

6.9.2.1 Recommendations for further research, development and implementation

- Older players should be aware of their body's capabilities
- Older players should undertake appropriate training prior to competing in social and other competitions
- Masters participants should be educated about appropriate age related training and competitive practices from available literature

6.9.3 Women

Traditionally and currently netball is predominantly a female sport. There are factors related to the female athlete which can increase the risk of injury above that of their male counterparts. The following sections review issues relating specifically to female netball players.

6.9.3.1 Anaemia

Iron is contained in the haemoglobin molecule of the red blood cells and is necessary for oxygen transport. A normal iron level is especially important in netballers and all active sports participants, where maximal carrying capacity is needed for maximal energy output (Griffin, 1993). Women are at risk of developing anaemia, due to iron lost via the menstrual cycle, along with strenuous exercise which increases iron loss (through increased destruction of blood cells, and increased losses in sweat, faeces and urine), and perhaps reduced iron absorption (Australian Sports Medicine Federation, undated).

If a menstruating netballer does not include 18 mg of iron in her diet (recommended daily allowance), treatment is recommended (Griffin, 1993). Treatment often involves the addition of iron supplements, however, a successful management plan should also be undertaken to modify excessive iron losses and improve dietary intake (Griffin, 1993). Good sources of iron include lean red meat, poultry, fish, legumes, green leafy vegetables and wholegrain cereals (Larkins, 1990).

6.9.3.2 Amenorrhoea

Athletic amenorrhoea is thought to be caused by many factors including increased training intensity, loss of body weight and fat, low calorie intake or a combination of these factors, leading to hormonal imbalances and especially, low oestrogen levels (Larkins, 1990). There is no evidence to suggest that amenorrhoea is harmful to the female reproductive system, however there may be associated osteoporotic hazards and therefore counselling regarding changes to their diet and training schedules is required (Larkins, 1990). Osteoporosis is a condition whereby the bones become brittle and fragile, often as a result of hormonal change or deficiency of calcium or vitamin D.

Amenorrhoea can be treated by reducing training intensity and increasing weight. If the condition is “athletic” in origin the women will usually be put on the contraceptive or mini pill (Australian Sports Medicine Federation, undated). There is some suggestion also that the use of the oral contraceptive pill may be associated with a lower risk of injury (Bennell, 1996).

6.9.3.3 Recommendations for further research, development and implementation

- More research into the role of menstrual disturbances and the risk of overuse injuries needs to be undertaken. In particular, the exact relationship between menstrual health, bone health and stress fractures is yet to be elucidated.
- The impact of dietary behaviours and habits on the incidence of injuries, particularly in women, needs to be determined.

6.9.4 Pregnancy

In recent years there has been an increasing number of female athletes who have demonstrated that becoming pregnant does not necessarily mean the end of sport (Edwards, 1994). Medical evidence and popular belief have encouraged the idea that pregnant women can derive benefit from continuing some level of physical activity during their pregnancy (Edwards, 1994).

Despite increased awareness and participation of pregnant women in netball, legality issues are immense. The Equal Opportunity Act 1995 prohibits discrimination in sport, stating that a person must not be discriminated against by another person for participating in a sporting activity. There is however an exception to this statement with the Act relating to Health and Safety indicating that a person may discriminate against another person on the basis of pregnancy if discrimination is reasonably necessary to protect the health and safety of any person.

Spyrou (1996) suggested that to solve this conflict of issues that Netball Victoria should introduce a rule that players should not be allowed to participate in competitive sport whilst pregnant, unless the player has a medical certificate confirming that she is fit to do so. However this is difficult as umpires and coaches cannot always tell nor are they always informed if a women is pregnant. Therefore it has been suggested that a recommendation be issued to players that they do not participate in competitive sport whilst they are pregnant, thus acting as a warning rather than a rule and taking the onus away from the association, umpires and coaches (Spyrou, 1996).

To assist in discussion and caution regarding pregnancy and sport, Sports Medicine Australia (SMA) have developed guidelines entitled “Participation of the pregnant athlete in contact sports”. This document states:

“In limited contact sports contact may occur minimally (either legally or illegally) or there is a small risk of falls or contact with a projectile. If pregnancy is progressing normally these sports are suitable during the first trimester. Ongoing consultation with the physician or obstetrician may make sporting participation in this group of sports possible into the second trimester” (Medicine and Science for Women in Sport Committee of the Australian Sports Medicine Federation, 1994).

The guidelines for pregnant women are:

- not to commence a new competitive sport during pregnancy
- consult closely with their doctors whilst continuing with sporting participation especially if playing high risk contact or collision sports
- advise their coach, trainer or fitness leader of their pregnancy so that training can be modified accordingly
- be aware that participation in contact or collision sports carries risks for themselves and their unborn child
- under the supervision of their doctors the pregnant sportswomen with high levels of fitness and a normal pregnancy may continue to participation into the second trimester in non contact and limited contact sports
- avoid overheating (body core temp>38C) especially in the first trimester
- if any medical or obstetric complication should occur, the sport’s women should cease participation and contact their doctor immediately
- if maintaining fitness is the goal of sports participation, the pregnant sportswomen should consider changing to a lower risk activity eg. non contact sports like swimming and walking as the pregnancy advances
- not to attempt to increase their level of training or exercise at any stage during pregnancy
- to pay special attention to:
 - a thorough warm up and cool down
 - consumption of adequate fluids before, during and after participation
 - regulation of intensity (heart rate) at times of maximal exertion so that it does not exceed 140 beats per minute for more than 15 minutes

Netball Victoria has also produced an information sheet “Infonet 5: Pregnancy and Netball”. This sheet outlines many of the issues concerned and safety aspects. As part of the Netball Victoria Risk Management Plan the following are recommended:

- display a copy of the summary of the statement issued by the Medicine and Science for Women in Sport committee of the Australian Sports Medicine Federation on your notice board
- remove any reference to pregnancy from your By-Laws
- provide a safe environment for all netballers

6.9.4.1 Recommendations for further research development and implementation

- Pregnant women should be provided with educational material regarding physical wellbeing, pregnancy and sport.
- Further research findings on the effects of sports participation and training on pregnancy should be monitored and relevant findings incorporated into risk management plans.

7. NETBALL INJURY PREVENTION PROGRAMS

7.1 “Your Body - Your Choice”

New Zealand netball officials and the Accident Compensation and Rehabilitation Corporation (ACC) first tackled the large problem of netball injuries in 1990, establishing a formal working party to develop an injury prevention package. In 1993 Netball injury prevention kits entitled “Your Body: Your Choice” were distributed to 10 Dunedin secondary schools by Netball New Zealand as part of an ACC funded pilot study. Secondary school players were targeted as they were identified as the largest sub-group of players; easily reached through the school system; at an age when basic skills are being developed; less resistant to modification or changes in behaviour; the future social players with a large number of injuries; the future parents and coaches of the next generation of netball players (Wilson, undated).

These kits consisted of an 11 minute instructional video, printed educational resources and a wobble board. The written material included sections on the cause of injuries, guidelines for training, supporting material to the video on proper techniques, specific strengthening exercises, avoiding collisions, injury treatment and sources of additional resources (Wilson, undated). The aims and objectives of the programme were:

- reduce the number and severity of netball injuries.
- to increase awareness of the need for correct technique and appropriate training programmes
- to increase the number of players using correct first aid treatment and rehabilitation procedures

Baseline data was collected for the 10 participating Secondary schools in 1992, prior to the kit implementation. During the 1993 season, when kits were distributed, evaluation surveys were also implemented monthly to determine if there had been changes in injury pattern associated with the kit. The number of injuries was reported to be reduced by 14%, greater than the expected 10% reduction rate. Awareness of correct technique, appropriate training programs, correct first-aid, treatment and rehabilitation was also reported to have increased with the introduction of the kit. The table below clearly outlines the impact of the kit.

Table 10 Analysis of “Your Body: Your Choice” prevention program

Measure	1991 (pre kit) n=840	1993 (post kit) n=938	Notes
No. of schools participating	8	10	More participants in 1991 This represents a 14% decrease
No. of injuries	50%	51%	
Netball injury rate	6.3/100 players	5.4/100 players	
Immediate treatment	46%	76%	
Finished game after injury	46%	29%	
Left court immediately after injury	42%	61%	

Source: Wilson (undated)

The parts of the kit found most useful by participants were the wobble boards, warm/up cool down sheets, video, specific strengthening exercises and body balance and landing (Wilson, undated). The video received a rating of 6 or higher (scale 1-7, 7=excellent) in 83% of cases, 4 was the lowest

rating given. Seventy percent of schools also rated the kit at 6 or better, again the lowest score of 4. Seventy percent of the schools believed the use of the kit would help reduce the incidence of netball injury, and the remaining 30% thought it might reduce injury, no school thought it would be of no use (Wilson, undated).

Given the success of the pilot study, in achieving the aims stipulated, phase II, the introduction of the kit to all New Zealand secondary schools where netball is played began in 1994. The expected short term outcome is a reduction in injury of 10% in New Zealand schools, with an expected long term outcome of the reduction of national netball injuries overall by 5% (Wilson, undated).

7.2 Injury Prevention Strategy Research

Hume and Steele (1997) conducted a study of 132 injured players attending the sports medicine van from approximately 1800 players in a three day New South Wales Netball Championship. It was reported that despite educational materials available regarding factors associated with injury prevention such as shoe selection, rehabilitation and warm-up, a large percentage of netball players demonstrated behaviours which could predispose them to the risk of injury. The authors concluded that further investigation of how to encourage players to adopt injury prevention strategies is necessary to ensure cost-effectiveness strategies are implemented to reduce the frequency and severity of netball injury

7.3 Recommendations for Further Research Development and Implementation

- A program based on the New Zealand model should be implemented and evaluated in Australia
- Further investigate how to encourage players to adopt injury prevention strategies.

8. VARIATIONS OF TRADITIONAL NETBALL

Traditionally netball was played outdoor by females. However indoor, mixed and netball played of the nets have all increased markedly within recent years. There has also been an increase in privately conducted netball competitions, resulting in variations of rules and methods in which the game is conducted.

There are standard rules across all clubs, associations and organisations affiliated with Netball Victoria, affiliated competitions make up their own rules. However, generally speaking, indoor netball is played under standard rules and therefore the injury countermeasures outlined above may be considered. Particular attention may be placed on the environmental conditions such as temperature, surface and surrounding structures.

Likewise the outlined injury countermeasures need to be considered for both mixed and netball played off the nets. Mixed netball is played either indoors or outdoors with standard rules. The difference is that the team consists of both males and females (4:3 ratio). Some clubs require that two members of the same gender do not play in the ring together, other organisations indicate that each male must be positioned in separate playing thirds on the court. The variation in rulings indicates the need for standard rules across all clubs and organisations. Further, there is no available data comparing the incidence of injury within mixed compared with traditional netball. As with child sport, it may be necessary to ensure that these games are played matching physical abilities.

Netball played off the nets is played indoors on a reduced size court with netting surrounding the court boundaries. This game is quite intense given the court size and the ruling that the ball may be played of the net. The factors of pace and fingers being caught in the netting could increase the risk of injuries in comparison to other forms of netball. Again, no research has been conducted into the incidence of injury.

8.1 Recommendations for Further Research Development and Implementation

- Research should be conducted into the incidence and cause of injuries in mixed games and netball played in indoor cricket centres in comparison to traditional forms of netball.

9. SUMMARY AND ADDITIONAL RECOMMENDATIONS

This report has discussed the a range of injury prevention activities identified in the formal and informal literature for preventing netball injuries. Recommendations for further countermeasure research, development and implementation are based on the review presented here, analyses of data collected by Victorian public hospital emergency departments and discussions with experts acknowledged in this report. Separate sections on overuse injury and injury risk in children and women are also presented because of the particular factors involved.

Many of the recommended countermeasures have yet to be proven to be effective and more attention to controlled studies “in the field” are needed. More effort directed to basic scientific studies to better understand the biomechanics of netball, the mechanisms of injury and the role of various risk factors in injury causation are also required. Indeed, the evidence for the effectiveness of certain countermeasures such as warm-up and shoe design remains equivocal.

In addition to the specific recommendations in this report, the following set of more general recommendations is made based on this report:

- Improved standardised data collection for netball injuries and their associated factors needs to be developed and maintained for both formal and recreational play.
- Data collections should conform to national guidelines for sports injury surveillance.
- Ideally, data should be maintained on all players at least at senior levels, including participation details in competition and training and a record kept of all injuries.
- Information about preventing netball injuries should be disseminated widely through points of sale (eg. shoes), netball magazines and more general magazines.
- Guidelines for minimum safety requirements for netball events (including the need for mobile phones, telephone contacts, first aid kits, etc) should be developed and widely disseminated.
- Guidelines for netball specific risk management plans should be made available to netball clubs and associations at all levels and to schools and facility managers.
- A cost of sports injury study is required to determine overall and relative costs of sports injuries in order to attract commensurate levels of research and prevention funds.

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Appendix 1

Netball injury data: literature review

Incidence of netball injuries per body part

Author	McKay et al., (1996)	Hopper (1986)	Hopper (1995)	NSW 1991	Purdam (1987)	Tas Netball (1993)	Finch et al (1995)
data source	prospective study of both netball and basketball	Saturday winter competition. Range of age and skill level. All female	Winter competition Range of age and skill level. All female	School survey	Netball players on scholarships at the Australian Institute of Sport		child presentations to Australian emergency departments
n	9190	3,108 (158 injuries)	11,228 (608 injuries)		20		2,165 injuries
Period	2 seasons	14 week season	5 years of a 14 week season		20		
head	3.9% (neck)			2%		4.1%	5.8%
face					4% (neck)		
upper extremities	25.7%	13.3%	2.8%	59%		19.2%	54.4%
arm				30%			
shoulder	1.6%						
elbow	1.6%						
wrist	1.6%						
hand/finger	20.9%	13.3%	2.8%	29%			
lower extremities	65.9%	73.4%	92.6%	39%	32%	67.1%	37.3%
leg				5%			
calf/shin	10.1%						
foot	0.8%				8%		
knee	17.8%	15.2%	8.3%	7%	13%		
lower leg							
ankle	30.2%	58.2%	84.3%	27%	14%		
upper leg							
thigh	7.0% (hip)						
groin					2%		
back	4.7%				17%		
trunk						1.4%	1.4%
other		13.3%	4.6%		1%	8.2%	1.1%

Incidence of netball injuries per body part (continued)

Author	Finch et al. (1995)	North Sydney Area Health Service (1997)	Rochester (1989)	Steele (1990)	Routley (1995)	Routley & Valuri (1993)
data source	adult presentations to emergency departments	School children (years 7,9 & 11) PROPORTION (%)	Inter Country Tournament	Elastoplast-Nivea Netball Classic, 1997 (over 30 year olds)	Child Victorian emergency department presentations	Adult Victorian emergency department presentations
n	3587	704	54 squads (96 injuries)	1053 (47 injuries)	137 injuries	388 injuries
Period		12 months	tournament	tournament		
head	4.9%	4% (neck)	2.1% (neck)		5%	2%
face						5%
upper extremities	27.5%	43%	10.3%	22.8%	59%	27%
arm					27%	
shoulder			2.1%			3%
elbow						11%
wrist		11%	8.3% (hand)			
hand/finger		32%		22.8% (wrist)	32%	13%
lower extremities	63.9%		69.8%	70.4%	32%	65%
leg						
calf/shin				13.6%		
foot		9.0%	11.5%	13.6%	10%	6%
knee		43%	17.7%	9.1%	3%	14%
lower leg		7%			2%	3%
ankle		50%	40.6%	29.6%	17%	41%
upper leg		55				1%
thigh				4.5% (hip)		
groin						
back		6%	4.2%	6.8% (neck)		
trunk	2.0%					1%
other	1.8%		13.5%		4%	1%

Incidence of netball injuries by injury type: literature review

Author	McKay et al., (1996)	NSW 1991	Steele (1990)	Routley & Valuri (1993)	Finch et al (1995)	North Sydney Area Health Service (1997)	Cunningham and Cunningham
data source	prospective study of both netball and basketball	School sports survey	Elastoplast-Nivea Netball Classic, 1997 (over 30 year olds)	adult presentations to emergency departments	adult presentations to emergency departments	School children (years 7,9 & 11)	1994 Australian University Games
n	9190		1053 (47 injuries)	388 injuries	3587	704	5106 (1177 injuries)
Period	2 seasons		tournament			12 months	6 days
sprain	62.9% (strain)	43%	52.3% (sprains)	54% (sprains)	57.5%	70%	49%
strain							
contusion				3%			5.3%
dislocation/ subluxation					3.2%	9%	
fracture		18%	9.1% (dislocations)	15%	13.3%	9%	1.6%
wound		2%			4.2%		1.6%
bruise/laceration	17.6%		15.9%	10%	19.3%	35%	26.3%
concussion		2%		1%		2%	3.5%
other	19.5%		15.9%	2%	?		3.2%
overuse							
blisters			6.9%				8.8%
swelling				15%			

Injury rates by number of participants: literature review

Author	Hopper (1986)	Hopper (1995)	McKay et al., (1996)
data source	Saturday winter competition. Range of age and skill level. All female	Winter competition Range of age and skill level. All female	prospective study of both netball and basketball
n	3108 (158 injuries)	11228 (608 injuries)	9190
Period	14 week season	5 years of a 14 week season	2 seasons
Game	5.2%	5.4%	1.73%
Practice			

Injury cause

Author	Hopper (1995)	McKay et al., (1996)	Cunningham and Cunningham
data source	Winter competition Range of age and skill level. All female	prospective study of both netball and basketball	1994 Australian University Games
n	11228 (608 injuries)	9190	5106 (1177 injuries)
Period	5 years of a 14 week season	2 seasons	6 days
Slip or fall	23.2%	13.4%	
Collision with player	22.6%	20.2%	22.8%
Sudden stop		1.8%	
Incorrect landing	38.7%	15.1%	10.5%
landed on opponents foot		6.3%	
running			21.1%
tripped		6.3%	
sharp twist/turn		8.2%	7.0%
overuse			15.9%
hit by ball		18.2%	
contact ground/object			10.5%
Other	15.5%	9.5%	6.0%

Appendix 2

Ground reaction forces reported in various studies

Table I. Summary of the magnitude and rate of loading of vertical forces generated at landing in netball. All values are mean (SD)

Condition	Peak VGRF (BW)	Time to peak (msec)	Initial peak VGRF (BW)	Time to peak (msec)	Reference
Barefoot	4.26 (0.94)	18.0 (7.1)			Steele & Milburn (1987b)
Shoes A	4.02 (0.69)	32.3 (9.3)			
B	3.92 (0.53)	28.3 (8.4)			
C	3.99 (0.72)	31.7 (9.2)			
Standard ^a	3.83 (0.80)	23.8 (8.6)		17.7 (5.6)	Steele & Milburn (1988b)
High pass ^b	3.69 (1.27)	39.5 (20.0)		15.6 (12.6)	
Footwork ^c	3.51 (0.62)	21.0 (7.8)		17.9 (3.9)	
Concrete	3.77 (0.61)	24.2 (9.2)	3.18 (0.85)	15.2 (5.6)	Steele & Milburn (1988c)
Bitumen	3.90 (0.67)	20.8 (9.2)	3.56 (0.82)	15.4 (5.1)	
Grass A	3.79 (0.76)	25.0 (8.5)	3.50 (0.83)	18.7 (5.0)	
B	3.90 (0.66)	25.6 (7.2)	3.54 (0.82)	18.9 (5.8)	
C	3.90 (0.93)	26.5 (8.3)	3.42 (0.98)	18.7 (7.4)	
Rubber A	3.83 (0.88)	27.0 (9.5)	3.41 (0.92)	16.3 (4.6)	
B	3.74 (0.76)	22.7 (8.0)	3.32 (0.89)	16.2 (4.2)	
C	3.91 (0.65)	21.8 (8.6)	3.42 (0.79)	15.4 (3.7)	
D	3.79 (0.75)	26.1 (7.8)	3.25 (0.91)	16.8 (4.0)	
E	3.71 (0.72)	22.9 (9.0)	3.40 (0.82)	16.1 (5.5)	
F	3.84 (0.82)	22.5 (8.2)	3.41 (0.82)	16.7 (4.4)	
G	3.74 (0.74)	24.9 (8.2)	3.41 (0.82)	17.4 (4.4)	
Forefoot	3.30 (1.1)	47.4 (18.3)	1.70 (0.6)	15.0 (14.6)	Steele & Milburn (1989)
Heel	4.50 (1.4)	21.0 (8.2)	4.40 (1.5)	17.0 (6.4)	
Forefoot	5.70 (1.1)	30.6 (6.5)	3.20 (1.9)	16.5 (9.4)	Steele & Lafortune (1989b)
Heel	5.25 (0.9)	31.2 (6.1)	3.90 (1.5)	18.0 (3.5)	

a Receiving a standard chest level pass, adhering to netball footwork rules.

b Receiving a high pass, adhering to netball footwork rules.

c Receiving a standard chest level pass, but taking an additional step on landing.

Abbreviations: BW = force equal to the number of times the bodyweight; VGRF = vertical ground reaction force.

Table II. Summary of the magnitude and rate of loading of braking and resultant forces generated at landing in netball. All values are mean (SD)

Condition	Horizontal braking force (BW)	Time to peak (msec)	Total resultant force (BW)	Time to peak (msec)	Reference
Barefoot	4.23 (0.85)				Steele & Milburn (1987b)
Shoes A	4.56 (0.77)				
B	4.50 (0.80)				
C	4.61 (0.56)				
Standard	4.02 (0.95)	29.0 (6.8)			Steele & Milburn (1988b)
High pass	3.04 (1.08)	23.4 (17.4)			
Footwork	2.98 (0.74)	23.3 (5.3)			
Concrete	3.80 (0.78)	30.4 (3.5)			Steele & Milburn (1988c)
Bitumen	3.51 (0.85)	30.0 (9.5)			
Grass A	3.44 (0.88)	27.1 (8.5)			
B	3.14 (0.76)	25.3 (7.1)			
C	3.81 (1.16)	26.4 (7.8)			
Rubber A	3.54 (1.04)	30.1 (9.5)			
B	3.22 (0.98)	29.5 (6.9)			
C	3.18 (0.79)	28.7 (8.4)			
D	3.33 (1.14)	29.4 (5.0)			
E	2.98 (0.67)	32.8 (14.9)			
F	3.67 (1.16)	31.3 (6.9)			
G	3.42 (1.02)	30.8 (5.7)			
Forefoot	2.60 (0.9)	22.3 (20.6)			Steele & Milburn (1989)
Heel	4.10 (0.6)	26.0 (5.2)			
Forefoot	2.00 (0.3)	23.9 (10.3)	5.90 (1.2)	30.5 (6.4)	Steele & Lafortune (1989b)
Heel	3.30 (0.6)	30.5 (4.6)	6.00 (1.0)	31.7 (4.0)	

Abbreviation: BW = force equal to the number of times the bodyweight.

Source: Steele (1990)

Appendix 3

Technique and common faults - Produced by Netball Victoria



SIDE STEPPING

- * Bend knees and drop weight down
- * Arms held at side, on thighs
- * Keep body and head upright
- * Use quick foot movements
- * Push off strongly with the leading foot
- * Distance between feet in sliding motion should be about shoulder width apart

COMMON FAULTS

- * Knees not bent, weight not down
- * Arms held up too high
- * Body bent forwards
- * Feet too wide apart
- * Feet too narrow
- * Stepping movements too large
- * Footwork flat
- * Movements too slow

LANDING

- * Leap out to catch the ball
- * Land - Right foot first
 - Left foot first
 - Two feet simultaneously
- * Ground the other foot quickly about shoulder width distance apart to give a steady base
- * Ankles, knees and hips flex (bend) to cushion land
- * Shoulders should be level
- * Weight should be evenly distributed between both feet
- * When landing from a sideways motion, weight should be over the outside leg - land on outside foot - other leg comes down quickly on the inside

COMMON FAULTS

- * Player unsure of first grounded foot
- * Second foot not grounded quickly enough and over balance on the first occurs
- * No cushioning on land
- * On side movement, second leg coming down across the outside leg

PIVOT

- * Bring weight over grounded foot
- * Turn on the ball of the foot
- * Non-grounded foot is lifted and regrounded to maintain balance throughout the movement
- * Turn away from defending player if possible
- * Rotation should be towards the direction of the play
- * The ball should be kept close to the body and positioned ready to throw
- * Inside and outside rotations need to be mastered (see p. 23, Level 2 Manual)

COMMON FAULTS

- * Ground foot drags during pivoting motion
- * Weight not over grounded foot
- * Grounded foot is lifted and regrounded during pivot
- * Weight of grounded foot is moved from heel to toe during pivot



CATCHING

- * Move to meet the ball
- * Extend arms and finger tips towards the ball
- * Keep eyes on the ball
- * Fingers spread to the side of the ball
 - thumbs behind
- * Snatch the ball in the air and pull towards body
- * Controlled land - one or two feet
- * Cushion land with flexed ankle, knee and hip
- * Allow time to gain balance
- * Pivot and prepare to pass

COMMON FAULTS

- * Movement away from the ball
 - body
 - arms
- * Arms bent and held close to body
- * Eyes not on the ball
- * Catching with palms of hand
- * Thumbs not behind ball
- * Fingers under the ball
- * Uncontrolled land
- * Unsure of landed foot
- * No cushioning of land
- * Not sufficient time to gain balance

SHOULDER PASS

- * Ball held with two hands initially
- * Take ball back behind shoulder
- * Ball controlled by the finger tips of preferred arm
- * Arm extended - elbow slightly bent, shoulders turned
- * Weight on back foot
- * Other foot forward ready to take the weight
- * Alternate foot forward to throwing arm
- * Transfer weight forward as throwing arm comes through at waist/head height
- * Follow through throwing arm till almost extended
 - fingers and wrist extend in direction of pass
- * Hips and shoulders rotate as the ball is whipped through
- * The pass should be directed to the space ahead of the receiver (pass should be hard and direct)

COMMON FAULTS

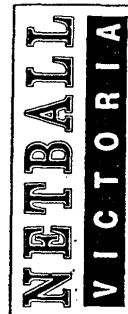
- * Ball on the palm of hands
- * Elbow not bent when taken back
- * Weight on front foot initially- little weight transfer resulting in loss of power
- * Same arm and foot forward
- * No shoulder rotation as ball taken back
 - stab pass
- * No hip/shoulder rotation as ball comes through
- * Arm taken back too high, ball whipped down
- * Hand under the ball- ball will side spin
- * Wrist and fingers flick to side on release
- * Pass not directed to the space in front of the receiver

Appendix 4

Example of netball insurance coverage

Netball Insurance How does it Work?

W
S P Y R O U
INSURANCE BROKERS
m
A.C.N. 006 797 619



A Guide - 1997

Provide a safe environment for your members.

Make sure your umpires and coaches are accredited.

Most injuries occur in the first part of the year.

Ask your coach for pre-season fitness activities.

Develop a warm up and cool down routine.

Are your shoes suitable for netball?

Take a first aid kit to the courts. Don't forget the ice!

WE COVER	WE DO NOT COVER
Death and Capital Benefits Funeral Expenses to a maximum of \$5,000	Pre-existing injuries The gap in respect of the Medicare rebate. The Australian Health Act does not permit us to contribute to any charges by Medicare.
Weekly Benefits - Temporary Total Disablement (income earners only) - 75% of usual earnings to a maximum of \$300 per week - must be deemed necessary by a qualified medical practitioner. Excess: 10 consecutive working days.	100% of income.
Weekly Benefits - Temporary Partial Disablement (income earners only) - 75% of reduction in usual earnings to a maximum of \$75 per week - must be deemed necessary by a qualified medical practitioner.	Weekly benefits for more than 104 weeks from the date of injury.
Non-Medicare Medical Expenses - 50% of costs up to \$2,000 - must be referred by a qualified medical practitioner.	100% of Non-Medicare Medical Expenses.
Emergency Home Help (non-income earners only) - 75% of costs up to \$100 per week to a maximum of \$1,000. Excess: 7 days.	Non-Medicare Medical Expenses that occur 12 months after the date of injury.
Student Tutorial Costs (non-income earners only) - 75% of costs up to \$100 per week to a maximum of \$1,000. Excess: 7 days.	Emergency Home Help and Student Tutorial Costs unless they are deemed necessary by a qualified medical practitioner.
Parents Inconvenience Allowance (non-income earners only) - whilst the injured person is hospitalised \$15 per day to a maximum of \$1,500.	Services that are carried out by family members or friends.
Bed Care Confinement	Expenses that are incurred after the insured resumes playing and/or training.
Emergency Ambulance	Injuries if claim forms are not completed in their entirety.
Medical Expenses Incurred Outside Australia.	Injuries if doctors statements are not completed.

Who is covered?

All financial member players, coaches and umpires. Volunteers such as scorers, office bearers, sponsors and employees are also covered for the same benefits free of charge.

Umpire: all must be registered members.
Coach: all must be registered members.

When am I covered?

Whilst engaged in any activity organised and/or authorised by the Victorian Netball Association Inc. (Netball Victoria) anywhere in the world (excluding U.S.A. & Canada).

What do I do when I suffer an Injury?

1. Follow accepted first aid procedures.
2. Report the injury to your Club and Association & collect a Doctor Statement form.
3. See your local Doctor (Sports Medicine recommended).
4. See related Professionals for treatment if required by Doctor.
5. Ring Spyrou Insurance Brokers to report claim and ask for a claim form on 1800 679096.
6. Return your completed claim form as soon as possible.

Initial Diagnosis

Under the conditions of the Netball Victoria policy the Insurer requires all injuries to be initially diagnosed by a Medical Practitioner. This provides a better knowledge of the injury and the potential treatment required.

Do I have to pay first?

The Insurance is a reimbursement policy. You have to pay everything up front and then forward receipts to Spyrou Insurance Brokers with the claim form.

Can I claim for Medicare covered expenses?

The Insurance policy is a non Medicare policy. You cannot claim for expenses which are covered by Medicare or for the gap between the amount you have paid and the Medicare rebate. The policy is not a Private Medical Insurance cover and by law only Insurance companies registered to provide Medical cover can offer this type of reimbursement.

Is this a Medical Health Fund?

No! This policy provides another benefit to members. It does not purport to be a private health fund. However, if you have your own private health fund, you must claim from that fund first.

Pre-existing Conditions

If you have suffered an injury it is important that you are declared fully fit prior to returning to play. If you return to play prior to clearance from a medical professional, the insurers will not reimburse you for expenses incurred for any further treatment to that injury.

Delays in Finalisation of Claims

Most delays in finalising claims are due to incomplete claim forms. Please ensure that all sections of the claim form have been completed and that relevant documents are attached.

Problems with your claim?

Contact Spyrou (Aust) first. They are there to help you. However, if you are having difficulties, ask your Association Secretary for a Membership Satisfaction Form.

How does my Association benefit?

A major benefit of the policy is related to Public Liability (\$10m), Products Liability (\$10m), Professional Indemnity (\$10m), Personal Liability (\$10m), Office Bearers Liability (\$5m), and Committee Members Liability (\$5m).

Certificate of Insurance

Association Secretaries can request a certificate of Insurance from Netball Victoria. This document is usually required by groups such as schools & councils where Associations hire facilities as proof of public liability insurance cover. This document outlines details of the Insurance Company, Policy Number, Period of Insurance, Details of Insurance and other relevant information.

Enquiries?

For enquiries related to benefits available under the Insurance Policy, telephone 9699 5466.

For a detailed copy of the Netball Victoria Insurance policy, telephone 9329 7766.

See the back of this brochure for a summary of what is and isn't covered.

Risk management: examples from Netball Victoria

VICTORIAN NETBALL ASSOCIATION INC.

TAKING THE RISK MANAGEMENT INITIATIVE
AND USING IT

Presented by Paul Toniolo
From W.M. Spyrou (Aust) Pty.Ltd.
Level 2, 150 Albert Road
SOUTH MELBOURNE VIC 3205
(03) 699 5466
(03) 696 8291

Claims line: 1800 679096

June 1995

INTRODUCTION

RISK MANAGEMENT

We believe one of the most important factors in achieving continuity of maximum cover and competitive premiums, is the fact that the VNA and Its Clubs have the responsibility of managing their assets and liabilities to avoid possible losses/claims.

The management of assets and liabilities is achieved through risk awareness or Risk Management.

We can assist the Association in identifying those areas where there is a more than possible exposure of a loss occurring and put in place a loss control program which will hopefully help in stopping , if not minimising a loss occurring.

We will combine both claims analysis and risk management to provide the Association with a program which would identify risks and possible losses not after they happen but before they happen. This is done on a monthly basis with the VNA.

We believe by W.M SPYROU (AUST) PTY .LTD. meeting on a monthly basis, with the appointed representatives from the VNA that this will help to provide a forum for clearly identifying and discussing all claims and losses and the possible ramifications which could have on the Association, financially and legally.

Our Risk Management Program is currently being utilised by other sporting bodies and we are pleased to advise of its success, enabling these Associations to continue to obtain competitive premiums and broad coverage on an ongoing basis.

VICTORIAN NETBALL ASSOCIATION INC.

INSPECTION CHECKLIST

**REGIONAL CO-ORDINATORS CHECKLIST TO BE CARRIED OUT
ON A MONTHLY BASIS.**

BUILDING - When owned/or tenanted by the VNA		ACTION	
		YES	NO
Entry/Exit	Clearly Lit Disabled Access Provided Stairs - Clear - Non slip - Nosings intact		
Handrails	Secure Undamaged		
Doors	Open freely Glass panels marked		
Floors	Clean Timber free of cracks Non slip surface Obstructions in floor marked or area cordoned No projecting nail heads		
Lights	Switches undamaged No globes/tubes out Adequate for occupancy/activity Protected against damage where ball games are played		
Toilets	Disabled provided Signposted Clean Function correctly		
Windows	Open/close easily Clean Protected against impact		
Housekeeping	Fire exits accessible Fire fighting equipment accessible Electrical switchboards accessible External areas tidy, grass controlled, trees and shrubs cut back		

		ACTION	
		YES	NO
Noise	Noise emission will be controlled to meet the community standards especially after 10pm.		
BUILDING & CONTENTS			
Equipment	All sporting equipment: Stored in clean dry place Inspection prior to use, damaged equipment will not be used.		
Furniture	Secure and undamaged No splinters No projecting fasteners Clean Stored clear of - Fire exits - Electrical boards - Fire fighting equipment - Switches and power points		
Electrical Equipment	Will be undamaged Insulation intact - Plugs and switches free of cracks - Multi plugs fitted with overload protection - Damaged Electrical equipment will not be used		
Electrical leads	Will be run overhead where possible Will be kept clear of hot surfaces		
Maintenance	All maintenance will be carried out by - Licensed tradesman carrying adequate Public Liability Insurance.		
Kitchens and Food Areas	All kitchens and food areas will be kept free of insects and vermin. All cutlery, crockery and utensils are stored separately from cleaning materials. If gas heating is used, it will be turned off at the main at the end of each day. If gas cylinders are used, each cylinder will be isolated at the end of each day. Only authorised people identified by each club will be permitted to use kitchens and kitchen equipment.		

SUPERVISION

		ACTION	
		YES	NO
	A supervisor is present at all activities		
	No activity will commence without the presence of a supervisor.		
	All attendance will be observed by supervisors		
	Supervisors and or VNA representatives will be competent to provide first aid for injury and will ensure immediate referral for more serious injuries		
	All accidents which could give rise to unfavourable publicity.		
	Injuries are to be treated by a member of the medical profession when a potential claim for injury is to be made.		
Supervisors	Will check <ul style="list-style-type: none"> - All grounds. - Room space. - Equipment before it is used. - That damaged equipment will not be used. - That all grounds and floor space will be made safe before use. 		
Supervisors	Will ensure <ul style="list-style-type: none"> - That all equipment is used correctly - No makeshift arrangements will be permitted. - Numbers as a minimum will be: <ul style="list-style-type: none"> Team sports - 1 per team Group activities - 1 per 20 participants 		

INJURY RECORD

An injury record will be available at each location, preferably near or with the first aid kit. All injuries and treatments will be recorded. The record will be an entry on an occurrence pad and injury notification form.

Incidents which could rise to injury or damage will be recorded.

The record will give:

- The name of injured person.
- The date and time of injury.
- Date and time of treatment.
- Name of person giving treatment.
- Brief summary of treatment.
- Brief note on cause of injury.

FIRST - AID KIT

A first aid kit will be available at each game. One person will be nominated to be responsible for all kits and maintenance of stock.

The kit will be in a clean area, close to a source of clean running water with provision for sitting or lying receive treatment.

Portable kits will be provided for excursions or for carrying to field games or activities.

ACTIVITY: NETBALL

PRECAUTIONS

CHECK FREQUENCY

Element:	Annual	Six monthly	Three monthly	Monthly	Weekly	Daily	Each time
* Parental consent must be obtained - members under 14 years of age	●						
* Court area and surrounds to be kept clear and clean.							●
* Playing surface to be free of stones, cracks, splits, loose gravel and in the case of floor boards, projecting nail heads.							●
* Water spillage							●
* Perspiration on courts							●
* Rainwater To be cleaned up immediately							●
* Posts and nets to be secure							●
* Spectators to be 3.05 metres from court side							●
* Warming up and stretching exercises							●
* First aid kit							●