

# Recreational and sporting injury to the adolescent knee and ankle: Prevalence and causes

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This study describes the prevalence of adolescent ankle and knee injuries from participation in recreational and sporting activities. Data were collected over a one-week retrospective time frame from 3,538 subjects aged 11-12 years and 15-16 years from the Adelaide metropolitan region. Young people reported participating in 142 recreational activities and, overall, one injury was reported by every fourth subject and in every third activity. Knee and ankle injuries were the most prevalent, reflecting approximately 13 and 14 per cent respectively overall. The most commonly reported activities which had large numbers of knee and/or ankle injuries were investigated in this paper. There were significant differences in risk of ankle and knee injury within age and gender strata for different activities, although similar mechanisms and types of injury were found for both knees and ankles. Strategies to prevent adolescent lower limb sporting and recreational injury are discussed. [Jones D, Louw Q and Grimmer K (2000): Recreational and sporting injury to the adolescent knee and ankle: Prevalence and causes. *Australian Journal of Physiotherapy* 46: 179-188]

Key words: Adolescence; Ankle Injuries; Knee Injuries; Sports

## Introduction

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Injury has been identified as a common reason for young people ceasing regular participation in sports and recreational activities (Dollman 1998, Du Randt et al 1991, Sale 1992). Physiotherapists should be concerned with such potential attrition, considering the health-related benefits of physical activity throughout life (van Mechelin et al 1996).

Young people's physical and psychosocial response to injury differs from adults (Micheli 1994). Due to the physiology and biomechanics of growth, young people show a unique set of injuries in which minor injury may have major ramifications (Macera and Wooton 1994). The variability in maturation rate of adolescents further compounds the aetiology of injuries (Micheli 1996), and therefore preventative and management principles developed for the treatment of adults are not necessarily transferable to the problems of growing individuals (Hyndman 1994). Appropriate preventative action relies on a sound understanding of the epidemiology of injuries in young people, which recognises the paradox of physical differences between adults and growing

children, and the nature and mechanism of specific injuries (Micheli 1994).

Literature describing ankle and knee injuries in young people is sparse and, in general, predictive factors have been extrapolated from adult studies. Ankle and knee injuries have been described as the most frequently misdiagnosed and mistreated injuries in the skeletally immature athlete, with the severity of injuries often downplayed (Lanthinos and Nicholas 1996, Smith and Stanley 1995, Staninski 1997). Overuse injury resulting from repetitive sub-acute trauma has been reported for elite young athletes (Dalton 1992, Gallahue and Ozmun 1995, Winter and Bishop 1993), and this same concern could be raised for non-elite young athletes who are exposed to the same stresses (van Mechelin et al 1976). Reports of indirect mechanisms of injury (events of injury not related to a specific trauma) may identify insidious or overuse injury (Dalton 1992, Staninski 1997).

This paper addresses the paucity of literature regarding the prevalence of knee and ankle injuries that occur during sporting and recreational activities by Australian adolescents. The data set offers a unique

cross-sectional view of injury sustained by young people at the beginning and end of an important transitional period into high school (ages 11-12 and 15-16 years), when decisions are frequently made regarding ongoing participation in regular recreational and sporting activities (Sale 1991). This paper compares the risk of knee and ankle injury with injury to all other body parts in common recreational activities, and offers insights into the causation of injury and associated presentations. This information provides a baseline for the development of specific and directed educational and health promotion material which aims to minimise injury risk and enhance ongoing commitment to participation in healthy recreational exercise within common recreational and sporting activities.

## Method

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**Sample** Two adolescent groups were surveyed: final year primary school students (Year Seven, aged 11-12 years) and third year high school students (Year Ten, aged 15-16 years). Year levels are used throughout the paper to aid identification of strata. The study sample was drawn from the Adelaide metropolitan region. Written consent was obtained from all students and their parents prior to participation, and approval for the study was provided by the Human Research Ethics Committees of the University of South Australia, and the Department of Education, Training and Employment (South Australia).

One hundred randomly selected metropolitan Adelaide schools (60 primary schools and 40 secondary schools) were invited to participate in the study. Selection was by random numbers from the 1997 list of schools and services provided by the South Australian Department of Education, Training and Employment. School compliance with the study was 72 per cent overall (47 primary schools and 25 secondary schools). Class teachers in participating schools administered a purpose-built validated questionnaire (Grimmer et al 1997, Grimmer et al 1999) to all students in the school of the target ages. Completion of the questionnaire was a class exercise. Participation by individual schools was such that data collection was spread evenly across winter and summer semesters, providing an overview of seasonally-related activities and associated injuries.

During its development, the questionnaire was

validated first by expert opinion on question content, wording and layout, and then by youth opinion to refine question wording and layout. The reliability of self-reports of injury by adolescents using the questionnaire was then determined by repeated questionnaire administration to a sample of 75 young people in the target age groups, and by checking the responses of 59 of these young people with their parents. Irrespective of age or gender, young people were found to be reliable in their self-reporting of recent recreational injury (Grimmer et al 2000).

The questionnaire was designed to collect information retrospectively (over the preceding week) on sporting and recreational activities, and injury sustained from them. Students could nominate up to three activities, which were linked to all subsequent questionnaire items. Students could report multiple body parts that were injured during these activities, and information was recorded about injury nature and mechanism. The nature of the injury was described by a list of symptoms and presentations, such as bruising, aches and pains, muscle strains etc. Mechanism of injury was described as tripping, landing badly, contact with another player, falling etc. An "other" option was provided for each of these questions so that the complete range of injury nature and mechanisms could be recorded. Respondents were encouraged to provide multiple responses to both the nature and mechanism of injury, where appropriate, and one injury could involve more than one presentation and more than one mechanism.

**Data analysis** Participation and injury data were analysed descriptively, using SAS Version 6.12 (SAS Users Manual 1997). Analysis for this paper focused on the activities in which more than 100 participations were recorded (that is, the most common activities) and, of these, the activities in which the number of knee and/ or ankle injuries exceeded 20. By imposing these criteria, robust figures were provided for calculation of injury risk within most of the common activities, and within most of the gender and age strata. Calculation of risk was not attempted when the number of injuries to knees or ankles in the stratum was less than five.

Stratum-specific analysis of injury data for knees and ankles was conducted for males and females in Year Seven (11-12 years) and Year Ten (15-16 years), because different rates of growth for males and

**Table 1.** List of broad activity types reported by participants.

1. Abseiling	18. Field/PE activities	36. Lacrosse	54. Softball
2. Archery	19. Go cart racing	37. Lawnbowls	55. Squash
3. Athletics	20. Golf	38. Life saving	56. Surf activities
4. Australian Rules football	21. Grid iron	39. Martial sports	57. Swimming
5. Badminton	22. Gym activities	40. Minor games	58. T ball
6. Baseball	23. Gymnastics	41. Motor bike riding	59. Table games
7. Basketball	24. Handball	42. Netball	60. Table tennis
8. Bicycle riding	25. Hockey	43. Orienteering	61. Ten pin bowling
9. BMX racing	26. Horse polo	44. Pistol shooting	62. Tennis
10. Boogie boarding	27. Horseriding	45. Rockclimbing	63. Touch (football)
11. Boxing	28. Ice hockey	46. Rollering	64. Triathlon
12. Bushwalking/hiking	29. Ice skating	47. Rowing	65. Underwater hockey
13. Canoeing	30. Indoor cricket	48. Rugby League	66. Various dance
14. Coaching, umpiring	31. Indoor hockey	49. Rugby Union	67. Volleyball
15. Cricket (including Kanga cricket)	32. In-line hockey	50. Sailing	68. Walking
16. Cross country	33. Jogging/running	51. Skateboarding	69. Water skiing
17. Fencing	34. Korfbal	52. Snow sports	70. Weight lifting
	35. Kayaking	53. Soccer	71. Windsurfing

females may incur different potentiates of lower limb injury from recreational sporting activity (Gallahue and Ozmun 1995). Odds ratios were calculated from stratum-specific 2 x 2 tables to describe the risk of knee or ankle injury compared with injuries to all other body parts, for the recreational activities of interest. The upper and lower 95 per cent confidence limits around each odds ratio are presented as estimates of the significance of the finding. Where the lower 95 per cent confidence limit approximates 1, the risk of knee or ankle injury, compared with injury to any other body part for an activity, could be assumed to be significant. Conversely, where the upper 95 per cent confidence limit approximates 1, the activity could be assumed to be protective of knee or ankle injury compared with injury to any other body part.

## Results

**Subjects** The survey was completed by 3,538 students over the period of March to November 1997. Within participating schools, the average compliance with the study was 97.5 per cent. The sample

comprised 22.4 per cent girls aged 11-12 years (Year Seven) ( $n = 794$ ), 19.4 per cent boys aged 11-12 years (Year Seven) ( $n = 687$ ), 27.3 per cent girls aged 15-16 years (Year Ten) ( $n = 966$ ) and 30.8 per cent boys aged 15-16 years (Year Ten) ( $n = 1091$ ).

**Activities** Subjects reported participating in 8,997 events of sports and recreational activities in the week preceding the study (an average of 2.5 participations per student). One hundred and forty-two activities were reported, reflecting a broad range of social and organised activities. Many of these activities were similar in nature, reflecting the same type of activity (for instance more than 20 activities constituted minor games, and more than 10 activities comprised various dance activities). Amalgamation of similar nature activities provided 71 broad recreational activities sports (listed in Table 1).

There were 20 activities with more than 100 reported participations, deemed to be the most common activities. These comprised walking, basketball, Australian Rules football, bike riding, netball, soccer, various dance activities (for instance ballet, jazz and

**Table 2.** Activities with high frequency of reported participations (more than 100 participations), and high frequency of injury to knee or ankle (more than 20 overall) in gender strata. These activities are described as female (F) and male (M) by the proportion of all reported participations, the number of gender knee and ankle injuries, and the percentage of the total number of gender knee and ankle injuries. The total number of injuries reported per activity is provided for reference.

Activity	% of subjects participating		n (%) knee injuries		n (%) ankle injuries		Total all injuries	
	F	M	F	M	F	M	F	M
Australian Rules football	7.8	28.1	8 (7.5)	40 (15)	11 (10.4)	29 (10.9)	106	266
Basketball	17.8	31.6	24 (13.2)	29 (14.9)	26 (14.3)	27 (13.8)	182	195
Walking	39.9	13.4	7 (11.3)	4 (33.3)	20 (32.3)	2 (16.7)	62	12
Soccer	11.1	24.9	17 (15)	24 (14.2)	21 (18.5)	32 (19)	113	168
Bikeriding	12.7	22.9	10 (17.5)	21 (12.8)	6 (10.2)	7 (4)	57	163
Netball	31.6	2.4	66 (21.4)	1 (14.2)	60 (19.4)	0 (0)	308	7
Jogging	15.9	9.1	8 (16.3)	2 (8.6)	13 (26.5)	7 (30.4)	49	23
Rollering	8.6	6.6	7 (14)	19 (20.8)	5 (10)	9 (9.8)	50	91
Various dance activities	30.8	4.7	18 (18.7)	0 (0)	27 (28.1)	1 (100)	96	1

tap dance), calisthenics, jogging, cricket, swimming, tennis, rollering activities (a category combining roller-skating/blading and in-line hockey), gym activities, volleyball, golf, martial sports, handball, softball, badminton and hockey. These 20 activity categories reflected 82.9 per cent of the total number of reported participations in the study.

**Injury prevalence and risk** Nine hundred and thirty-six students reported sustaining at least one injury in the preceding week from participating in a recreational/sporting activity, with 3,199 participations being related to an injury. This was an injury rate of approximately one injury per four students, and one injury per three participations. Of all the injuries reported, the ankle and knee were most commonly injured, with injury to the knee contributing 14 per cent of the total number of injuries, and injury to the ankle contributing 13 per cent.

Of the 20 most common activities, nine were associated with more than 20 reports of ankle or knee injuries across strata of males and females. The prevalence of overall participation in these activities is listed in Table 2 for females and males. The number of ankle and knee injuries for males and females in each age group is provided for each common activity, this also being expressed as the proportion of the total number of injuries reported for each of these activities. Combined, these nine activities represent 92.5 per cent of all knee, and 91 per cent of ankle, injuries reported in the study. These activities form the basis of all subsequent analyses in this paper.

Differences were observed in the prevalence of knee and ankle injury within strata of gender and year levels. Younger (Year Seven) males and females sustained similar frequency of knee injuries (15 and 16 per cent of all injuries) but Year Seven females sustained a higher frequency of ankle injuries than the Year Seven males (17 and 10 per cent respectively).

**Table 3.** Activity specific odds ratios (95 per cent confidence intervals) for knee injuries, compared with injuries to all other body parts*NB: Not calculable indicates categories with less than five knee injuries*

Activity	Year 7 females	Year 7 males	Year 10 females	Year 10 males
ARF	0.74 (0.17-2.64)	1.73 (1.05-2.83)	0.33 (0.11-0.87)	0.93 (0.48-1.79)
Basketball	0.60 (0.32-1.12)	1.16 (0.60-2.21)	1.40 (0.63-3.03)	1.38 (0.73-2.58)
Bikeriding	1.81 (0.77-4.13)	0.90 (0.42-1.88)	0.28 (0.01-2.01)	1.16 (0.56-2.36)
Jogging	0.53 (0.24-0.86)	Not calculable	1.47 (0.40-4.87)	Not calculable
Netball	1.90 (1.22-2.95)	Not calculable	1.44 (0.86-2.40)	Not calculable
Rollering	0.87 (0.29-2.42)	1.43 (0.59-3.35)	0.94 (0.26-3.45)	2.46 (1.14-5.21)
Soccer	0.88 (0.45-1.70)	1.18 (0.65-2.09)	1.30 (0.36-4.21)	2.27 (1.29-5.63)
Various dance	0.78 (0.27-2.14)	Not calculable	0.91 (0.46-1.77)	Not calculable
Walking	0.21 (0.01-1.48)	Not calculable	1.10 (0.40-2.86)	Not calculable

**Table 4.** Activity specific odds ratios (95 per cent confidence intervals) for ankle injuries, compared with injuries to all other body parts*NB: Not calculable indicates categories with less than five ankle injuries*

	Year 7 females	Year 7 males	Year 10 females	Year 10 males
ARF	1.27 (0.41-3.65)	0.73 (0.35-1.46)	0.38 (0.15-0.95)	1.67 (0.92-3.01)
Basketball	0.95 (0.55-1.62)	1.95 (0.99-3.78)	0.56 (0.19-1.52)	1.27 (0.64-2.45)
Bikeriding	0.43 (0.10-1.49)	0.57 (0.17-1.68)	0.92 (0.21-3.40)	0.29 (0.07-0.98)
Jogging	2.23 (0.92-5.27)	3.80 (0.99-13.4)	1.41 (0.39-4.65)	5.83 (1.08-28.6)
Netball	1.06 (0.66-1.69)	Not calculable	1.53 (0.93-2.52)	Not calculable
Rollering	4.11 (0.91-17.8)	0.70 (0.17-2.45)	0.21 (0.01-1.52)	1.26 (0.47-3.21)
Soccer	0.98 (0.52-1.82)	2.38 (1.32-4.27)	2.15 (0.73-6.09)	3.26 (1.54-6.79)
Various dance	1.67 (0.74-3.66)	Not calculable	1.26 (0.68-2.30)	Not calculable
Walking	42.7 (5.38-916.4)	Not calculable	2.81 (1.28-6.11)	Not calculable

Conversely, the older (Year Ten) females sustained a higher frequency of both knee and ankle injuries than their male counterparts (15 and 16 per cent compared with 11 and 10 per cent respectively).

Table 3 describes the risk of knee injuries for particular activities compared with all other body parts from that activity, and Table 4 describes the risk of ankle injuries for particular activities compared with injuries to all other body parts for that activity.

There was an elevated risk of knee injuries for younger males playing Australian Rules football, older males playing soccer and rollering and younger females playing netball, indicating that if an injury is going to occur in these activities in these strata of young people, it is likely to be to the knee. On the other hand, a risk of less than one for knee injuries was found for older females playing Australian Rules football and younger females jogging. This indicates a significantly reduced likelihood of injuring the knee during these activities for these young people, by

**Table 5.** Proportion of indirect injury (of all injury mechanisms) for knee and ankle.

Activity	Indirect mechanisms	
	Knee	Ankle
ARF	30.8%	21.9%
Basketball	18.2%	18.7%
Bikeriding	17.6%	20.8%
Cricket	33.3%	23.1%
Hockey	21.4%	0.0%
Jogging	20.7%	43.0%
Netball	14.6%	25.0%
Rollering	14.3%	25.0%
Soccer	20.5%	33.9%
Various dance	27.9%	48.3%
Walking	46.2%	64.4%

**Table 6.** The most commonly reported problems associated with knee and ankle injury

Problem	Knee	Ankle
Aches and pains	19.5%	19.8%
Bruises	19.3%	16.7%
Muscle strain	13.6%	15.4%
Joint sprain	8.0%	11.2%
Swelling	7.6%	10.9%
Bleeding	8.4%	4.9%
Blisters	3.9%	4.1%
Gravel rash/grass burn	6.5%	3.4%

comparison with injures to any other body part.

For ankles, elevated risk of injury was found for all males in soccer and jogging, all females when walking, younger females when jogging and rollering, older females playing netball, older males playing Australian Rules football and younger males playing basketball. The high proportion of young female ankle injuries within the low number of young female injuries overall from rollering, jogging and walking, highlights the fact that if any injury is going to occur in these activities to young females, it is likely to occur to the ankle rather than any other body part. Conversely, significantly reduced risks were found for ankle injuries for older males riding bicycles, and older females playing Australian Rules football, an indication that if injury is going to occur in these sports in these strata of young people, it is unlikely to occur to the ankle.

**Type and mechanism of injury** A total of 49 different mechanisms were reported for ankle injuries and 52 for knees. Responses reflected direct mechanisms such as “hit by ball” and indirect mechanisms, such as “overuse”, which young people could not relate to a specific event of trauma. Specific descriptions of mechanisms were also provided by some injured respondents, such as “brakes failed”. Over all activities, the average number of mechanisms

reported for ankle and knee injuries was 1.6 and 1.7 respectively, a finding that was also consistent over specific activities. There were no significant differences in the number of injury mechanisms across year groups or gender.

“Landing badly” was the most common mechanism reported for both ankles and knees (24 per cent and 22 per cent respectively of all injury mechanisms). The same seven most frequently reported mechanisms were found in similar rankings for ankle and knee injuries, representing 84 per cent and 85 per cent respectively of the total number of mechanisms of injury. As well as “landed badly”, these were “bumped into someone”, “tripped”, “fell”, “just happened”, “overuse” and “don’t know”. Equipment failure was reported in 2 per cent of knee injuries and 0.3 per cent of ankle injuries. This mainly involved failure of cycling and skateboarding equipment, for instance “wheel on skates jammed” and “forks snapped” on cycle.

The authors employed indirect mechanisms of injury such as “just happened”, “don’t know” and “over-use” as indicators of possible overuse type injuries related to insidious injury onset (Dalton 1992, Staninski 1997). When all sports and recreational activities were combined, indirect injuries represented approximately one quarter of all reported mechanisms

for both ankles and knees. The proportion of indirect mechanisms within specific activities is reported in Table 5, and highlights differences between indirect injury mechanisms for ankles and knees within activities such as jogging, netball, roller skating, soccer, dance and walking. Differences in prevalence of indirect injury to the knee were also noted between similar court based sports, basketball and netball. Older females showed a significantly elevated prevalence of indirect mechanisms of knee injury compared with younger females (35 per cent compared with 23 per cent), as well as when compared with younger and older males (21.5 per cent and 23 per cent respectively).

A total of 32 different categories describing the nature (type of problem) of knee injuries were reported, and a total of 24 categories for ankles. As with mechanisms of injury, multiple reports of problems were common for the one injury. There was an overall average of 2.5 problems per ankle injury and 2.7 problems per knee injury, with consistent findings across activity, age and gender strata. Aches and pains, bruises and muscle strains represented the highest proportion of problems reported for both ankle and knee (52 per cent and 52.5 per cent respectively). The seven most frequently reported problems were common to both ankles and knees, with the exception of elevated reports of gravel rash for knees and blisters for ankles. These are reported in Table 6, representing more than 80 per cent of problems for ankle and knee injury described by the respondents.

Serious injury (described as dislocation or broken bones) was reported in 3 per cent of ankle injuries and 4 per cent of knee injuries.

## Discussion

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Muscles and joints of the leg are potentially subject to great physical stresses during sports and recreational activity, predisposing the lower limb to injury. This study found that knees and ankles were the most frequently injured body parts reported by adolescents, representing 27 per cent of all injuries. These findings concur with other research (Alcock et al 1997, Backx 1991, Watkins and Peabody 1996), and supports the need to protect young people from lower limb injury during participation in recreational activities.

The activities that had a high prevalence of ankle and knee injuries described both organised sports and recreational pursuits. Differences in risk of knee and ankle injuries across gender and age strata may relate to gender differences in intrinsic factors such as growth rates, joint laxity and muscle strength, plus extrinsic factors such as footwear, level and skill of participation, type of activities and surfaces on which they are played. After the age of 11 years, the muscle strength of females tends to plateau, while males continue to gain strength (Gallahue and Ozmun 1995). This suggests that, compared with males, females overall may have less dynamic stability of the ankle when participating in adolescent recreational pursuits.

Kicking and running sports such as soccer and Australian Rules football appeared to represent the most consistent risk of injury to knees and ankles among males. These sports are relatively male-dominated in Australia, and the low rate of ankle and knee injuries to females from these activities possibly reflects females' lack of opportunity to play these sports at a high level. By their nature, these sports involve significant lower limb manipulation skills, tackling, sudden collisions, passing and trapping the ball. They also require locomotion skills such as jumping, running, stopping and changing direction. Safe participation necessitates accurate proprioceptive responses to uneven surfaces and a significant level of skill development. Kicking is the most widely studied soccer skill (Lees and Nolan 1998) with common kicking skill-related problems demonstrated by young players including loss of balance, poor opposition of arms and legs, and poor summation of the forces to contribute to the force of the kick (Gallahue and Ozmun 1995). Until skills in these sports are well developed, participation in them may render the growing adolescent susceptible to injury.

Underdeveloped skills may also explain the higher risk of knee injuries for younger students compared with older students (for example males playing Australian Rules football, and females playing netball). Netball and Australian Rules football require specialised skills depending on sound perceptual ability. Skills improve with age, due to improved visual acuity, reaction time and sensorimotor integration (Gallahue and Ozmun 1995). Given the high participation levels in these two sports, and that younger females are at their peak height velocity (Roemmich and Rogol 1995), the increased risk of

knee injuries for this age group suggests the potential for long lasting effects to a significant proportion of the teenage population.

Older males showed an increased risk of knee injury, while younger females showed an elevated risk of ankle injury when rollerblading. This is mainly a social/recreational activity, in which males' participation may reflect an aggressive or reckless approach, while young female ankle injuries while rollerblading may illustrate lower levels of skill coupled with ankle instability from vigorous lower limb growth. On the other hand, the protective nature of bike riding for older males suggests this activity may offer a useful alternative during rehabilitation.

At least two of the activities with high participation levels (walking and jogging) require basic skills development compared with specialised skills such as kicking, and reflect activities that are commonly continued into adulthood. Although both activities had low numbers of injury reports overall, lower limb injuries were the most prominent. Jogging was significantly protective for knee injuries in the younger females and the low number of knee injuries reported by males precluded interpretation as odds ratios. However, jogging incurred an elevated risk of ankle injuries for all males in the sample and for younger females. Elevated risk of injury to the ankle from walking for females was also observed, although the odds ratios must be interpreted with caution, as they are artificially inflated by a high proportion of injuries to one body part in overall low numbers of all injured body parts. Despite this, the findings suggest the need for further investigation into the manner in which these activities are undertaken, to reduce the risk of lower limb injury (for instance, it is possible that males use jogging as a more aggressive form of training, while females may walk faster and more vigorously as a form of exercise/weight loss).

The most common injury mechanism for both knees and ankles was landing badly, which concurs with previous research findings (Anderson and Hall 1990, Robbins and Waked 1997). Landing is a complex action which is influenced by many factors such as the sporting surface, weight of the player and muscle inflexibility (Steele 1993). Some of these factors, such as impaired co-ordination and flexibility, can be affected by growth, leading to an elevated risk of injury (Backx 1991, Dalton 1992, Macera and Wooton 1994). The complexity of the action suggests

that the younger player may have difficulty in mastering the technique. Common landing difficulties experienced by young people include landing flat footed, landing without control, failure to flex knees sufficiently to absorb the impact of landing, and failure to land simultaneously on both feet (Gallahue and Ozmun 1995). The study findings suggest the need for coaches and trainers to appreciate the complexity of landing in relation to the growth and development of individual players. Poor techniques are not energy efficient and premature muscle fatigue will consequently increase the chances of injury. Thus careful instruction and controlled acquisition of skills seems necessary to minimise injury risk for young players.

Difficulty in identifying overuse injury for young people was highlighted in this study. The authors' use of indirect mechanisms of injury as indicators of overuse injury (as suggested by Dalton (1992) and Staninski (1997)) requires validation, particularly as accurate determination of the number of overuse injuries was not possible due to the self-report nature of injury, the short report period (one week) and the recording of only a single injury event. Irrespective of these concerns, approximately one-quarter of the mechanisms were not attributable to direct injury. This possibly indicates the need to educate adolescents, coaches and parents regarding management of injury which cannot be related to a specific event, and to seek expert advice regarding persistent, ongoing problems, however minor. The knee was more frequently associated with indirect mechanisms of injury than the ankle in seven of the nine common activities. When comparing the prevalence of indirect mechanisms in age and gender strata, the Year Ten (older) females were consistently more affected than any other. This may relate to the physical maturation level of older females, many of whom are reaching the end of their growth period with the development of the wider hips of a mature female, and thus an increased Q-angle at the knee. Muscle strength for females tends to plateau after the age of 11, while males continue to gain strength (Gallahue and Ozmun 1995). This suggests that older females have less dynamic stability around the knee, which may result in abnormal tracking of the patella during knee movement. This is believed to be a factor in insidious onset of anterior knee pain (Meyer 1993).

The majority of knee and ankle injuries were minor, consisting of aches and pains, bruises and muscle strains. This finding concurs with other population-



based studies on adolescent sporting injury (Alcock et al 1997, Backx et al 1989, Watkins and Peabody 1996) and demonstrates the need to inform adolescents and their carers on the effective management of minor trauma. Particularly if inadequately treated, the ramifications of minor injury in adolescence may be far reaching with respect to tissue damage and attrition from physical activity (Macera and Wooten 1994, Sale 1992). The relatively high prevalence of minor trauma highlights that clinic/hospital based collection of injury information inadequately represents the adolescent sporting injury profile (Finch et al 1995).

Although serious injury (described as dislocation or broken bone) represented only a small percentage of injury problems (4 per cent of knee injuries and 3 per cent of ankles), the reporting of 21 ankle dislocations and 40 knee dislocations appears unduly high. Generally, confidence in the accuracy of respondents' reports of injury was high, as the pilot reliability study (Grimmer et al 1997, Grimmer et al 1999) established good agreement between parents and young people regarding the reporting of location and nature of recent injury. However, the high number of dislocations reported may represent an error of self report due to the poor understanding of this clinically more complex event. While this requires further investigation, it adds possible weight to the need to educate young people about the true nature of their injuries, and appropriate ways of managing them.

## Conclusion

The findings presented in this paper suggest a picture of significant risk of ankle and knee problems from adolescent participation in common sports and recreational activity. Long lasting effects, particularly of knee injury during development, have been demonstrated (Kujala et al 1995, Mandelbaum 1991) and continuing lower limb joint problems may preclude ongoing participation in sports and recreational activities in adulthood. The injury profiles found in this study suggest that multifaceted preventative strategies should be developed to:

- provide young people and their carers with comprehensive education on effective injury management;
- encourage the delivery of comprehensive coaching advice that addresses young people's

developmental stages (eg the need to develop appropriate landing and kicking skills);

- recognise growth as a possible risk factor for injury; and
- implement appropriate strengthening and stretching regimes. For instance, the findings suggest that appropriate risk prevention strategies may include improvements in proprioceptive skills in adolescent females to address the high risk of ankle injury, or strengthening exercises for vastus medialis obliquus to minimise potential patella mal-tracking resulting from skeletal growth.

Moreover, as equipment failure was highlighted as a potential injury source, the ability of young people to perform basic safety checks on equipment should be fundamental to safe participation in sports and recreational activities. Therefore, young people should be educated on not only the appropriate use of protective equipment, but also its maintenance.

The study findings provide the impetus for health professionals and teachers to develop appropriate and targeted educational initiatives to minimise the risk of adolescent injury during activity participation. These initiatives should take account of stages of physical maturation and skill development in young people.

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